

# **City & Guilds Level 2 Certificate/Diploma in Engineering Operations (Knowledge) (4510-11-12)**

**Version 2.4 (April 2025)**

**Qualification Handbook**

## Qualification at a glance

<b>Subject area</b>	Engineering
<b>City &amp; Guilds number</b>	4510
<b>Age group approved</b>	16+
<b>Entry requirements</b>	None
<b>Assessment types</b>	Short Answer, Centre devised
<b>Grading</b>	Pass/Fail
<b>Approvals</b>	Fast track approval /Full approval
<b>Support materials</b>	Assessment pack
<b>Registration and certification</b>	Consult the Walled Garden/Online Catalogue for last dates

<b>Title and level</b>	<b>City &amp; Guilds qualification number</b>	<b>Ofqual accreditation number</b>	<b>GLH</b>	<b>TQT</b>
City & Guilds Level 2 Certificate in Engineering Operations (Knowledge)	4510-11	603/6595/X	220	230
City & Guilds Level 2 Diploma in Engineering Operations (Knowledge)	4510-12	603/6596/1	370	390

Version and date	Change detail	Section
V1.0 Sept 2020	Ofqual accreditation no. added	
V2.0 July 2021	Added optional City & Guilds devised assessments	4 Assessment
V2.1 August 2021	Added optional City & Guilds devised assessments	4 Assessment strategy
V2.2 April 2023	Qualification regulatory table updated with GLH and TQT Unit 201 AC 1.5 range updated  Appendix 1 updated and Appendix 2 deleted Page numbering updated	Qualification at a glance Unit 201 Working in an Engineering Environment Appendices Throughout
V2.3 September 2024	Handbook reviewed and updated to new template Removal of centre devised assessment option for some units: 202, 203, 204, 206, 207, 208, 209, 210, 211, 212, 213, 214, 218	Throughout Assessment
V2.4 April 2025	Unit 204 title amended to “Fitting and Assembly Techniques”	Throughout

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# 1 Introduction

This document tells you what you need to do to deliver the qualification:

Area	Description
Who is the qualification for?	Those working as engineering operatives within the engineering and manufacturing sector.
What does the qualification cover?	This qualification allows learners to develop the knowledge required for employment and/or career progression in the engineering and manufacturing industry sector in general.
What opportunities for progression are there?	Upon completion, apprentices will have achieved the on-programme knowledge qualification. This is a mandatory component of the level 2 engineering operative apprenticeship framework. Whilst progression into further study is an option, the intent for this standard is that progression is into one of the job roles defined within the standard as an operative.
Who did we develop the qualification with?	This qualification has been developed in collaboration with the Engineering and Manufacturing Employer Group which included the following organisations: Roquette UK, William Hare Ltd, JCB, MoveTech, Ministry of Defence, KMF, Severfield (UK) Limited, Royal Armoured Corps, Cooney Marine, Unipres (UK) limited, Quinton Major, Renishaw, Siemens, CSPS.
Is it part of an apprenticeship framework or initiative?	Yes. This qualification forms part of the on-programme engineering operative apprenticeship standard.  The qualification can also be used for full time students who would like to gain the knowledge that will enable them to progress into further training.

## Structure

### City & Guilds Level 2 Certificate in Engineering Operations (Knowledge) (4510-11)

Learners must achieve the mandatory unit (201), plus a minimum of 3 optional units from (202-247). This qualification has a minimum qualification time of 220 hours and a TQT of 230 hours.

### City & Guilds Level 2 Diploma in Engineering Operations (Knowledge) (4510-12)

Learners must achieve the mandatory unit (201), plus a minimum of 6 optional units from (202-247). This qualification has a minimum qualification time of 370 hours and a TQT of 390 hours.

City & Guilds unit number	Unit title	GLH
<b>Mandatory</b>		
201	Working in an engineering environment	70
<b>Optional</b>		
202	Engineering techniques	40
203	Engineering mathematics and science principles	70
204	Fitting and assembly techniques	50
205	Business improvement techniques	60
206	Principles of turning and milling	80
207	Manual turning techniques	50
208	Manual milling techniques	50
209	Grinding techniques	50
210	Principles of computer numerical control (CNC) machining/fabrication	50
211	Computer numerical control (CNC) turning techniques	50
212	Computer numerical control (CNC) milling techniques	50
213	Computer aided design (CAD)	50
214	Electrical and electronic principles	40
215	Electrical and electronic testing methods	50
216	Electrical and electronic systems and devices	40
217	Fabrication and welding principles	50
218	Manual welding techniques	70

City & Guilds unit number	Unit title	GLH
<b>Optional</b>		
219	Producing components from metal plate	50
220	Producing components from sheet metal	50
221	Sheet metalwork technology	50
222	Non-fusion thermal joining methods	50
223	Thermal cutting techniques	40
224	Engineering maintenance safety practices	40
225	Engineering maintenance techniques	50
226	Engineering maintenance planning	50
227	Engineering materials processes	60
228	Electrical installation methods, wiring and circuit protection	50
229	Basic electrical circuit inspection, testing and fault diagnosis	50
230	Building services engineering pipework fixing, bending and jointing methods	50
231	Building services engineering pipework fabrication processes and techniques	50
232	Building services pipework systems	50
233	Building services engineering systems and their layout requirements	50
234	Installation and servicing of refrigeration equipment	50
235	Installation and servicing of air-conditioning equipment	50
236	Design of security systems	50
237	Installation of security systems	50
238	Plan and carry out a project in engineering	60
239	Applied mathematics in engineering	70
240	Leading a team in engineering	40
241	Engineering manufacturing techniques	50

City & Guilds unit number	Unit title	GLH
<b>Optional</b>		
242	Engineering design techniques	50
243	Marketing an engineering product	50
244	Additive manufacturing (3D printing)	40
245	Effective working practices in an engineering environment when working on military vehicles and equipment	30
246	Principles of military vehicle and equipment maintenance	60
247	Procedures and processes for fault identification on military vehicles and mechanical systems	70

### Barred units

#### Unit 206 is barred with units 207 and 208

If unit 206 is undertaken then units 207 and 208 cannot be taken

#### Unit 210 is barred with units 211 and 212

If unit 210 is undertaken then units 211 and 212 cannot be taken

## Total Qualification Time

Total Qualification Time (TQT) is the total amount of time, in notional hours, which represents an estimate of the total amount of time expected for a learner to achieve and demonstrate the achievement of the level of attainment a necessary to award a qualification.

TQT is comprised of the following two elements:

- 1) the number of hours which an awarding organisation has assigned to a qualification for Guided Learning, and
- 2) an estimate of the number of hours a learner will be likely to spend in preparation, study or any other form of participation in education or training, including assessment, which takes place as directed by - but, not under the immediate guidance or supervision of a lecturer, supervisor, tutor or other education or training provider.

Title and level	GLH	TQT
City & Guilds Level 2 Certificate in Engineering Operations (Knowledge)	220	230

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Title and level	GLH	TQT
City & Guilds Level 2 Diploma in Engineering Operations (Knowledge)	370	390

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## 2 Centre requirements

### Approval

If your centre is approved to offer the following qualifications then you can apply for fast track approval of the Level 2 Certificate/Diploma in Engineering Operations (Knowledge) using the fast track approval form, available from the City & Guilds website:-

Level 2 Certificate in Engineering - Manufacturing Technology (2850-20)  
Level 2 Certificate in Engineering - Maintenance Technology (2850-21)  
Level 2 Certificate in Engineering - Fabrication and Welding Technology (2850-22)  
Level 2 Certificate in Engineering - Electrical & Electronics Technology (2850-23)

Level 2 Diploma in Engineering - Manufacturing Technology (2850-24)  
Level 2 Diploma in Engineering - Maintenance Technology (2850-25)  
Level 2 Diploma in Engineering - Fabrication and Welding Technology (2850-26)  
Level 2 Diploma in Engineering - Electrical & Electronics Technology (2850-27)

To offer these qualifications, new centres will need to gain both centre and qualification approval. Please refer to the Centre Manual - Supporting Customer Excellence for further information.

Centre staff should familiarise themselves with the structure, content and assessment requirements of the qualifications before designing a course programme.

### Resource requirements

#### Centre staffing

Staff delivering these qualifications must be able to demonstrate that they meet the following occupational expertise requirements. They should:

- be occupationally competent or technically knowledgeable in the areas for which they are delivering training and/or have experience of providing training. This knowledge must be to the same level as the training being delivered
- have recent relevant experience in the specific area they will be assessing
- have credible experience of providing training.

Centre staff may undertake more than one role, e.g. tutor and assessor or internal verifier, but cannot internally verify their own assessments. They must:

- be technically knowledgeable in the area(s) for which they are delivering training/assessing, with appropriate qualifications.

### Quality assurance

#### [Centre Handbook: Quality Assurance Standards](#)

This document is for all approved centres and provides guidance to support their delivery of our qualifications. It includes information on:

- centre quality assurance criteria and monitoring activities
- administration and assessment systems
- centre-facing support teams at City & Guilds/ILM
- centre quality assurance roles and responsibilities.

The Centre Handbook should be used to ensure compliance with the terms and conditions of the centre contract.

This document sets out the minimum common quality assurance requirements for our regulated and non-regulated qualifications that feature centre-assessed components. Specific guidance will also be included in relevant qualification handbooks and/or assessment documentation.

It incorporates our expectations for centre internal quality assurance and the external quality assurance methods we use to ensure that assessment standards are met and upheld. It also details the range of sanctions that may be put in place when centres do not comply with our requirements or actions that will be taken to align centre marking/assessment to required standards. Additionally, it provides detailed guidance on the secure and valid administration of centre assessments.

## **Learner entry requirements**

City & Guilds does not set entry requirements for these qualifications. However, centres must ensure that candidates have the potential and opportunity to gain the qualifications successfully.

Individual employers will set the criteria, but employers who recruit learners without English and Maths at level 1 (or equivalent), must ensure that the learner achieves this requirement and take the test for Level 2, prior to completion of the Apprenticeship.

This qualification is a mandatory component of the on-programme phase of the Engineering Operative Apprenticeship Standard for the following occupational engineering job roles; maintenance operative, mechanical manufacturing operative, electrical and electronic operative, fabrication operative, materials, processing, finishing operative, and technical support operative.

The Standard and Assessment plan was designed by Employers. Centres should make themselves familiar with the Standard, Assessment Plan and Employer Occupational Brief requirements, details of which can be found on the UK Government website in apprenticeship standards. [www.gov.uk](http://www.gov.uk)

## **Age restrictions**

This qualification is approved for learners aged 16 or above.

## Access arrangements and reasonable adjustments

City & Guilds has considered the design of this qualification and its assessments to best support accessibility and inclusion for all learners. We understand however that individuals have diverse learning needs and may require reasonable adjustments to fully participate. Reasonable adjustments, such as additional time or alternative formats, may be provided to accommodate learners with disabilities and support fair access to assessment.

Access arrangements are adjustments that allow candidates with disabilities, special educational needs, and temporary injuries to access the assessment and demonstrate their skills and knowledge without changing the demands of the assessment. These arrangements must be made before assessment takes place.

Equities legislation requires City & Guilds to make reasonable adjustments where a disabled person would be at a substantial disadvantage in undertaking an assessment.

It is the responsibility of the centre to ensure at the start of a programme of learning that candidates will be able to access the requirements of the qualification.

Please refer to the Joint Council for Qualifications (JCQ) access arrangements and reasonable adjustments and access arrangements in the [Centre Document Library](#) on the City & Guilds website [www.cityandguilds.com](http://www.cityandguilds.com) for when and how applications need to be made to City & Guilds.

## 3 Delivering the qualification

### Initial assessment and induction

An initial assessment of each candidate should be made before the start of their programme to identify:

- if the candidate has any specific training needs
- support and guidance they may need when working towards their qualifications
- the appropriate type and level of qualification.

We recommend that centres provide an induction programme so the candidate fully understands the requirements of the qualifications, their responsibilities as a candidate, and the responsibilities of the centre. This information can be recorded on a learning contract.

### Inclusion and diversity

City & Guilds is committed to improving inclusion and diversity within the way we work and how we deliver our purpose which is to help people and organisations develop the skills they need for growth.

More information and guidance to support centres in supporting inclusion and diversity through the delivery of City & Guilds qualifications can be found here: [Inclusion and diversity | City & Guilds \(cityandguilds.com\)](#)

### Sustainability

City & Guilds are committed to net zero. Our ambition is to reduce our carbon emissions by at least 50% before 2030 and develop environmentally responsible operations to achieve net zero by 2040 or sooner if we can. City & Guilds is committed to supporting qualifications that support our customers to consider sustainability and their environmental footprint.

More information and guidance to support centres in developing sustainable practices through the delivery of City & Guilds qualifications can be found here: [Our Pathway to Net Zero | City & Guilds \(cityandguilds.com\)](#)

Centres should consider their own carbon footprint when delivering this qualification and consider reasonable and practical ways of delivering this qualification with sustainability in mind. This could include:

- reviewing purchasing and procurement processes (such as buying in bulk to reduce the amount of travel time and energy, considering and investing in the use of components that can be reused, instead of the use of disposable or single use consumables)
- reusing components wherever possible

- waste procedures (ensuring that waste is minimised, recycling of components is in place wherever possible)
- minimising water use and considering options for reuse/salvage as part of plumbing activities wherever possible.

## Support materials

The following resources are available for these qualifications:

Description	How to access
Sample assessment pack	<a href="http://www.cityandguilds.com">www.cityandguilds.com</a>

## 4 Assessment

### Assessment of the qualification

#### Candidates must:

- have completed the relevant compulsory City & Guilds externally set assessment for the Mandatory unit, 201.
  - Short answer tests for Mandatory unit 201
- have completed the relevant assessment for each optional unit chosen. If available, these assessments must be the City & Guilds externally set assessments. Otherwise, where a City & Guilds externally set assessments is not available on the City & Guilds website ([www.cityandguilds.com](http://www.cityandguilds.com)), all centre devised assessments require prior approval from City and Guilds. See Section 2, Centre requirements, Quality assurance.

#### Available assessments

City & Guilds has written the following assessments which must be used with this qualification. Whilst these assessments are externally set, they are internally marked.

- Short answer tests for Optional unit 202
- Short answer tests for Optional unit 203
- Short answer tests for Optional unit 204
- Short answer tests for Optional unit 206
- Short answer tests for Optional unit 207
- Short answer tests for Optional unit 208
- Short answer tests for Optional unit 209
- Short answer tests for Optional unit 210
- Short answer tests for Optional unit 211
- Short answer tests for Optional unit 212
- Short answer tests for Optional unit 213
- Short answer tests for Optional unit 214
- Short answer tests for Optional unit 218
- Short answer tests for Optional unit 225
- Short answer tests for Optional unit 227
- Short answer tests for Optional unit 242

If a City & Guilds externally set assessment is not available on the City & Guilds website ([www.cityandguilds.com](http://www.cityandguilds.com)), all centre devised assessments require prior approval. See Section 2, Centre requirements, Quality assurance.

## Assessment Types

Unit	Title	Assessment method	Grading	Where to obtain assessment materials
201	Working in an engineering environment	Externally set, internally marked assessment	P/X	www.cityandguilds.com
202	Engineering techniques	Externally set, internally marked assessment	P/X	www.cityandguilds.com
203	Engineering mathematics and science principles	Externally set, internally marked assessment	P/X	www.cityandguilds.com
204	Fitting and assembly techniques	Externally set, internally marked assessment	P/X	www.cityandguilds.com
205	Business improvement techniques	Centre Devised Internally set and marked assessment	P/X	www.cityandguilds.com
206	Principles of turning and milling	Externally set, internally marked assessment	P/X	www.cityandguilds.com
207	Manual turning techniques	Externally set, internally marked assessment	P/X	www.cityandguilds.com
208	Manual milling techniques	Externally set, internally marked assessment	P/X	www.cityandguilds.com
209	Grinding techniques	Externally set, internally marked assessment	P/X	www.cityandguilds.com

Unit	Title	Assessment method	Grading	Where to obtain assessment materials
210	Principles of computer numerical control (CNC) machining/fabrication	Externally set, internally marked assessment	P/X	www.cityandguilds.com
211	Computer numerical control (CNC) turning techniques	Externally set, internally marked assessment	P/X	www.cityandguilds.com
212	Computer numerical control (CNC) milling techniques	Externally set, internally marked assessment	P/X	www.cityandguilds.com
213	Computer aided design (CAD)	Externally set, internally marked assessment	P/X	www.cityandguilds.com
214	Electrical and electronic principles	Externally set, internally marked assessment	P/X	www.cityandguilds.com
215	Electrical and electronic testing methods	Centre Devised Internally set and marked assessment	P/X	www.cityandguilds.com
216	Electrical and electronic systems and devices	Centre Devised Internally set and marked assessment	P/X	www.cityandguilds.com
217	Fabrication and welding principles	Centre Devised Internally set and marked assessment	P/X	www.cityandguilds.com

Unit	Title	Assessment method	Grading	Where to obtain assessment materials
218	Manual welding techniques	Externally set, internally marked assessment	P/X	<a href="http://www.cityandguilds.com">www.cityandguilds.com</a>
219	Producing components from metal plate	Centre Devise Internally set and marked assessment	P/X	<a href="http://www.cityandguilds.com">www.cityandguilds.com</a>
220	Producing components from sheet metal	Centre Devise Internally set and marked assessment	P/X	<a href="http://www.cityandguilds.com">www.cityandguilds.com</a>

Unit	Title	Assessment method	Grading	
221	Sheet metalwork technology	Centre Devised Internally set and marked assessment	P/X	www.cityandguilds.com
222	Non-fusion thermal joining methods	Centre Devised Internally set and marked assessment	P/X	www.cityandguilds.com
223	Thermal cutting techniques	Centre Devised Internally set and marked assessment	P/X	www.cityandguilds.com
224	Engineering maintenance safety practices	Centre Devised Internally set and marked assessment	P/X	www.cityandguilds.com
225	Engineering maintenance techniques	Externally set, internally marked assessment	P/X	www.cityandguilds.com
226	Engineering maintenance planning	Centre Devised Internally set and marked assessment	P/X	www.cityandguilds.com
227	Engineering materials processes	Externally set, internally marked assessment	P/X	www.cityandguilds.com
228	Electrical installation methods, wiring and circuit protection	Centre Devised Internally set and marked assessment	P/X	www.cityandguilds.com
229	Basic electrical circuit inspection, testing and fault diagnosis	Centre Devised Internally set and marked assessment	P/X	www.cityandguilds.com

Unit	Title	Assessment method	Grading	
230	Building services engineering pipework fixing, bending and jointing methods	Centre Devised Internally set and marked assessment	P/X	www.cityandguilds.com
231	Building services engineering pipework fabrication processes and techniques	Centre Devised Internally set and marked assessment	P/X	www.cityandguilds.com
232	Building services pipework systems	Centre Devised Internally set and marked assessment	P/X	www.cityandguilds.com
233	Building services engineering systems and their layout requirements	Centre Devised Internally set and marked assessment	P/X	www.cityandguilds.com
234	Installation and servicing of refrigeration equipment	Centre Devised Internally set and marked assessment	P/X	www.cityandguilds.com
235	Installation and servicing of air-conditioning equipment	Centre Devised Internally set and marked assessment	P/X	www.cityandguilds.com
236	Design of security systems	Centre Devised Internally set and marked assessment	P/X	www.cityandguilds.com
237	Installation of security systems	Centre Devised Internally set and marked assessment	P/X	www.cityandguilds.com

Unit	Title	Assessment method	Grading	Where to obtain assessment materials
238	Plan and carry out a project in engineering	Centre Devised Internally set and marked assessment	P/X	www.cityandguilds.com
239	Applied mathematics in engineering	Centre Devised Internally set and marked assessment	P/X	www.cityandguilds.com
240	Leading a team in engineering	Centre Devised Internally set and marked assessment	P/X	www.cityandguilds.com
241	Engineering manufacturing techniques	Centre Devised Internally set and marked assessment	P/X	www.cityandguilds.com
242	Engineering design techniques	Externally set, internally marked assessment	P/X	www.cityandguilds.com
243	Marketing an engineering product	Centre Devised Internally set and marked assessment	P/X	www.cityandguilds.com
244	Additive manufacturing (3D printing)	Centre Devised Internally set and marked assessment	P/X	www.cityandguilds.com
245	Effective working practices in an engineering environment when working on military vehicles and equipment	Centre Devised Internally set and marked assessment	P/X	www.cityandguilds.com

Unit	Title	Assessment method	Grading	Where to obtain assessment materials
246	Principles of military vehicle and equipment maintenance	Centre Devised Internally set and marked assessment	P/X	<a href="http://www.cityandguilds.com">www.cityandguilds.com</a>
247	Procedures and processes for fault identification on military vehicles and mechanical systems	Centre Devised Internally set and marked assessment	P/X	<a href="http://www.cityandguilds.com">www.cityandguilds.com</a>

## **Assessment strategy**

Mandatory unit 201 is assessed by an external short answer test created by City & Guilds which is graded Pass/Fail only.

Optional units 202-204, 206-214, 218, 225, 227, 242 are assessed by a short answer test, which is graded Pass/Fail only. This is a test created by City & Guilds. The test is marked by the centre and externally quality assured.

Optional units 205, 215-217, 219-224, 226, 228-247 are assessed by short answer tests, which are approved centre devised, internally marked by centres and externally verified. These assessments are graded Pass/Fail only.

All centre devised require prior approval from City and Guilds. See Section 2, Centre requirements, Quality assurance

### ***Time constraints***

All assessments must be completed within the candidate's period of registration. All examinations are short answer questions with varying marks available per question. Examinations will typically be between 1 and 2 hours.

### **Recognition of prior learning (RPL)**

RPL is not allowed for this qualification.

### ***Test Specifications***

The way the knowledge is covered by each test is laid out in the tables below.

**Assessment title:** 4510-201 Working in an engineering environment

**Assessment type:** Short answer test

**Assessment conditions:** Supervised examination conditions

**Grading:** P/X

	<b>Duration: 2 hours</b>		
	<b>Learning Outcome</b>	<b>Number of marks</b>	<b>%</b>
<b>Unit 201</b>	1. Understand health and safety requirements in engineering	22	31
	2. Understand how engineering businesses are organised	16	23
	3. Know types of workshop equipment and their applications	16	23
	4. Understand fitting and assembly activities	16	23
<b>Total</b>		<b>70</b>	<b>100</b>

**Assessment title:** 4510-202 Engineering techniques

**Assessment type:** Short answer test

**Assessment conditions:** Supervised examination conditions

**Grading:** P/X

	<b>Duration: 1 hour</b>		
	<b>Learning Outcome</b>	<b>Number of marks</b>	<b>%</b>
<b>Unit 202</b>	1. Understand drawings used by engineering businesses	26	65
	2. Understand quality processes in engineering	14	35
<b>Total</b>		<b>40</b>	<b>100</b>

**Assessment title:** 4510-203 Engineering mathematics & science principles

**Assessment type:** Short answer test

**Assessment conditions:** Supervised examination conditions

**Grading:** P/X

	<b>Duration: 1 hour 30 minutes</b>		
	<b>Learning Outcome</b>	<b>Number of marks</b>	<b>%</b>
<b>Unit 203</b>	1. Understand arithmetical and trigonometrical applications	15	21
	2. Know how to determine perimeters, areas and volumes of shapes	15	21
	3. Understand terminology used in engineering science	17	25
	4. Understand the effect of changes of temperature on engineering materials	9	13
	5. Understand the properties of engineering material	14	20
	<b>Total</b>	<b>70</b>	<b>100</b>

**Assessment title:** 4510-204 Fitting and assembly techniques

**Assessment type:** Short answer test

**Assessment conditions:** Supervised examination conditions

**Grading:** P/X

	<b>Duration: 1 hour 15 minutes</b>		
	<b>Learning Outcome</b>	<b>Number of marks</b>	<b>%</b>
<b>Unit 204</b>	1. Understand engineering health and safety requirements	20	40
	2. Understand fitting and assembly techniques	30	60
<b>Total</b>		<b>50</b>	<b>100</b>

**Assessment title:** 4510-205 Business improvement techniques

**Assessment type:** Centre devised short answer test

**Assessment conditions:** Supervised examination conditions

**Grading:** P/X

	<b>Duration: 1 hour 30 minutes</b>		
	<b>Learning Outcome</b>	<b>Number of marks</b>	<b>%</b>
<b>Unit 205</b>	1. Understand the concept of continuous improvement	20	33
	2. Understand what is meant by workplace organisation	14	23
	3. Understand what is meant by visual management	10	17
	4. Understand problem solving techniques	16	27
<b>Total</b>		<b>60</b>	<b>100</b>

**Assessment title:** 4510-206 Principles of turning and milling

**Assessment type:** Short answer test

**Assessment conditions:** Supervised examination conditions

**Grading:** P/X

	<b>Duration: 2 hours</b>		
	<b>Learning Outcome</b>	<b>Number of marks</b>	<b>%</b>
<b>Unit 206</b>	1. Know equipment required for turning and milling operations	34	43
	2. Understand how to produce manually machined components	32	40
	3. Understand how to meet quality requirements for machining components	14	17
	<b>Total</b>	<b>80</b>	<b>100</b>

**Assessment title:** 4510-207 Manual turning techniques

**Assessment type:** Short answer test

**Assessment conditions:** Supervised examination conditions

**Grading:** P/X

	<b>Duration: 1 hour 15 minutes</b>		
	<b>Learning Outcome</b>	<b>Number of marks</b>	<b>%</b>
<b>Unit 207</b>	1. Know the equipment required for turning operations	18	36
	2. Understand how to produce turned components on a lathe	22	44
	3. Understand how to meet quality requirements for turning operations	10	20
	<b>Total</b>	<b>50</b>	<b>100</b>

**Assessment title:** 4510-208 Manual milling techniques

**Assessment type:** Short answer test

**Assessment conditions:** Supervised examination conditions

**Grading:** P/X

	<b>Duration: 1 hour 15 minutes</b>		
	<b>Learning Outcome</b>	<b>Number of marks</b>	<b>%</b>
<b>Unit 208</b>	1 Know the equipment required for milling operations	18	36
	2 Understand how to produce components on a milling machine	22	44
	3 Understand how to meet quality requirements for milling operations	10	20
<b>Total</b>		<b>50</b>	<b>100</b>

**Assessment title:** 4510-209 Grinding techniques

**Assessment type:** Short answer test

**Assessment conditions:** Supervised examination conditions

**Grading:** P/X

	<b>Duration: 1 hour 15 minutes</b>		
	<b>Learning Outcome</b>	<b>Number of marks</b>	<b>%</b>
<b>Unit 209</b>	1. Know the equipment required for grinding operations	20	40
	2. Understand how to produce components on grinding machines	20	40
	3. Understand how to meet quality requirements for grinding operations	10	20
<b>Total</b>		<b>50</b>	<b>100</b>

**Assessment title:** 4510-210 Principles of CNC machining/fabrication

**Assessment type:** Short answer test

**Assessment conditions:** Supervised examination conditions

**Grading:** P/X

	<b>Duration: 1 hour 15 minutes</b>		
	<b>Learning Outcome</b>	<b>Number of marks</b>	<b>%</b>
<b>Unit 210</b>	1. Understand the equipment available for CNC fabrication operations	24	48
	2. Understand the programming of CNC fabrication machinery	16	32
	3. Understand the benefits and limitations of using CNC fabrication machinery	10	20
	<b>Total</b>	<b>50</b>	<b>100</b>

**Assessment title:** 4510-211 CNC turning techniques

**Assessment type:** Short answer test

**Assessment conditions:** Supervised examination conditions

**Grading:** P/X

	<b>Duration: 1 hour 15 minutes</b>		
	<b>Learning Outcome</b>	<b>Number of marks</b>	<b>%</b>
<b>Unit 211</b>	1. Know the equipment required for CNC turning operations	24	48
	2. Understand how to produce turned components on a CNC lathe	20	40
	3. Understand quality requirements for CNC turning operations	6	12
	<b>Total</b>	<b>50</b>	<b>100</b>

**Assessment title:** 4510-212 CNC milling techniques

**Assessment type:** Short answer test

**Assessment conditions:** Supervised examination conditions

**Grading:** P/X

	<b>Duration: 1 hour 15 minutes</b>		
	<b>Learning Outcome</b>	<b>Number of marks</b>	<b>%</b>
<b>Unit 212</b>	1. Know the equipment required for CNC milling operations	22	44
	2. Understand how to produce components on a CNC mill	22	44
	3. Understand quality requirements for CNC milling operations	6	12
	<b>Total</b>	<b>50</b>	<b>100</b>

**Assessment title:** 4510-213 Computer aided design (CAD)

**Assessment type:** Short answer test

**Assessment conditions:** Supervised examination conditions

**Grading:** P/X

	<b>Duration: 1 hour 15 minutes</b>		
	<b>Learning Outcome</b>	<b>Number of marks</b>	<b>%</b>
<b>Unit 213</b>	1. Understand the principles of using a CAD system	24	48
	2. Know the main capabilities of CAD software	26	52
	<b>Total</b>	<b>50</b>	<b>100</b>

**Assessment title:** 4510-214 Electrical and electronic principles

**Assessment type:** Short answer test

**Assessment conditions:** Supervised examination conditions

**Grading:** P/X

	<b>Duration: 1 hour</b>		
	<b>Learning Outcome</b>	<b>Number of marks</b>	<b>%</b>
<b>Unit 214</b>	1. Understand electrical and electronic circuit principles	8	20
	2. Understand the units of measurement used to quantify electrical parameters	7	18
	3. Understand methods of calculating values in electrical and electronic circuits	25	62
	<b>Total</b>	<b>40</b>	<b>100</b>

**Assessment title:** 4510-215 Electrical and electronic testing methods

**Assessment type:** Centre devised short answer test

**Assessment conditions:** Supervised examination conditions

**Grading:** P/X

	<b>Duration: 1 hour 15 minutes</b>		
	<b>Learning Outcome</b>	<b>Number of marks</b>	<b>%</b>
<b>Unit 215</b>	1. Understand the units of measurement used to quantify electrical parameters	14	28
	2. Understand the applications of electrical and electronic test equipment	24	48
	3. Understand electrical and electronic test equipment calibration techniques	12	24
	<b>Total</b>	<b>50</b>	<b>100</b>

**Assessment title:** 4510-216 Electrical and electronic systems and devices

**Assessment type:** Centre devised short answer test

**Assessment conditions:** Supervised examination conditions

**Grading:** P/X

	<b>Duration: 1 hour</b>		
	<b>Learning Outcome</b>	<b>Number of marks</b>	<b>%</b>
<b>Unit 216</b>	1. Understand the functions of electrical and electronic components and devices	24	60
	2. Understand methods of representing electrical and electronic systems	16	40
<b>Total</b>		<b>40</b>	<b>100</b>

**Assessment title:** 4510-217 Fabrication and welding principles

**Assessment type:** Centre devised short answer test

**Assessment conditions:** Supervised examination conditions

**Grading:** P/X

	<b>Duration: 1 hour 15 minutes</b>		
	<b>Learning Outcome</b>	<b>Number of marks</b>	<b>%</b>
<b>Unit 217</b>	1. Understand the equipment available to produce fabricated components	14	28
	2. Understand cutting and forming methods used for fabrication	18	36
	3. Understand the joining and assembly methods for fabrication	18	36
<b>Total</b>		<b>50</b>	<b>100</b>

**Assessment title:** 4510-218 Manual welding techniques

**Assessment type:** Short answer test

**Assessment conditions:** Supervised examination conditions

**Grading:** P/X

	<b>Duration: 2 hours</b>		
	<b>Learning Outcome</b>	<b>Number of marks</b>	<b>%</b>
<b>Unit 218</b>	1. Understand safe working practices associated with welding processes	12	17
	2. Understand principles of manual welding	20	29
	3. Understand the Manual Metal Arc (MMA) welding process	6	9
	4. Understand the Metal Inert Gas/Metal Active Gas (MIG/MAG) welding processes	10	14
	5. Understand the Tungsten Inert Gas (TIG) welding process	10	14
	6. Understand inspection methods for weld defects	12	17
	<b>Total</b>	<b>70</b>	<b>100</b>

**Assessment title:** 4510-219 Producing components from metal plate

**Assessment type:** Centre devised short answer test

**Assessment conditions:** Supervised examination conditions

**Grading:** P/X

	<b>Duration: 1 hour 15 minutes</b>		
	<b>Learning Outcome</b>	<b>Number of marks</b>	<b>%</b>
<b>Unit 219</b>	1. Understand tools and equipment used to produce metal plate components	18	36
	2. Understand cutting methods for metal plate	12	24
	3. Understand forming methods for metal plate	6	12
	4. Understand joining and assembly methods for metal plate	14	28
	<b>Total</b>	<b>50</b>	<b>100</b>

**Assessment title:** 4510-220 Producing components from sheet metal

**Assessment type:** Centre devised short answer test

**Assessment conditions:** Supervised examination conditions

**Grading:** P/X

	<b>Duration: 1 hour 15 minutes</b>		
	<b>Learning Outcome</b>	<b>Number of marks</b>	<b>%</b>
<b>Unit 220</b>	1. Understand tools and equipment used to produce sheet metal components	16	32
	2. Understand cutting methods for sheet metal	8	16
	3. Understand forming methods for sheet metal	10	20
	4. Understand joining and assembly methods for sheet metal	16	32
	<b>Total</b>	<b>50</b>	<b>100</b>

**Assessment title:** 4510-221 Principles of sheet and plate metal work technology

**Assessment type:** Centre devised short answer test

**Assessment conditions:** Supervised examination conditions

**Grading:** P/X

	<b>Duration: 1 hour 15 minutes</b>		
	<b>Learning Outcome</b>	<b>Number of marks</b>	<b>%</b>
<b>Unit 221</b>	1. Understand methods of work organisation	14	28
	2. Understand cutting and forming principles	24	48
	3. Know pattern development techniques	12	24
	<b>Total</b>	<b>50</b>	<b>100</b>

**Assessment title:** 4510-222 Non-Fusion thermal joining methods

**Assessment type:** Centre devised short answer test

**Assessment conditions:** Supervised examination conditions

**Grading:** P/X

	<b>Duration: 1 hour 15 minutes</b>		
	<b>Learning Outcome</b>	<b>Number of marks</b>	<b>%</b>
<b>Unit 222</b>	1. Understand the soft soldering method of joining metals	15	30
	2. Understand the hard-soldering method of joining metals	15	30
	3. Understand the use of adhesives to join materials	20	40
	<b>Total</b>	<b>50</b>	<b>100</b>

**Assessment title:** 4510-223 Thermal cutting techniques

**Assessment type:** Centre devised short answer test

**Assessment conditions:** Supervised examination conditions

**Grading:** P/X

	<b>Duration: 1 hour</b>		
	<b>Learning Outcome</b>	<b>Number of marks</b>	<b>%</b>
<b>Unit 223</b>	1. Understand the principle of oxy-fuel thermal cutting	26	65
	2. Understand the principle of plasma cutting	8	20
	3. Understand the principle of laser cutting	6	15
	<b>Total</b>	<b>40</b>	<b>100</b>

**Assessment title:** 4510-224 Engineering maintenance safety

**Assessment type:** Centre devised short answer test

**Assessment conditions:** Supervised examination conditions

**Grading:** P/X

	<b>Duration: 1 hour</b>		
	<b>Learning Outcome</b>	<b>Number of marks</b>	<b>%</b>
<b>Unit 224</b>	1. Understand safe working practices, tools and equipment for maintenance activities	30	75
	2. Know how to clean and restore work areas following maintenance activities	10	25
	<b>Total</b>	<b>40</b>	<b>100</b>

**Assessment title:** 4510-225 Engineering maintenance techniques

**Assessment type:** Short answer test

**Assessment conditions:** Supervised examination conditions

**Grading:** P/X

	<b>Duration: 1 hour 15 minutes</b>		
	<b>Learning Outcome</b>	<b>Number of marks</b>	<b>%</b>
<b>Unit 225</b>	1. Understand fault diagnostic methods	14	28
	2. Understand measuring systems and instrumentation	10	20
	3. Understand how plant and equipment is maintained	26	52
	<b>Total</b>	<b>50</b>	<b>100</b>

**Assessment title:** 4510-226 Engineering maintenance planning

**Assessment type:** Centre devised short answer test

**Assessment conditions:** Supervised examination conditions

**Grading:** P/X

	<b>Duration: 1 hour 15 minutes</b>		
	<b>Learning Outcome</b>	<b>Number of marks</b>	<b>%</b>
<b>Unit 226</b>	1 Understand different types of planned maintenance	18	36
	2 Understand health and safety requirements for planning maintenance activities	12	24
	3 Understand the planning of maintenance activities	20	40
	<b>Total</b>	<b>50</b>	<b>100</b>

**Assessment title:** 4510-227 Engineering materials

**Assessment type:** Short answer test

**Assessment conditions:** Supervised examination conditions

**Grading:** P/X

	<b>Duration: 1 hour 30 minutes</b>		
	<b>Learning Outcome</b>	<b>Number of marks</b>	<b>%</b>
<b>Unit 227</b>	1. Understand the properties of materials	24	40
	2. Understand methods by which the properties of materials can be changed	12	20
	3. Understand failure mechanisms in materials	24	40
	<b>Total</b>	<b>60</b>	<b>100</b>

**Assessment title:** 4510-228 Electrical installation methods, wiring and circuit protection

**Assessment type:** Centre devised short answer test

**Assessment conditions:** Supervised examination conditions

**Grading:** P/X

	<b>Duration: 1 hour 15 minutes</b>		
	<b>Learning Outcome</b>	<b>Number of marks</b>	<b>%</b>
<b>Unit 228</b>	1. Understand the principles of electrical circuit wiring	16	32
	2. Know electrical installation and wiring methods	26	52
	3. Understand the applications of electrical circuit protection devices	8	16
	<b>Total</b>	<b>50</b>	<b>100</b>

**Assessment title:** 4510-229 Electrical circuit inspection, testing and fault diagnosis

**Assessment type:** Centre devised short answer test

**Assessment conditions:** Supervised examination conditions

**Grading:** P/X

	<b>Duration: 1 hour 15 minutes</b>		
	<b>Learning Outcome</b>	<b>Number of marks</b>	<b>%</b>
<b>Unit 229</b>	1. Understand safe electrical isolation procedures	10	20
	2. Understand methods of inspecting, testing and fault-finding electrical circuits	34	68
	3. Know standards and guidance relating to electrical testing and fault diagnosis	6	12
	<b>Total</b>	<b>50</b>	<b>100</b>

**Assessment title:** 4510-230 Building services engineering pipework fixing, bending and

jointing methods

**Assessment type:** Centre devised short answer test

**Assessment conditions:** Supervised examination conditions

**Grading:** P/X

	<b>Duration: 1 hour 15 minutes</b>		
	<b>Learning Outcome</b>	<b>Number of marks</b>	<b>%</b>
<b>Unit 230</b>	1. Understand the materials used in domestic pipework applications	4	8
	2. Understand methods of bending pipework	6	12
	3. Understand methods of joining pipes	10	20
	4. Understand methods of fixing pipework to the fabric of a building	16	32
	5. Understand methods of testing domestic pipework	14	28
	<b>Total</b>	<b>50</b>	<b>100</b>

**Assessment title:** 4510-231 Building services engineering pipework fabrication processes and techniques

**Assessment type:** Centre devised short answer test

**Assessment conditions:** Supervised examination conditions

**Grading:** P/X

	<b>Duration: 1 hour 15 minutes</b>		
	<b>Learning Outcome</b>	<b>Number of marks</b>	<b>%</b>
<b>Unit 231</b>	1. Understand pipework fabrication and installation methods	24	48
	2. Understand methods of supporting domestic pipework	10	20
	3. Understand methods of testing domestic pipework	16	32
	<b>Total</b>	<b>50</b>	<b>100</b>

**Assessment title:** 4510-232 Building services pipework systems

**Assessment type:** Centre devised short answer test

**Assessment conditions:** Supervised examination conditions

**Grading:** P/X

	<b>Duration: 1 hour 15 minutes</b>		
	<b>Learning Outcome</b>	<b>Number of marks</b>	<b>%</b>
<b>Unit 232</b>	1. Understand hot and cold water supply systems used for domestic plumbing	16	32
	2. Understand the principles of central heating systems	12	24
	3. Understand above ground discharge systems	10	20
	4. Understand energy and environmental issues arising from heating and water usage	12	24
	<b>Total</b>	<b>50</b>	<b>100</b>

**Assessment title:** 4510-233 Building services engineering systems and their layout requirements

**Assessment type:** Centre devised short answer test

**Assessment conditions:** Supervised examination conditions

**Grading:** P/X

	<b>Duration: 1 hour 15 minutes</b>		
	<b>Learning Outcome</b>	<b>Number of marks</b>	<b>%</b>
<b>Unit 233</b>	1. Understand types of cold water systems used in domestic buildings	16	32
	2. Understand types of hot water systems used in domestic buildings	10	20
	3. Understand the principles of central heating systems	10	20
	4. Understand types of sanitary pipework systems	10	20
	5. Understand energy sources used in the building services industry	4	8
	<b>Total</b>	<b>50</b>	<b>100</b>

**Assessment title:** 4510-234 Installation and servicing of refrigeration equipment

**Assessment type:** Centre devised short answer test

**Assessment conditions:** Supervised examination conditions

**Grading:** P/X

	<b>Duration: 1 hour 30 minutes</b>		
	<b>Learning Outcome</b>	<b>Number of marks</b>	<b>%</b>
<b>Unit 234</b>	1. Understand the principles of thermodynamics	17	28
	2. Understand the operating principles and controls for refrigeration systems	11	18
	3. Understand the principles of installing refrigeration systems	22	37
	4. Understand the principles of maintaining and servicing refrigeration systems	10	17
	<b>Total</b>	<b>60</b>	<b>100</b>

**Assessment title:** 4510-235 Installation and servicing of air-conditioning equipment

**Assessment type:** Centre devised short answer test

**Assessment conditions:** Supervised examination conditions

**Grading:** P/X

	<b>Duration: 1 hour 30 minutes</b>		
	<b>Learning Outcome</b>	<b>Number of marks</b>	<b>%</b>
<b>Unit 235</b>	1. Understand the principles of thermodynamics	17	28
	2. Understand the operating principles and controls for air-conditioning systems	11	18
	3. Understand the principles of installing air-conditioning systems	22	37
	4. Understand the principles of maintaining and servicing air-conditioning systems	10	17
	<b>Total</b>	<b>60</b>	<b>100</b>

**Assessment title:** 4510-236 Installation of security systems

**Assessment type:** Centre devised short answer test

**Assessment conditions:** Supervised examination conditions

**Grading:** P/X

	<b>Duration: 1 hour 30 minutes</b>		
	<b>Learning Outcome</b>	<b>Number of marks</b>	<b>%</b>
<b>Unit 236</b>	1. Understand types of security systems	10	16
	2. Understand circuit wiring and transmission paths	22	37
	3. Understand the design considerations of security systems	22	37
	4. Understand the testing requirements of security systems	6	10
	<b>Total</b>	<b>60</b>	<b>100</b>

**Assessment title:** 4510-237 Installation of security systems

**Assessment type:** Centre devised short answer test

**Assessment conditions:** Supervised examination conditions

**Grading:** P/X

	<b>Duration: 1 hour</b>		
	<b>Learning Outcome</b>	<b>Number of marks</b>	<b>%</b>
<b>Unit 237</b>	1. Understand site planning for a security system	8	20
	2. Understand safety considerations for installation	12	30
	3. Know methods of installing security systems	14	35
	4. Understand procedures for commissioning and handover	6	15
	<b>Total</b>	<b>40</b>	<b>100</b>

**Assessment title:** 4510-238 Project management in engineering

**Assessment type:** Centre devised short answer test

**Assessment conditions:** Supervised examination conditions

**Grading:** P/X

	<b>Duration: 1 hour 30 minutes</b>		
	<b>Learning Outcome</b>	<b>Number of marks</b>	<b>%</b>
<b>Unit 238</b>	1. Understand the importance of project management	14	23
	2. Understand how to plan, monitor and review a project	46	77
	<b>Total</b>	<b>60</b>	<b>100</b>

**Assessment title:** 4510-239 Applied mathematics in engineering

**Assessment type:** Centre devised short answer test

**Assessment conditions:** Supervised examination conditions

**Grading:** P/X

	<b>Duration: 2 hours</b>		
	<b>Learning Outcome</b>	<b>Number of marks</b>	<b>%</b>
<b>Unit 239</b>	1. Apply principles of algebra to solve engineering problems	11	16
	2. Apply principles of calculus and use graphs to solve engineering problems	26	37
	3. Apply principles of trigonometry to solve engineering problems	15	21
	4. Apply statistics to solve engineering problems	18	26
	<b>Total</b>	<b>70</b>	<b>100</b>

**Assessment title:** 4510-240 Leading an engineering team

**Assessment type:** Centre devised short answer test

**Assessment conditions:** Supervised examination conditions

**Grading:** P/X

	<b>Duration: 1 hour</b>		
	<b>Learning Outcome</b>	<b>Number of marks</b>	<b>%</b>
<b>Unit 240</b>	1. Understand approaches to leading a team	18	45
	2. Understand types of communication used in engineering businesses	8	20
	3. Understand how to resolve problems and conflict in the workplace	14	35
	<b>Total</b>	<b>40</b>	<b>100</b>

**Assessment title:** 4510-241 Engineering manufacturing techniques

**Assessment type:** Centre devised short answer test

**Assessment conditions:** Supervised examination conditions

**Grading:** P/X

	<b>Duration: 1 hour 15 minutes</b>		
	<b>Learning Outcome</b>	<b>Number of marks</b>	<b>%</b>
<b>Unit 241</b>	1. Understand how to prepare for manufacturing operations	16	32
	2. Understand the principles of manufacturing operations	20	40
	3. Understand factors that affect the efficiency of manufacturing	14	28
	<b>Total</b>	<b>50</b>	<b>100</b>

**Assessment title:** 4510-242 Engineering design techniques

**Assessment type:** Short answer test

**Assessment conditions:** Supervised examination conditions

**Grading:** P/X

	<b>Duration: 1 hour 15 minutes</b>		
	<b>Learning Outcome</b>	<b>Number of marks</b>	<b>%</b>
<b>Unit 242</b>	1. Understand the factors that affect the development of a product design specification (PDS)	20	40
	2. Understand strategies and techniques used to develop design solutions	18	36
	3. Understand the factors that affect the evaluation of a product design	12	24
	<b>Total</b>	<b>50</b>	<b>100</b>

**Assessment title:** 4510-243 Marketing engineered products

**Assessment type:** Centre devised short answer test

**Assessment conditions:** Supervised examination conditions

**Grading:** P/X

	<b>Duration: 1 hour 15 minutes</b>		
	<b>Learning Outcome</b>	<b>Number of marks</b>	<b>%</b>
<b>Unit 243</b>	1. Understand the principles of marketing	20	40
	2. Understand the marketing process for an engineered product	22	44
	3. Understand marketing as a communication method	8	16
	<b>Total</b>	<b>50</b>	<b>100</b>

**Assessment title:** 4510-244 Additive manufacturing (3D printing)

**Assessment type:** Centre devised short answer test

**Assessment conditions:** Supervised examination conditions

**Grading:** P/X

	<b>Duration: 1 hour</b>		
	<b>Learning Outcome</b>	<b>Number of marks</b>	<b>%</b>
<b>Unit 244</b>	1. Understand the principles of additive manufacturing	12	30
	2. Understand the set-up and operation of 3D printing	28	70
	<b>Total</b>	<b>40</b>	<b>100</b>

**Assessment title:** 4510-245 Effective working practices in an engineering environment when working on military vehicles and equipment

**Assessment type:** Centre devised short answer test

**Assessment conditions:** Supervised examination conditions

**Grading:** P/X

	<b>Duration: 1 hour 15 minutes</b>		
	<b>Learning Outcome</b>	<b>Number of marks</b>	<b>%</b>
<b>Unit 245</b>	1. Understand the procedures for carrying out an engineering activity on military vehicles and equipment.	16	32
	2. Understand data used for engineering activities	22	44
	3. Understand the importance of quality control	12	24
	<b>Total</b>	<b>50</b>	<b>100</b>

**Assessment title:** 4510-246 Principles of military vehicle and equipment maintenance

**Assessment type:** Centre devised short answer test

**Assessment conditions:** Supervised examination conditions

**Grading:** P/X

	<b>Duration: 1 hour</b>		
	<b>Learning Outcome</b>	<b>Number of marks</b>	<b>%</b>
<b>Unit 246</b>	1. Understand the different types of maintenance	22	55
	2. Understand the procedures for maintenance on military equipment in line with the technical literature available	12	30
	3. Understand the procedures for removing and replacing components	6	15
	<b>Total</b>	<b>40</b>	<b>100</b>

**Assessment title:** 4510-247 Procedures and processes for fault identification on military vehicles and mechanical systems

**Assessment type:** Centre devised short answer test

**Assessment conditions:** Supervised examination conditions

**Grading:** P/X

	<b>Duration: 1 hour 15 minutes</b>		
	<b>Learning Outcome</b>	<b>Number of marks</b>	<b>%</b>
<b>Unit 247</b>	1. Understand the function of military vehicles and mechanical systems	10	22.5
	2. Understand how to identify the symptoms of a fault	16	35
	3. Understand procedures for rectifying / remedying faults	9	20
	4. Understand the process for testing / checking the function of equipment following repair	10	22.5
	<b>Total</b>	<b>45</b>	<b>100</b>

## 4 Grading

### Grading of individual assessments

Candidates must achieve a pass in all components for the qualification to be achieved, as per the marking scheme provided or developed.

## 5 Units

### Structure of the units

These units each have the following:

- City & Guilds reference number
- Title
- Level
- Guided learning hours (GLH)
- Learning outcomes, which are comprised of a number of assessment criteria

### Guidance for delivery of the units

This qualification comprises a number of units. A unit describes what is expected of a competent person in particular aspects of their job.

Each unit is divided into learning outcomes which describe in further detail the skills and knowledge that a candidate should possess.

Each learning outcome has a set of assessment criteria (performance and knowledge and understanding) which specify the desired criteria that must be satisfied before an individual can be said to have performed to the agreed standard.

Range statements define the breadth or scope of a learning outcome and its assessment criteria by setting out the various circumstances in which they are to be applied.

Supporting information provides guidance of the evidence requirement for the unit and specific guidance on delivery and range statements. Centres are advised to review this information carefully before delivering the unit.

## Unit 201

## Working in an Engineering Environment

<b>Unit level:</b>	Level 2
<b>GLH:</b>	70
<b>Unit aim:</b>	The aim of this unit is to introduce learners to basic principles of working in engineering environment. It provides the learner with knowledge of the information, tools and equipment needed to create products. They will also learn about basic business concepts relating to organisational structure, communication and quality systems.

### Learning outcome

The learner will:

- 1 Understand health and safety requirements in engineering

### Assessment criteria

The learner can:

- 1.1 Describe the key requirements of health and safety legislation in engineering
- 1.2 Explain the health and safety responsibilities of employers and employees
- 1.3 Explain safe working practices in engineering
- 1.4 Describe fire prevention and control methods
- 1.5 Describe types of safety signs and their applications
- 1.6 Explain the risk assessment process

### Range

#### AC1.1 Health and safety legislation

- Health and Safety at Work Act
- Provision and Use of Work Equipment Regulations (PUWER)
- Personal Protective Equipment Regulations
- Control of Substances Hazardous to Health Regulations (COSHH)
- Manual Handling Operations Regulations
- Reporting of Diseases and Dangerous Occurrence Regulations
- Electricity at Work Regulations

#### AC1.3 Safe working practices

- Appropriate PPE for task
- Ensuring area is safe prior to commencing work
- Safe isolation of energy sources

- Reinstating work area on completion e.g. tool storage, waste disposal, cleaning

#### AC1.4 Fire prevention

- The fire triangle
- Types of fire extinguishers and their application
- Evacuation procedures

#### AC1.5 Types of safety signs

- Warning
- Mandatory
- Prohibition
- Emergency escape or first aid
- Firefighting
- Hazardous substances

#### AC1.5 Applications

- Shape
- Colour
- Pictogram

#### AC1.6 Risk assessment:

- Hazard
- Risk: (likelihood, severity, number of people involved)
- Control measures
- Hierarchy of control

---

### Learning outcome

The learner will:

- 2 Understand how engineering businesses are organised

### Assessment criteria

The learner can:

- 2.1 Describe sectors of the engineering industry
- 2.2 Explain characteristics of engineering businesses
- 2.3 Describe the functional areas of engineering businesses
- 2.4 Explain factors that cause change in engineering businesses
- 2.5 Explain the principles and methods of communication
- 2.6 Describe the types of communication used in engineering businesses

---

### Range

#### AC2.1 Sectors

- Aerospace
- Automotive
- Construction & civil
- Defence
- Electrical & electronic
- Manufacturing
- Marine
- Power generation
- Petrochemical

#### AC2.2 Characteristics of businesses

- Size
- Geographical operation: local, national, international
- Organisational structures: product, functional, matrix
- Roles and responsibilities

#### AC2.3 Functional areas

- Support e.g. human resources, administration
- Sales and marketing
- Distribution
- Production
- Maintenance
- Quality
- Product development

#### AC2.4 Factors

- Market pull
- Technology push
- Legislation
- Environmental

#### AC 2.5 Principles and methods of communication

- Two-way process
- Exchange of information
- Methods of communication (oral, written, electronic, non-verbal)
- Formal/informal

## AC2.6 Types of communication

- Job cards
  - Standard operating procedures
  - Bill of materials
  - Technical reports
  - Emails
  - Virtual and augmented reality
  - Mobile applications
- 

### Learning outcome

The learner will:

- 3 Know types of workshop equipment and their applications

### Assessment criteria

The learner can:

- 3.1 Describe engineering workshop tools and their applications
  - 3.2 Describe types of marking out tools and their applications
  - 3.3 Describe types of measuring equipment and their applications
- 

### Range

AC3.1 Tools including:

- Hacksaws
- Files
- Chisels
- Drills
- Taps and dies
- Screwdrivers
- Spanners
- Hammers and mallets
- Pliers
- Torque wrenches

AC3.2 Marking out tools including:

- Rules
- Dividers
- Scribes
- Punches
- Scribing blocks
- Engineers square
- Protractors
- Callipers

AC3.2 Applications including:

- Profiles (square/rectangular, circles, radial, angular)
- Hole positions (linear, pitch circle diameter - PCD)
- Angles
- Use of datums and the avoidance of accumulated error

AC3.3 Measuring equipment including:

- Micrometers (internal, external, depth)
- Tape measures
- Vernier Callipers
- Rules
- Engineers square
- Protractors
- Dial test indicators (DTI)
- Coordinate measuring machine (CMM)

---

**The learner will:**

4 Understand fitting and assembly activities

**Assessment criteria**

The learner can:

- 4.1 Identify information required and information sources for engineering activities
  - 4.2 Describe the processes used for fitting and assembly
  - 4.3 Explain the purpose of quality systems in engineering
- 

**Range**

AC4.1 Information

- Health and safety requirements
- Quantity to be produced
- Materials and components required
- Tools and equipment
- Dimensions and tolerances
- Quality checks
- Order of operations
- Finishes

AC4.1 Sources of information including:

- Engineering drawings
- Specifications
- Production plans
- Job cards

- Technical manuals
- Standards: national, international
- Codes of practice

#### AC4.2 Processes

##### Work holding

- Work holding devices
- Jigs and fixtures

##### Fitting

- Filing
- Grinding
- Chiselling
- Sawing

##### Assembly

- Bolting
- Screwing
- Riveting
- Welding
- Soldering
- Brazing
- Adhesives
- Use of Washers
- Methods to prevent loosening of bolts/screws: (plastic insert, adhesives, spring and star washers)

#### AC4.3 Quality systems

- Quality assurance
- Quality control
- Inspections
- Conformance/fitness for purpose
- Customer requirements
- Reference of standards
- Safety requirements
- Quality records
- Traceability
- Corrective action procedures

# **Unit 201                      Working in an Engineering Environment**

## **Supporting Information**

### ***Unit guidance***

This is a theory unit intended to underpin the development of practical skills and safe behaviours whilst working in an engineering environment.

It is suggested that learning is based on engineering information such as engineering drawings. From this, the learner can interpret the information presented and consider the appropriate tools, equipment and machinery required to create industrial products in the workplace. Learners can then consider the operational requirements and processes that will deliver the product from the engineering information.

## Unit 202

## Engineering Techniques

<b>Unit level:</b>	Level 2
<b>GLH:</b>	40
<b>Unit aim:</b>	The aim of this unit is to introduce learners to two of the key techniques used by engineering businesses: engineering drawings and quality processes. Learners will gain an understanding of different types of engineering drawings and how they are interpreted. They will learn the difference between quality control and quality assurance and how these are applied in engineering.

### Learning outcome

The learner will:

- 1 Understand drawings used by engineering businesses

### Assessment criteria

The learner can:

- 1.1 Explain types of drawings used in engineering
- 1.2 Describe information available on engineering drawings
- 1.3 Describe the types of symbols used on engineering drawings
- 1.4 Explain the benefits and limitations of Computer Aided Drawing (CAD) compared to manual drawing

### Range

AC1.1 Types of engineering drawings

- Part
- General assembly
- Orthographic: first angle, third angle
- Isometric
- Exploded
- Section
- Detail
- Breakout
- Freehand sketches

AC1.2 Information on engineering drawings

- Dimensions
- Line types
- Zones
- Title block
- Scale

- Paper size
- Revision
- Tolerance
- Associated drawings
- Bill of Materials (BoM)/parts list

### AC1.3 Types of symbols

#### Mechanical symbols

- Diameter
- Counterbore
- Countersink
- Depth
- Centre mark

#### Geometric Dimensioning and Tolerancing (GDT) symbols

- Datum
- Parallelism
- Perpendicularity
- Concentricity
- Flatness
- Straightness

#### Surface finishing symbols

- Roughness (Ra Value)
- Surface type

### AC1.4 Benefits

- Ability to edit
- Distribution
- Document control
- Accuracy
- Storage
- Ability to simulate testing
- Ability to transfer instructions to CNC equipment

#### Limitations

- Data security
- Training requirements
- Cost

### Learning outcome

The learner will:

- 2 Understand quality processes in engineering

### Assessment criteria

The learner can:

- 2.1 Explain the principles of quality assurance and quality control
  - 2.2 Explain the characteristics of quality assurance
  - 2.3 Explain the types and methods of quality control
- 

## Range

### AC2.1 Principles

- Definition of quality
- Difference between quality assurance and quality control
- Reasons for equipment calibration
- Dimensional tolerance
- Product specification

### AC2.2 Characteristics of quality assurance

- Documentation: inspection reports, test results
- Right first time - prevention of defects
- Systems and procedures

### AC2.3 Types and methods of quality control

- Objective assessment of finished products
- Subjective assessment of finished products
- Measurement of components during manufacture
- Sampling methods related to volume of production and criticality
- Statistical process control for high volume manufacture

# Unit 202                      Engineering Techniques

## Supporting Information

### ***Unit guidance***

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

It is recommended that learning is based on engineering information such as engineering drawings and specifications from which learners can interpret the information presented and consider the appropriate tools, equipment and machinery required to create the components. Learners can then consider the operational requirements and processes that will deliver the product from the engineering information.

#### Learning Outcome 1 AC1.2

Information from drawings should be in accordance with the conventions in relevant standards e.g. BSEN 8888

#### Learning Outcome 2 AC2.1

Quality assurance is considered as preventative and related to systems. Quality control is considered as reactive where issues are detected after occurrence.

## Unit 203

# Engineering Mathematics & Science Principles

<b>Unit level:</b>	Level 2
<b>GLH:</b>	70
<b>Unit aim:</b>	This unit is concerned with the basic principles of mathematics and science, along with the materials technology that underpin engineering applications. It covers common applied engineering calculations, the application of different types of materials and their properties.

### Learning outcome

The learner will:

- 1 Understand arithmetical and trigonometrical applications

### Assessment criteria

The learner can:

- 1.1 Perform simple arithmetic operations on integers and decimal numbers
- 1.2 Determine fractions and percentages
- 1.3 Use rules of arithmetical preference to solve simple equations
- 1.4 Use a scientific calculator to determine numbers when raised to a given power
- 1.5 Apply appropriate degree of accuracy to express numbers
- 1.6 Solve simple trigonometrical problems

---

### Range

AC1.1

Addition, subtraction, multiplication, division

AC1.2

Proper and improper fractions, determination of percentages and conversion to ratios

AC1.3

BODMAS (Brackets, Of, Division, Multiplication, Addition, Subtraction)

AC1.4

Squares ( $x^2$ ) and square roots ( $\sqrt{x}$ ), cubes ( $x^3$ ) and cube roots ( $\sqrt[3]{x}$ )

AC1.5

Rounding-off, decimal places, significant figures, approximations, fractions as a decimal quantity

AC1.6

Sine, cosine, tangent

---

### Learning outcome

The learner will:

2 Know how to determine perimeters, areas and volumes of shapes

### Assessment criteria

The learner can:

- 2.1 Identify 2D and 3D shapes
- 2.2 Describe properties of 2D shapes
- 2.3 Apply Pythagoras' theorem
- 2.4 Calculate perimeters of simple shapes
- 2.5 Determine areas of 2D shapes
- 2.6 Determine volumes of 3D shapes

---

### Range

AC2.1 2D shapes

- Rectangle
- Square
- Triangle
- Circle

3D shapes

- Cube
- Cuboid
- Cylinder
- Cone
- sphere

AC2.2 Properties

- Rectangle (four sides, all angles  $90^\circ$ )
- Square (rectangle with four equal sides)
- Triangle (three sides, total of internal angles =  $180^\circ$ )
- Circle (one full circle =  $360^\circ$ )

---

## Learning outcome

The learner will:

- 3 Understand terminology used in engineering science

## Assessment criteria

The learner can:

- 3.1 Describe common terms used in engineering science
  - 3.2 Name the units used to quantify the terms used in engineering
  - 3.3 Perform calculations relating to the common terms used in engineering
- 

## Range

### AC3.1 Common terms

- Length
- Mass
- Time
- Force
- Velocity
- Acceleration
- Moment
- Pressure
- Efficiency
- Density

### AC3.2 Units

- Length: metre (m)
- Mass: kilogramme (kg)
- Time: second (s)
- Force: newton (n)
- Velocity: metre per second (m/s)
- Acceleration: metre per second squared ( $m/s^2$ )
- Moment: newton metre (nm)
- Pressure: Pascal or Newton per metre squared (Pa or  $N/m^2$ )
- Efficiency: No units it is a ratio or a percentage
- Density: mass per unit volume ( $kg/m^3$ )

### AC3.3 Calculations

- Mass
  - Force
  - Velocity
  - Acceleration
  - Moment
-

- Pressure
  - Efficiency
  - Density
- 

### Learning outcome

The learner will:

- 4 Understand the effect of changes of temperature on engineering materials

### Assessment criteria

The learner can:

- 4.1 Explain the difference between heat and temperature
  - 4.2 Explain the effect of changes of temperature on the physical state of a material
  - 4.3 Explain the effect of changes of temperature on the dimensions of a material
  - 4.4 Perform simple calculations on the effect of temperature on materials
- 

### Range

AC4.2 Physical state

- Solid
- Liquid
- Gas

AC4.4 Calculations

- Sensible heat
- Latent heat
- Coefficient of expansion

---

## Learning outcome

The learner will:

5 Understand the properties of engineering materials

## Assessment criteria

The learner can:

- 5.1 Describe the types of materials used in common engineering applications
- 5.2 Describe the physical properties of materials
- 5.3 Explain the mechanical properties of materials

---

## Range

### AC5.1 Materials

- Ferrous metals
  - carbon steels (low, medium, high),
  - stainless steels (austenitic, ferritic, martensitic),
  - cast iron
- Non-ferrous metals
  - aluminium and aluminium alloys
  - copper and copper alloys (brass, bronze)
- Non-metallic materials
  - plastics (thermoplastic, thermosetting),
  - composites (glass fibre, carbon fibre, aramid fibre)
  - rubber

### AC5.2 Physical properties

- Melting points of metals
- Density
- Colour
- Magnetism
- Corrosion resistance
- Conductivity
- Insulation

### AC5.3 Mechanical properties

- Strength (compressive, tensile)
- Toughness
- Hardness
- Elasticity
- Ductility
- Malleability

## **Unit 203**

# **Engineering Mathematics & Science Principles**

## Supporting Information

### ***Unit guidance***

Centres may provide a formula sheet to support the assessment for this unit.

## Unit 204 Fitting and Assembly Techniques

<b>Unit level:</b>	Level 2
<b>GLH:</b>	50
<b>Unit aim:</b>	This unit provides the learner with knowledge of the tools, equipment and machinery used to create components. Learners will develop an understanding of quality requirements and how they can evaluate the quality of a component against a specification.

---

### Learning outcome

The learner will:

- 1 Understand engineering health and safety requirements

### Assessment criteria

The learner can:

- 1.1 Describe the legislation affecting health and safety in engineering
- 1.2 Describe safe working practices in engineering
- 1.3 Explain the process for carrying out risk assessments

---

### Range

#### AC1.1 Legislation

- Health and Safety at Work Act
- Provision and Use of Work Equipment Regulations (PUWER)
- Personal Protective Equipment Regulations
- Control of Substances Hazardous to Health Regulations (COSHH)
- Manual Handling Operations Regulations
- Reporting of Diseases and Dangerous Occurrence Regulations
- Electricity at Work Regulations

#### AC1.2 Safe working practices

Safety signs

- Warning
- Mandatory

- Safe condition
- Prohibition

Identification of fire extinguishers

- Colour of extinguishers
- Type of fire used for

General housekeeping

- Storage of tools
- Disposal of waste
- Reinstating work area after use

AC1.3 Risk assessment

- Identification of hazards
- Assess risk (severity, likelihood, number affected, risk rating)
- Recommendation of control measures
- Record findings
- Review controls

---

## Learning outcome

2. Understand fitting and assembly techniques

### Assessment criteria

The learner can:

- 2.1 Explain considerations required when planning engineering workshop activities
- 2.2 Explain the purpose and limitations of tools and equipment required for fitting and assembly
- 2.3 Explain fitting and assembly operations
- 2.4 Explain quality checks and the equipment used to carry them out

---

## Range

AC2.1 Planning considerations

- Health and safety
- Working environment
- Drawings/specifications
- Materials
- Equipment
- Tools
- Time
- Quality checks
- Tolerances

- Sequence of operations

#### AC 2.2 Purpose and limitations of tools and equipment

- Tools: Screwdrivers, hammer, spanners, wrenches, pliers, hand held drills, hacksaws
- Measuring equipment: micrometers, Vernier callipers, engineering rules

#### AC 2.3 Fitting and assembly operations

- Filing
- Scraping
- Lapping
- Polishing
- Blue bedding
- Drilling
- Threading
- Permanent: brazing, soldering, welding (MIG, MAG, TIG, Oxyacetylene), adhesives, riveting
- Semi-permanent: screws, bolts

#### AC 2.4 Quality checks

- Functional checks
- Surface finish
- Dimensional checks
- Visual inspection

#### Equipment used to carry out quality checks

- Micrometers: internal, external, depth
- Multimeters
- Vernier Calliper
- Comparison plates
- Rules
- Protractors
- Gauges/ slip gauges
- Dial test indicator (DTI)
- Coordinate measuring machine (CMM)

### ***Unit guidance***

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

It is recommended that learning is based on engineering information such as engineering drawings and specifications from which learners can interpret the information presented and consider the appropriate tools, equipment and machinery required.

Assessment of outcomes could be through the presentation of engineering information or presentations on the types of machinery and components.

## Unit 205

## Business Improvement Techniques

<b>Unit level:</b>	Level 2
<b>GLH:</b>	60
<b>Unit aim:</b>	The aim of this unit is for learners to gain an understanding of the importance of continuous improvement to engineering businesses. They will learn how to categorise work and different types of waste. They will learn about different techniques used for business improvement and how they are used in engineering businesses.

### Learning outcome

The learner will:

- 1 Understand the concept of continuous improvement

### Assessment criteria

The learner can:

- 1.1 Explain the meaning of continuous improvement
- 1.2 Describe continuous improvement strategies commonly used in engineering
- 1.3 Explain benefits of applying continuous improvement techniques
- 1.4 Define each stage of the plan–do–check–act (PDCA) improvement cycle
- 1.5 Explain the categories of waste in relation to business improvement

### Range

AC1.2 Strategies including

- Kaizen and Lean (elimination of waste)
- Quality circles (teams of employees using their knowledge to improve processes and resolve problems)
- Six Sigma (improved consistency and reduced scrap in high volume manufacturing by managing the process capability)
- Total Quality Management (TQM) (all members of an organisation work together to make improvements that result in increased customer satisfaction)

AC1.3 Benefits including

- Reduced cost e.g. production
- Improved quality e.g. reduced defects
- Improved safety e.g. safe to use
- Improved working practices e.g. reduced operator motion

- Improved delivery e.g. reduced transportation time, reduced lead time
- Reduction of waste e.g. over processing, excess inventory
- Resource utilisation e.g. reduced waiting time
- Improved customer satisfaction e.g. meeting customer requirements

#### AC1.5 Categories of waste

- Transport
- Inventory
- Motion
- Waiting
- Over production
- Over processing
- Defects
- Skills/unrecognised people potential

---

### Learning outcome

The learner will:

2 Understand workplace organisation

### Assessment criteria

The learner can:

- 2.1 Explain the meaning of workplace organisation
- 2.2 Describe the benefits of having an organised working environment
- 2.3 Explain the potential effects of a disorganised work environment
- 2.4 Describe the 5S approach to workplace organisation
- 2.5 Explain the importance of Standard Operating Procedures (SOPs) within workplace organisation

---

### Range

#### AC2.3 Effects

- Poor quality
- Increased costs
- Reduced efficiency
- Poor delivery times
- Poor morale/teamwork
- Poor health and safety

#### AC2.4 5S approach

- Sort (decide what is needed)
- Set in order (organise)
- Shine (clean)
- Standardise

- Sustain

---

### Learning outcome

The learner will:

- 3 Understand visual management

### Assessment criteria

The learner can:

- 3.1 Explain the meaning of visual management
- 3.2 Describe the benefits of applying good visual management
- 3.3 Describe different types of visual management

---

### Range

#### AC3.2 Benefits

- Accurate and relevant
- Eye-catching
- Simple
- Greater ownership

#### AC3.3 Types of visual management

- Shadow boards
- PDCA worksheets
- Colour coding
- Floor footprints
- Storyboards
- Gauges
- Photographs/pictures
- Labelling
- Lights
- Schedule boards
- Kanban (pull systems)
- Graphs
- Management boards
- Other area-specific types of visual management

---

### Learning outcome

The learner will:

- 4 Understand problem solving techniques

## Assessment criteria

The learner can:

- 4.1 Explain what is meant by a problem within a work environment
  - 4.2 Describe the benefits of solving work related problems
  - 4.3 Describe different techniques used for identifying and analysing problems
  - 4.4 Explain the importance of applying the appropriate corrective action and eliminating the root cause of a problem
- 

## Range

### AC4.3 Techniques

- Tally charts
- Flow charts
- Histogram/pareto chart
- Benchmarking
- Process mapping
- Correlation diagram
- Run diagram
- Statistical process control
- Control charts
- Gantt charts
- Root cause paths
- Value stream maps
- Ishikawa diagrams (cause and effect, fishbone)
- Brainstorming
- Mind mapping
- 5 why analysis

## **Unit 205**

## **Business Improvement Techniques**

### Supporting Information

#### ***Unit guidance***

This is a theory unit intended to underpin the development of practical skills. It can be delivered as a part of an apprenticeship programme. A combination of theory and practice is more likely to reinforce the learning required to achieve the apprenticeship standard.

## Unit 206

## Principles of Turning and Milling

<b>Unit level:</b>	Level 2
<b>GLH:</b>	80
<b>Unit aim:</b>	This unit enables the learner to understand the principles of manual turning and milling skills. This unit provides the learner with knowledge of the tools, equipment and machinery used to create machined components. They will understand how the machinery is set up and operated safely. They will also develop knowledge of the processes required to create machined components. Learners will develop an understanding of quality requirements and evaluation techniques to ensure quality of a component against a specification.

### Learning Outcome

The learner will:

1. Know equipment required for turning and milling operations

### Assessment Criteria

The learner can:

- 1.1 Describe the characteristics and function of parts of a lathe
- 1.2 Describe the characteristics and function of parts of a milling machine
- 1.3 Describe the characteristics and types of workholding devices
- 1.4 Describe cutting tools and their purpose
- 1.5 Describe the characteristics and use of measuring equipment

### Range

AC 1.1 Parts of a lathe

- Isolators
- Speed control
- Feed control
- Chuck
- Emergency stops
- Coolant system
- Tailstock
- Headstock
- Bed

- Guards

#### AC 1.2 Parts of a milling machine

- Isolators
- Speed control
- Feed control
- Emergency stops
- Coolant system
- Base
- Column
- Ram
- Knee
- Turret/head
- Guards and interlocks
- Quill
- Spindle
- Work table
- Tool holding device

#### AC1.3 Workholding devices

##### Lathe

- 3 jaw chucks
- 4 jaw chucks
- Collet chucks
- Face plates
- Between centres
- Travelling steadies
- Fixed steadies

##### Milling machine

- Machine vice (fixed, swivel)
- T slot and clamps
- Angle plate
- V block and clamps
- Dividing head

#### AC1.4 Cutting tools

##### Lathe

- Tool types: roughing and finishing, turning, boring, grooving, undercutting, parting, forming, reaming, tapping, threading, drilling
- Characteristics: tool angles: rake and clearance, approach, materials, ISO Coding for indexable inserts
- Characteristics of cutting fluids and compounds

##### Milling machine

- Tool types: end mill, slot drill, shell cutter, bullnose cutter, ballnose cutter, face mill, fly cutter, dovetail cutter, drills, reamers, taps
- Characteristics: tool angles, materials
- Characteristics of cutting fluids and compounds

#### AC1.5 Measuring equipment

- Micrometers: internal, external, depth
- Vernier calliper
- Comparison plates
- Rules
- Protractors
- Gauges/ slip gauges
- Dial test indicator (DTI)
- Coordinate measuring machine (CMM)

---

### Learning outcome

The learner will:

2. Understand how to produce manually machined components

### Assessment criteria

The learner can:

- 2.1 Describe safety issues and control measures associated with manual machining
- 2.2 Describe the characteristics of different types of machined features
- 2.3 Describe alignment techniques for workholding devices and workpieces
- 2.4 Describe the techniques for mounting cutting tools
- 2.5 Explain how the process parameters vary for different materials and component dimensions

---

### Range

#### AC2.1 Safety issues

- Hazards: flying debris, entanglement, ejected workpieces, moving parts, sharp edges, heat
- Controls: machine safety checks, PPE, safe working practices, guards

#### AC2.2 Characteristics of machined features

Lathe

- Faces: datum, flat, perpendicular, parallel, tapered, knurling
- Diameters: internal, external, bored, tapered, concentric, eccentric
- Shoulders
- Grooves/undercuts

- Holes: drilled, reamed, blind, through, counterbored, countersunk, flat-bottomed
- Threads: internal, external

#### Milled

- Faces: datum, flat, perpendicular, parallel, tapered, step, slots: enclosed, open ended, tee
- Recesses
- Holes: drilled, reamed, blind, through, counterbored, countersunk, flat-bottomed, bored
- Threads: internal

#### AC2.3 Alignment techniques

- Mounting, alignment and removal of workholding device into/from machine
- Mount, secure and align the workpiece

#### AC2.4 Techniques for mounting cutting tools

##### Lathe

- Checking tools are fit for purpose
- Securing cutting tools in tool holding devices
- Aligning tool to centre height
- Orientate tool to workpiece

##### Milling

- Checking tools are fit for purpose
- Securing cutting tools in tool holding devices
- Aligning tool to work datum

#### AC 2.5 Materials

- Mild steel
- Brass
- Nylon
- Aluminium

---

### Learning outcome

The learner will:

3. Understand how to meet quality requirements for machining operations

### Assessment criteria

The learner can:

- 3.1 Describe methods of monitoring machine performance

### 3.2 Describe methods of evaluating machined components against specification requirements

---

#### Range

##### AC3.1 Monitoring machine performance:

- Potential defects: symptoms, causes, resolution
- In-process checks: trial cuts, dimensional check of workpiece, surface finish of workpiece
- Check condition of cutting tools

##### AC3.2 Evaluation methods:

- Turning quality criteria (tolerance, surface finish, concentricity, parallelism) from engineering information (drawings, specifications)
  - Milling quality criteria (tolerance, surface finish, parallelism) from engineering information (drawings, specifications)
  - Application of inspection techniques: measurement, visual
-

## **Unit 206**

## **Principles of Turning and Milling**

### **Supporting Information**

#### ***Unit guidance***

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

It is recommended that learning is based on engineering information such as engineering drawings and specifications from which learners can interpret the information presented and consider the appropriate tools, equipment and machinery required to create the components. Learners can then consider the operational requirements and processes that will deliver the component in the engineering information.

Learning Outcome 2 AC 2.5

Graphs may be used to demonstrate variations in process parameters as described in AC 2.5.

## Unit 207

## Manual Turning

<b>Unit level:</b>	Level 2
<b>GLH:</b>	50
<b>Unit aim:</b>	This unit enables the learner to acquire the essential knowledge and understanding needed to develop manual turning skills. This unit provides the learner with knowledge of the tools, equipment and machinery used to create turned components. They will learn how machinery is set up and operated safely and the processes to be followed to create turned components. Learners will develop an understanding of quality requirements and how they can evaluate the quality of a turned component against a specification.

### Learning outcome

The learner will:

- 1 Know the equipment required for turning operations

### Assessment criteria

The learner can:

- 1.1 Describe the characteristics and function of parts of a lathe
- 1.2 Describe the characteristics and types of workholding devices
- 1.3 Describe cutting tools and their purpose
- 1.4 Describe the characteristics and use of measuring equipment

### Range

AC1.1 Parts of a lathe

- Isolators
- Speed control
- Feed control
- Chuck
- Emergency stops
- Guards
- Coolant system
- Tailstock
- Headstock
- Bed

#### AC1.2 Workholding devices

- 3 jaw chucks
- 4 jaw chucks
- Collet chucks
- Face plates
- Between centres
- Travelling steadies
- Fixed steadies

#### AC1.3 Cutting tools

- Tool types: roughing and finishing, turning, boring, grooving, undercutting, parting, forming, reaming, tapping, threading, drilling
- Characteristics: tool angles: rake and clearance, approach, materials, ISO Coding for indexable inserts
- Characteristics of cutting fluids and compounds

#### AC1.4 Measuring equipment

- Micrometers: internal, external, depth
- Vernier Calliper
- Comparison plates
- Rules
- Protractors
- Gauges
- Dial Test Indicator (DTI)
- Coordinate Measuring Machine (CMM)

---

### Learning outcome

The learner will:

- 2 Understand how to produce turned components on a lathe

### Assessment criteria

The learner can:

- 2.1 Describe safety issues associated with the use of a lathe and control measures
- 2.2 Describe the characteristics of different types of turned features
- 2.3 Describe alignment techniques for workholding devices and workpieces
- 2.4 Describe the techniques for mounting cutting tools
- 2.5 Explain how the process parameters vary for different materials and component dimensions

---

## Range

### AC2.1 Safety issues

- Hazards: flying debris, entanglement, ejected workpieces, moving parts, sharp edges, heat
- Controls: machine safety checks, PPE, safe working practices

### AC2.2 Characteristics of different types of features

- Faces: datum, flat, perpendicular, parallel, tapered, knurling
- Diameters: internal, external, bored, tapered, concentric, eccentric
- Shoulders
- Grooves/undercuts
- Holes: drilled, reamed, blind, through, counterbored, countersunk, flat-bottomed
- Threads: internal, external

### AC2.3 Alignment techniques

- Mounting, alignment and removal of workholding device into/from machine
- Mount, secure and align the workpiece

### AC2.4 Techniques for mounting cutting tools

- Checking tools are fit for purpose
- Securing cutting tools in tool holding devices
- Aligning tool to centre height
- Orientate tool to workpiece

### AC2.5 Materials

- Mild steel
- Brass
- Nylon
- Aluminium

---

## Learning outcome

The learner will:

3 Understand how to meet quality requirements for turning operations

## Assessment criteria

The learner can:

3.1 Describe methods of monitoring machine performance

3.2 Describe methods of evaluating turned components against specification requirements

---

## Range

### AC3.1 Monitoring machine performance

- Potential defects: symptoms, causes, resolution
- In-process checks: trial cuts, dimensional check of workpiece, surface finish of workpiece
- Check condition of cutting tools

### AC3.2 Evaluation methods

- Quality criteria (tolerance, surface finish, concentricity, parallelism) from engineering information (drawings, specifications)
- Application of inspection techniques: measurement, visual

# Unit 207                      Manual Turning

## Supporting Information

### ***Unit guidance***

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

It is recommended that learning is based on engineering information such as engineering drawings and specifications from which learners can interpret the information presented and consider the appropriate tools, equipment and machinery required to create the components. Learners can then consider the operational requirements and processes that will deliver the component in the engineering information.

## Unit 208

## Manual Milling Techniques

<b>Unit level:</b>	Level 2
<b>GLH:</b>	50
<b>Unit aim:</b>	This unit enables the learner to acquire the essential knowledge and understanding needed to develop manual milling skills. This unit provides the learner with knowledge of the tools, equipment and machinery used to create milled components. They will learn how machinery is set up and operated safely and the processes to follow to create milled components. Learners will develop an understanding of quality requirements and how they can evaluate the quality of a milled component against a specification.

### Learning outcome

The learner will:

- 1 Know the equipment required for milling operations

### Assessment criteria

The learner can:

- 1.1 Describe the characteristics and function of parts of a milling machine
- 1.2 Describe the characteristics and types of workholding devices
- 1.3 Describe cutting tools and their purpose
- 1.4 Describe the characteristics and use of measuring equipment

### Range

AC1.1 Parts of a milling machine

- Isolators
- Speed control
- Feed control
- Emergency stops
- Coolant system
- Base
- Column
- Ram
- Knee
- Turret/head

- Guards and interlocks
- Quill
- Spindle
- Work table
- Tool holding device

#### AC1.2 Workholding devices

- Machine vice (fixed, swivel)
- T slot and clamps
- Angle plate
- V block and clamps
- Dividing head

#### AC1.3 Cutting tools

- Tool types: (end mill, slot drill, shell cutter, bullnose cutter, ballnose cutter, face mill, fly cutter, dovetail cutter, drills, reamers, taps)
- Characteristics: (tool angles, materials)
- Characteristics of cutting fluids and compounds

#### AC1.4 Measuring equipment

- Micrometers (internal, external, depth)
- Vernier Calliper
- Comparison plates
- Rules
- Protractors
- Angle gauges
- Slip gauges
- Dial Test Indicator (DTI)
- Coordinate Measuring Machine (CMM)

---

### Learning outcome

The learner will:

2 Understand how to produce components on a milling machine

### Assessment criteria

The learner can:

2.1 Describe safety issues associated with the use of a mill and control measures

- 2.2 Describe characteristics of different types of milled features
- 2.3 Explain alignment techniques for workholding devices and workpieces
- 2.4 Explain techniques for mounting cutting tools
- 2.5 Explain how the process parameters vary for different materials and component dimensions

---

## Range

### AC2.1 Safety issues

- Hazards: (flying debris, entanglement, moving parts, sharp edges, heat)
- Controls: (safety checks, PPE, safe working practices, machine guards)

### AC2.2 Milled features

- Faces: (datum, flat, perpendicular, parallel, tapered, Step, Slots: enclosed, open ended, tee)
- Recesses
- Holes: (drilled, reamed, blind, through, counterbored, countersunk, flat-bottomed, bored)
- Internal threads

### AC2.3 Alignment techniques

- Mounting, alignment and removal of workholding device into/from machine
- Mount, secure and align the workpiece

### AC2.4 Techniques for mounting cutting tools

- Checking tools are fit for purpose
- Securing cutting tools in tool holding devices
- Aligning tool to work datum

### AC2.5 Materials

- Mild steel
- Brass
- Nylon
- Aluminium

#### Process parameters

- Spindle speed (RPM) = Cutting speed x 1000 /  $\pi$  x drill diameter

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## Learning outcome

The learner will:

- 3 Understand how to meet quality requirements for milling operations

## Assessment criteria

### The learner can

- 3.1 Describe methods of monitoring machine performance
  - 3.2 Describe methods of evaluating milled components against specification requirements
- 

### Range

#### AC3.1 Monitoring machine performance

- Potential defects: (symptoms, causes, resolution)
- In-process checks: (trial cuts, dimensions of workpiece, surface finish of workpiece)
- Check condition of cutting tools

#### AC3.2 Evaluating milled components

- Identify quality criteria (tolerance, surface finish, parallelism) from engineering information (drawings, specifications)
  - Application of inspection techniques: (measurement, visual)
-

## Unit 208

## Manual Milling Techniques

### Supporting Information

#### ***Unit guidance***

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

It is recommended that learning is based on engineering information such as engineering drawings and specifications from which learners can interpret the information presented and consider the appropriate tools, equipment and machinery required to create the components. Learners can then consider the operational requirements and processes that will deliver the component in the engineering information.

## Unit 209

## Grinding Techniques

<b>Unit level:</b>	Level 2
<b>GLH:</b>	50
<b>Unit aim:</b>	This unit provides the learner with knowledge of the tools, equipment and machinery used to create components on a grinding machine. They will learn how machinery is set up and operated safely and the processes to be followed to create components on a grinding machine. Learners will develop an understanding of quality requirements and how they can evaluate the quality of a ground component against a specification.

### Learning outcome

The learner will:

- 1 Know the equipment required for grinding operations

### Assessment criteria

The learner can:

- 1.1 Identify types of grinding machines and their differences
- 1.2 Identify characteristics and function of parts of grinding machines
- 1.3 Describe characteristics, function and limitations of workholding devices
- 1.4 Identify characteristics, function and limitations of abrasive wheels
- 1.5 Describe characteristics, function and limitations of measuring equipment

### Range

AC1.1 Types of grinding machines

- Cylindrical (internal, external)
- Surface (horizontal, vertical)
- Universal
- Off-hand/ bench grinder

AC1.2 Parts of grinding machines

- Isolators

- Wheels
- Table control
- Emergency stops
- Coolant system
- Guards and interlocks
- Tail stock
- Feed systems
- Local Extraction and Ventilation (LEV) system
- Flanges
- Rests

#### AC1.3 Characteristics, function of workholding devices

- Chucks: (3 self centring (scroll) and 4 jaw (independent), magnetic, collet)
- Vices: (fixed, swivel, universal)
- V blocks and clamps
- Mandrels: (solid, expanding)

#### Limitations of workholding devices

- Shapes
- Types of material
- Size of component

#### AC1.4 Characteristics of abrasive wheels

- Shapes of wheel: (straight, cylinder, single taper, double taper, single concaved, straight cup)
- Types of wheel: (material: aluminium oxide, silicon carbide, bond type: vitrified, grain size, grade, structure, treatment)

#### Function

- Effects of cutting fluids/coolants

#### Limitations of abrasive wheels

- Removal rate of material

#### AC1.5 Characteristics and function of measuring equipment

- Micrometres: (internal, external, depth)
- Vernier calliper
- Comparison plates: (Rubert blocks)
- Gauges
- Dial Test Indicator (DTI)
- Coordinate Measuring Machine (CMM)

#### Limitations

- Accuracy of reading between manual and digital – operator skill
- Gauges to check conformity to limit

---

## Learning outcome

The learner will:

- 2 Understand how to produce components on grinding machines

## Assessment criteria

The learner can:

- 2.1 Describe safety issues and training requirements associated with the use of grinding machines
- 2.2 Identify components to be produced and wheel selection
- 2.3 Identify techniques for securing workholding devices
- 2.4 Describe methods of balancing and mounting abrasive wheels
- 2.5 Describe methods of maintaining abrasive wheels
- 2.6 Explain the principles of planning grinding operations

---

## Range

### AC2.1 Safety issues

- Hazards: (flying debris, entanglement, dust, sparks, explosion of wheel, ejected workpieces, moving parts, sharp edges, heat)
- Controls: (safety checks, PPE, safe working practices)

### Training requirements

- Provision and Use of Work Equipment Regulations (PUWER)
- Appointed person responsibilities
- Mandatory signs
- Guarding
- Manual handling

### AC2.2 Components to be produced

- Surfaces (flat, perpendicular, parallel, angular)
- Diameters (internal, external)
- Steps
- Tapers
- Grooves/undercuts
- Slots
- Profiles

### AC2.3 Securing techniques

- Chucks secured to spindle
- Vices clamped to table
- Vee blocks clamped to table or magnetic table
- Mandrels held between centres

#### AC2.4 Methods for balancing and mounting abrasive wheels

- Balancing wheels: (parallel ways: knife edges, overlapping discs, hub flanges)
- Securing abrasive wheels on the machine spindle
- Truing and dressing: (fixed installation diamond, portable diamond)
- Testing the mounted wheel

#### AC2.5 Methods of maintaining abrasive wheels

- Handling and storage of wheels
- Trueing the wheel
- Dressing the wheel

#### AC2.6 Principles of planning grinding operations

- Critical path
- Sequence of operations

---

### Learning outcome

The learner will:

- 3 Understand how to meet quality requirements for grinding operations

### Assessment criteria

The learner can:

- 3.1 Describe monitoring of machine performance
- 3.2 Identify defects and methods of rectifying them
- 3.3 Describe how to evaluate ground components against specification requirements

---

### Range

#### AC3.1 Monitoring machine performance

- In-process checks: (trial cuts, backlash, size of workpiece, surface finish of workpiece, condition of wheel, potential defects)
- Check for potential defects: (symptoms, causes, resolution)

#### AC3.2 Defects and methods of rectifying them

- Wheel chatter - True wheel, increase feed, use softer grade
- Rough finish - Finer grit wheel, use harder grade, increase work traverse
- Wheel loading - Use coarser grit, dress wheel, increase work traverse

#### AC3.3 Evaluate components against specification

- Identify quality criteria (tolerance, surface finish, flatness, squareness, concentricity) from engineering information (drawings, standards)
- Application of inspection techniques (measurement, visual)

## **Unit 209**

## **Grinding Techniques**

### **Supporting Information**

#### ***Unit guidance***

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

It is recommended that learning is based on engineering information such as engineering drawings and specifications from which learners can interpret the information presented and consider the appropriate tools, equipment and machinery required to create the components. Learners can then consider the operational requirements and processes that will deliver the component in the engineering information.

## Unit 210

## Principles of CNC Machining/Fabrication

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<b>Unit level:</b>	Level 2
<b>GLH:</b>	50
<b>Unit aim:</b>	This unit provides the learner with knowledge of the tools, equipment and machinery used to create components with CNC fabrication equipment. They will learn how machinery is set up and operated safely and the processes to be followed to create components. Learners will develop an understanding of quality requirements and how the control offered by CNC can improve production and the quality of a product.

---

### Learning outcome:

The learner will:

1. Understand the equipment available for CNC fabrication operations

### Assessment criteria

The learner can:

- 1.1 Describe the types of equipment available for CNC fabrication
- 1.2 Explain the function and characteristics of CNC fabrication equipment
- 1.3 Explain the health and safety requirements specific to CNC equipment

---

### Range

#### AC1.1 Types of equipment

- Guillotines
- Folders
- Press brakes
- Mechanical saws
- Turret punches
- Cutting machines (laser, plasma, water jet)

#### AC1.2 Function and characteristics

- Guillotines
- Backstops
- Front stops

- Cut length limiting
- Material thickness adjustments
- Programming options: (stored programs, stop adjustment, part cutting)
- Rake adjustment

#### Folders

- Clamping options
- Angle adjustment
- Backstops

#### Press brakes

- Axis controls (Y; X; R; Z1 + Z2)
- Programming options: (stored programs, visualisation of part manipulation)

#### Saws

- Bandsaws
- Circular saws
- Mechanical hacksaw
- Automatic material cutting: (clamping, material feed, part counts)

#### Turret punches

- Sheet clamping methods
- Processes: (cutting, bending, louvres)
- Automatic tooling changes
- Automatic material feed

#### Cutting machines (laser, plasma, water jet)

- Programming options: (stored programmes, nesting)

#### AC1.3 Health and safety requirements

- Electrical screening
- Shut down procedures
- Water beds for plasma cutting
- Slurry filtration and disposal for water jet cutting (COSHH Regulations)

---

### Learning outcome

The learner will:

2. Understand the programming of CNC fabrication machinery

## Assessment criteria

The learner can:

- 2.1 Describe manual data programming of CNC fabrication machinery
  - 2.2 Describe remote programming of CNC fabrication machinery
- 

## Range

AC2.1 Manual data programming

- Retrieval of stored programs
- One-off programs
- Material data: (type, thickness, width)
- Back and front stop data
- Feed rates: (saws)
- Rake angles: (guillotines)
- Angles: (folders, press brakes)
- Tooling: (turret punches, press brakes)
- Basic shape databases: (cutting machines)
- Nesting systems: (cutting machines)
- Number of items

AC2.2 Remote programming

- Benefits and limitations of remote programming
  - Methods of transferring data to machinery
  - File types (step, dxf, software specific)
- 

## Learning outcome

The learner will:

3. Understand the benefits and limitations of using CNC fabrication machinery

## Assessment criteria

The learner can:

- 3.1 Explain the benefits and limitations related to component quality
  - 3.2 Explain the benefits related to efficiency
- 

## Range

AC3.1 Benefits and limitations

- Importance of calibration
  - Expected accuracy of CNC machinery
  - Relationship between data entry and component accuracy
  - Repeatability
-

### AC3.2 Benefits

- Material nesting
- Improved production methods
- Recall of stored programs

## **Unit 210**

## **Principles of CNC Machining/Fabrication**

### **Supporting Information**

#### ***Unit guidance***

This unit focuses on how machinery can be controlled by CNC. It does not require learners to understand or describe complex programming methods. Learners will need to understand the basic CNC controlling of a range of fabrication equipment and the types of data that can be input directly, retrieved from the machine memory or transferred from another source.

This unit is closely related to the fabrication principles unit, where basic principles of cutting by shear, forming, and health and safety that can be applied to all fabrication equipment are covered generically.

#### **Learning Outcome 1**

This requires learners to explain the types of fabrication equipment that can be CNC controlled and the parts and function that benefit from this control. Health & safety using these processes is covered in the fabrication principles used.

#### **Learning Outcome 2**

Manual data programming refers to machines that have the CNC controller connected directly to the machine. Remote programming refers to, for example, CAD drawings produced in an office that are then transferred to the laser cutting machine via the intranet.

## Unit 211

## CNC Turning Techniques

<b>Unit level:</b>	Level 2
<b>GLH:</b>	50
<b>Unit aim:</b>	This unit provides the learner with knowledge of the tools, equipment and machinery used to create turned components. They will learn how machinery is set up and operated safely and the processes to be followed to create turned components. Learners will develop an understanding of quality requirements and how they can evaluate the quality of a turned component against a specification.

---

### Learning outcome

The learner will:

- 1 Know the equipment required for CNC turning operations

### Assessment criteria

The learner can:

- 1.1 Identify the characteristics and function of parts of a CNC lathe
- 1.2 Identify characteristics and function of workholding devices
- 1.3 Describe characteristics of cutting tools
- 1.4 Explain characteristics and limitations of measuring equipment

---

### Range

AC1.1 Characteristics and function of parts of a CNC lathe

- Isolators
- Emergency stops
- Coolant system
- Tailstock
- Guards and interlocks
- Tool holding device: (automatic tool changer, wedge locks, VDI tool holders)
- Control: (machine page, tool offset page, workshift page, program directory, program editor)

- Open loop control
- Closed loop control
- Servo motors/stepper motors
- Recirculating ball screws: (internal ball return, external ball return)
- Positional transducers

#### AC1.2 Characteristics and function of workholding devices

- 3 jaw chucks: (hydraulic, pneumatic, serrated based, soft, hard)
- Collet chucks
- Face drivers

#### AC1.3 Characteristics of cutting tools

- Tool types: (roughing, finishing, grooving, parting off, screw cutting, reaming, tapping, threading, drilling, profiling, boring)
- Classification of ISO coding for indexable inserts
- Types of cutting tool materials: (high speed steel (HSS), cobalt-chromium alloy, carbide)
- Characteristics of cutting tools: (shape, size, tip radius, rake angle, clearance angles, cutter length)
- Tool holder characteristics: (left/right hand tool, approach angle, clamping system, insert shape and size)
- Types and effects of cutting fluids

#### AC1.4 Characteristics and limitations of measuring equipment

- Micrometers: (internal, external, depth)
- Vernier calliper
- Comparison plates
- Rules
- Protractors
- Gauges
- Dial Test Indicator (DTI)
- Coordinate Measuring Machine (CMM)

##### Limitations

- Accuracy of reading between manual and digital – operator skill
- Gauges to check for conformity to limit

---

### Learning outcome

The learner will:

- 2 Understand how to produce turned components on a CNC lathe

### Assessment criteria

The learner can:

- 2.1 Identify safety issues and control measures associated with the use of a CNC lathe
- 2.2 Describe characteristics of turned features
- 2.3 Identify techniques for mounting cutting tools
- 2.4 Describe different methods of inputting CNC programs
- 2.5 Explain the principles of planning CNC turning operations

---

## Range

### AC2.1 Safety issues

- Hazards: (entanglement, ejected workpieces, moving parts, sharp edges, heat)
- Controls: (safety checks, COSHH, Manual handling, PPE, safe working practices)
- Mandatory safety signs

### AC2.2 Characteristics of turned features

- Faces: (datum, flat, parallel, tapered)
- Diameters: (internal, external, bored, tapered, concentric, eccentric)
- Shoulders
- Grooves/undercuts
- Holes: (drilled, reamed, blind, through, counterbored, countersunk, flat-bottomed)
- Threads: (internal, external)

### AC2.3 Techniques for mounting cutting tools

- Tools secured in tool holding devices
- Tools set in correct position
- Tools set in geometric offset

### AC2.4 Inputting CNC programs

- Coding: (machine axes, Cartesian coordinates absolute and incremental)
- Machine management: (spindle start/stop, coolant on/off, tool change, end of program, optional stop)
- Terminology: (part programs, word address, conversational)
- Methods of inputting program: manual, USB flash drive, Intranet, Direct Numerical Control (DNC))
- Methods of proving part programs: proof read, graphic simulation, single block, rapid override

### AC2.5 Principles of planning CNC turning operations

- Critical path
- Sequence of operations

---

## Learning outcome

The learner will:

- 3 Understand quality requirements for CNC turning operations

## Assessment criteria

The learner can:

- 3.1 Describe ways to monitor machine performance
- 3.2 Describe ways to evaluate turned components against specification requirements

---

## Range

### AC3.1 Monitor machine performance

- In-process checks: (trial cuts, backlash, size of workpiece, surface finish of workpiece, condition of cutting tools)
- Check for potential defects: (symptoms, causes, resolution)

### AC3.2 Evaluating turned components against specification

- Identify quality from engineering drawings: (tolerance, surface finish, concentricity, parallelism, tapers, threads, radii)
- Apply inspection techniques: (measurement, visual)

## Unit 211

## CNC Turning Techniques

### Supporting Information

#### ***Unit guidance***

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

It is recommended that learning is based on engineering information such as engineering drawings and specifications from which learners can interpret the information presented and consider the appropriate tools, equipment and machinery required to create the components. Learners can then consider the operational requirements and processes that will deliver the component in the engineering information.

## Unit 212

## CNC Milling Techniques

<b>Unit level:</b>	Level 2
<b>GLH:</b>	50
<b>Unit aim:</b>	This unit provides the learner with knowledge of the tools, equipment and machinery used to create milled components. They will learn how machinery is set up and operated safely and the processes to be followed to create milled components. Learners will develop an understanding of quality requirements and how they can evaluate the quality of a milled component against a specification.

---

### Learning outcome

The learner will:

- 1 Know the equipment required for CNC milling operations

### Assessment criteria

The learner can:

- 1.1 Identify characteristics and function of parts of CNC mills
- 1.2 Identify characteristics, function and limitations of workholding devices
- 1.3 Describe characteristics and limitations of cutting tools
- 1.4 Explain characteristics and limitations of measuring equipment

---

### Range

AC1.1 Characteristics and function of parts of a CNC mill

- Isolators
- Emergency stops
- Coolant system
- Guards and interlocks
- Automatic tool changer
- Control: (machine page, tool offset page, workshift page, program directory, program editor)
- Open loop control
- Closed loop control
- Servo motors/stepper motors

- Recirculating ball screws: (internal ball return, external ball return)
- Positional transducers

#### AC1.2 Characteristics, function of workholding devices

- Machine vice
- Clamps
- Fixtures

#### Limitations

- Machine vice: hold square, hexagon, parallel sided and cylindrical with a Vee block

#### AC1.3 Characteristics and limitations of cutting tools

- Tool types: (end mill, slot mill, shell cutter, bullnose cutter, corner rounding cutter, dovetail cutter, drills, reamers, taps)
- Characteristics of cutting tools: (tool angles, materials: High Speed Steel (HSS), stellite carbide)
- Effects of cutting fluids

#### AC1.4

##### Characteristics of measuring equipment

- Micrometres (internal, external, depth)
- Vernier calliper
- Comparison plates
- Rules
- Protractors
- Gauges
- Dial Test Indicator (DTI)
- Engineers square
- Coordinate Measuring Machine (CMM)

#### Limitations

- Accuracy of reading between manual and digital – operator skill
- Gauges to check for conformity to limit
- Square provides a 90° angle to a datum face

### Learning outcome

The learner will:

- 2 Understand how to produce components on a CNC mill

### Assessment criteria

The learner can:

- 2.1 Identify safety issues and control measures associated with the use of a CNC mill
- 2.2 Describe characteristics of different types of milled features
- 2.3 Identify techniques for securing workholding devices

- 2.4 Identify techniques for mounting cutting tools
- 2.5 Describe different methods of inputting CNC programs
- 2.6 Explain the principles of planning CNC milling operations

---

## Range

### AC2.1 Safety issues

- Hazards: (entanglement, moving parts, sharp edges, heat)
- Controls: (safety checks, COSHH, Manual handling, PPE, safe working practices, machine guards)
- Mandatory safety signs

### AC2.2 Characteristics of milled features

- Faces: (datum, flat, perpendicular, parallel, tapered)
- Steps
- Slots: (enclosed, open ended, tee, dovetail)
- Recesses
- Holes: (drilled, reamed, blind, through, counterbored, countersunk, flat-bottomed, bored, internal threads)

### AC2.3 Securing techniques

- Vices clamped to table
- Vee blocks clamped to table
- Clamps include stepped

### AC2.4 Techniques for mounting cutting tools

- Cutting tools secured in tool holding devices
- Tool set in correct position
- Use of different types of carousel
- Tool set in geometry offset

### AC2.5 Inputting CNC programs

- Coding: (machine axes, Cartesian coordinates, absolute and incremental)
- machine management: (spindle start/stop, coolant on/off, tool change, end of program, optional stop)
- Terminology: (part programs, word address, conversational)
- Methods of inputting program: (manual, USB flash drive, Intranet, Direct Numerical Control (DNC))
- Methods of proving part programs: (proof read, graphic simulation, single block, rapid override)

### AC2.6 Principles of planning CNC milling operations

- Critical path
- Sequence of operations

---

## Learning outcome

The learner will:

- 3 Understand quality requirements for CNC milling operations

## Assessment criteria

The learner can:

- 3.1 Describe ways to monitor machine performance
- 3.2 Describe ways to evaluate milled components against specification requirements

---

## Range

### AC3.1 Monitor machine performance

- In-process checks: (trial cuts, backlash, size of workpiece, surface finish of workpiece, condition of cutting tools)
- Check for potential defects: (symptoms, causes, resolution)

### AC3.2 Evaluate milled components

- Identify quality criteria from engineering drawings: (tolerance, surface finish, parallelism, tapers, threads, radii)
- Apply inspection techniques: (measurement, visual)

## Unit 212

## CNC Milling Techniques

### Supporting Information

#### ***Unit guidance***

This is a theory unit intended to underpin the development of practical skills. It can be delivered in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

Learning is based on engineering information such as engineering drawings. From this, learners can interpret the information presented and consider the appropriate tools, equipment and machinery required to create the components. Learners can then consider the operational requirements and processes that will deliver the turned component in the engineering information.

## Unit 213

## Computer Aided Design (CAD)

<b>Unit level:</b>	Level 2
<b>GLH:</b>	50
<b>Unit aim:</b>	This unit provides the learner with the principles and capabilities of a CAD system. These include health & safety requirements, benefits and limitations and applications.

### Learning outcome

The learner will:

- 1 Understand the principles of using a CAD system

### Assessment Criteria

- 1.1 Explain the health & safety requirements for a safe CAD working environment
- 1.2 Describe applications of CAD software
- 1.3 Identify current standards used for CAD drawing
- 1.4 Explain the purpose of storage and data management
- 1.5 Explain the benefits and limitations of using CAD software compared to manual drawing

### Range

#### AC1.1 Health & Safety

- Health and Safety (Display Screen Equipment) regulations
- Hazards associated with the use of CAD

#### AC1.2 Applications of CAD software

- 2D drawing
- 3D modelling
- Virtual testing
- Simulation (models, electrical circuits, fluid power systems)

#### AC1.4 Storage and data management

- Labelling/ file name conventions
- File format

- Version management
- Indexing
- Correct storing of files

#### AC1.5 Benefits

- Ability to edit
- Distribution
- Document control
- Accuracy
- Storage
- Ability to simulate testing
- Ability to transfer instructions to CNC equipment

#### Limitations

- Data security
- Training requirements
- Cost

---

### Learning outcome

The learner will:

- 2 Know the main capabilities of CAD software

### Assessment criteria

The learner can:

- 2.1 Describe the key operating features of CAD software
- 2.2 Describe the key operating features used in part modelling
- 2.3 Describe the key operating features used in assembly modelling

---

## 3 Range

### AC2.1 Operating features

- Navigation
- Use of pre-designed templates
- Use line types
- Styles and colours
- View placement
- Scale command
- Annotate (dimension, text, symbols)

### AC2.2 Part modelling features

- Navigation
- Create geometry

- Modify geometry
- Dimension
- Line types
- Extrusion
- Constraints

#### AC2.3 Assembly modelling features

- Navigation
- Grounding
- Positioning
- Align command
- Offset command
- Mate command
- Constraints

## Unit 213

## Computer Aided Design (CAD)

### Supporting Information

#### ***Unit guidance***

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

It is recommended that learning is based on engineering information such as engineering drawings and specifications from which learners can interpret the information presented and consider the appropriate tools, equipment and machinery required to create the components. Learners can then consider the operational requirements and processes that will deliver the component in the engineering information.

Learning Outcome 1 AC1.3

Standards from drawings should be in accordance with the conventions in relevant standards e.g. BSEN 8888

## Unit 214

## Electrical and Electronic Principles

<b>Unit level:</b>	Level 2
<b>GLH:</b>	40
<b>Unit aim:</b>	This unit will provide the knowledge and understanding of the basic principles, components and devices that make up electrical and electronic systems. It covers electrical and electronic circuits, the functions and applications of components and devices, and the ways in which systems and circuits are represented.

### Learning outcome:

The learner will:

- 1 Understand electrical and electronic circuit principles

### Assessment criteria

The learner can:

- 3.1 Explain electrical and electronic terms, laws and theorems
- 3.2 Explain types of electrical current and their advantages/disadvantages

### Range

#### AC1.1 Laws and theorems

- Electron theory
- Ohm's law
- Watt's law
- Magnetism
- Fleming's rules
- Electrostatic theory
- Electrical energy
- Electrical efficiency

#### Terms

- Voltage
- Current
- Resistance
- Power

#### AC1.2 Electrical current

- Alternating current (AC)

- Direct current (DC)
- 

### Learning outcome

The learner will:

- 2 Understand the units of measurement used to quantify electrical parameters

### Assessment criteria

The learner can:

- 2.1 State the SI units used to measure electrical parameters
  - 2.2 Convert units to different multiples and submultiples
- 

### Range

#### AC2.1 Parameters

- Resistance
- Capacitance
- Inductance
- Voltage
- Current
- Frequency
- Time
- Power
- Energy
- Magnetic flux
- Magnetic flux density

#### AC2.2 Multiples and submultiples

- Pico
  - Nano
  - Micro
  - Milli
  - Kilo
  - Mega
- 

### Learning outcome

The learner will:

- 3 Understand methods of calculating values in electrical and electronic circuits
-

## Assessment criteria

The learner can:

- 3.1 Calculate values using Ohm's law
  - 3.2 Calculate values using Watt's law
  - 3.3 Calculate resistance in series and parallel circuits
  - 3.4 Determine values using the resistor colour code
  - 3.5 Calculate electrical energy transferred in a circuit
  - 3.6 Calculate the efficiency of an electrical appliance
- 

## Range

AC3.1 Values – Ohm's law

- Voltage
- Current
- Resistance

AC3.2 Values – Watt's law

- Power
- Voltage
- Current

AC3.3 Circuits

- Maximum of 3 resistors in series
- Maximum of 3 resistors in parallel

## **Unit 214**

## **Electrical and Electronic Principles**

### Supporting Information

#### ***Unit guidance***

This unit could be taught effectively using CAD software to simulate the functions of electrical and electronic components. Centres could also use product analysis to investigate the application of different components.

Tutors should ensure that they keep up to date with current industry standards for e.g. BS3939 or IEC 60062:2016

## Unit 215

## Electrical and Electronic Testing Methods

<b>Unit level:</b>	Level 2
<b>GLH:</b>	50
<b>Unit aim:</b>	This unit provides the knowledge and understanding of methods used to test electrical and electronic circuits and components. It covers the units of measurement used to quantify electrical parameters, the functions and applications of electrical test equipment and the main principles of calibration.

### Learning outcome

The learner will:

- 1 Understand the units of measurement used to quantify electrical parameters

### Assessment criteria

The learner can:

- 1.1 Explain electrical and electronic laws and theorems
- 1.2 State the SI units used to measure electrical parameters
- 1.3 Convert units to different multiples and submultiples

### Range

#### AC1.1 Laws and theorems

- Electron theory
- Ohm's law
- Watt's law
- Magnetism
- Fleming's rules
- Electrostatic theory

#### AC1.2 Parameters

- Resistance
- Capacitance
- Inductance
- Voltage
- Current

- Frequency
- Time
- Power
- Energy
- Magnetic flux
- Magnetic flux density

#### AC1.3 Multiples and submultiples

- Pico
- Nano
- Micro
- Milli
- Kilo
- Mega

---

### Learning outcome

The learner will:

- 2 Understand the applications of electrical and electronic test equipment

### Assessment criteria

The learner can:

- 2.1 Describe the characteristics of waveform signal types
- 2.2 Explain the purpose and benefits/limitations of test equipment
- 2.3 Describe how test equipment is used to measure electrical parameters

---

### Range

#### AC2.1 Waveform signal types

- Sinusoidal
- Square
- Triangle
- Sawtooth
- Ramp
- Pulse

#### Waveform characteristics

- Frequency
- Periodic time
- Peak to peak
- Peak
- Root mean squared (RMS)
- Phase shift
- Offset

## AC2.2 Test equipment

- Digital multimeter
- Function generator
- Oscilloscope
- Frequency counter
- Logic probe
- Computer simulation/virtual instruments

## AC2.3 Parameters

- Resistance
- Current
- Voltage (AC circuits, DC circuits)
- Signal amplitude
- Signal frequency
- Logic state

---

## Learning outcome

The learner will:

- 3 Understand electrical and electronic test equipment calibration techniques

## Assessment criteria

The learner can:

- 3.1 Explain the principles of test equipment calibration
- 3.2 Describe procedures used to validate test equipment functionality

---

## Range

### AC3.1 Principles of calibration

- Need for calibration
- Accuracy
- Precision
- Resolution
- Linear
- Non-linear
- Recording
- Certification
- Frequency

### AC3.2 Procedures

- Calibration checks (frequency, reference against known values, reference against calibrated equipment)

- Zero checks (nulling leads, zeroing meter displays, parallax checks)
- Records/documentation

## **Unit 215**

## **Electrical and Electronic Testing Methods**

### Supporting Information

#### ***Unit guidance***

Although this is a knowledge unit, tutors could provide access to appropriate test equipment for the purpose of understanding their features, functions and applications.

Industrial examples of applications of how the testing methods and equipment covered in this unit are used in the workplace could be used to enhance learning.

#### Learning Outcome 2 AC2.2

This unit has been updated to reflect industry practices in relation to the use of digital testing equipment rather than analogue.

## Unit 216

# Electrical and Electronic Systems and Devices

<b>Unit level:</b>	Level 2
<b>GLH:</b>	40
<b>Unit aim:</b>	This unit will provide the knowledge and understanding of components and devices that make up electrical and electronic systems. It covers electrical and electronic circuits, the functions and applications of components and devices, and the ways in which systems and circuits are represented.

---

### Learning outcome

The learner will:

- 1 Understand the functions of electrical and electronic components and devices

### Assessment criteria

The learner can:

- 1.1 Describe the functions and applications of input, process, output and interface devices
- 1.2 Describe the functions and applications of passive components
- 1.3 Explain advantages/disadvantages of programmable microcontrollers

---

### Range

AC1.1 Input devices

- Switches: push-to-make, push-to-break, rocker, toggle, tilt, reed
- Sensors: light dependent resistors, thermistors, infra-red sensors, pressure sensor

Process devices

- Timers
- Counters
- Logic gates: AND, OR, NOT
- Amplifiers
- Regulators
- Microcontrollers

Output devices

- Lamps
- Light emitting diodes
- Buzzers

- Loudspeakers
- Motors

#### Interface devices

- Bipolar transistors
- Field-effect transistors
- Darlington drivers
- Relays

#### AC1.2 Passive components

- Resistors: fixed, variable
- Capacitors: polarised, non-polarised
- Diodes: signal, rectifier
- Inductors
- Fuses

---

### Learning outcome

The learner will:

- 2 Understand methods of representing electrical and electronic systems

### Assessment criteria

The learner can:

- 2.1 Explain the purpose of types of diagrams used to represent electrical and electronic systems
- 2.2 Interpret symbols and abbreviations (to current industry standards) of components used in circuit schematics

---

### Range

#### AC2.1 Types of diagrams

- Schematic
- Circuit diagram
- Wiring diagram
- Systems block diagram
- Flow chart

#### AC2.2 Components

- Switches
- Light dependent resistors
- Thermistors
- Logic gates
- Lamps
- Light emitting diodes
- Buzzers

- Loudspeakers
- Motors
- Transistors
- Relays
- Resistors
- Capacitors
- Diodes
- Inductors
- Fuses
- Power supplies

## **Unit 216**

# **Electrical and Electronic Systems and Devices**

## Supporting Information

### ***Unit guidance***

This unit could be taught effectively using CAD software to simulate the functions of electrical and electronic components. Centres could also use product analysis to investigate the application of different components.

Tutors should ensure that they keep up to date with current industry standards for component symbols and abbreviations e.g. BS3939

## Unit 217

## Fabrication and Welding Principles

<b>Unit level:</b>	Level 2
<b>GLH:</b>	50
<b>Unit aim:</b>	This unit provides the learner with the knowledge of basic principles related to fabrication and welding methods. These include measuring, marking out, cutting by shear, forming, thermal cutting, joining and assembly methods.

---

### Learning outcome

The learner will:

- 1 Understand the equipment available to produce fabricated components

### Assessment criteria

The learner can:

- 1.1 Describe the types of equipment available for marking out
- 1.2 Describe the types and purpose of datums
- 1.3 Explain marking out methods for a range of features
- 1.4 Describe fabrication hand tools, equipment and their application

---

### Range

AC1.1 Equipment to include

- Scribers
- Scribing block
- French chalk
- Centre and dot punch
- Rules
- Tape measures
- Vernier callipers
- Vernier height gauges
- Squares (engineers, adjustable and plate)
- Protractors
- Dividers and trammels
- Laser lines
- Marking out tables

### AC1.2 Datums

- Line
- Edge
- Centre point

### Purpose

- Avoidance of accumulated error
- Provide a reference point

### AC1.3 Marking out methods

- Direct marking
- Use of templates
- Tracing/transfer methods

### Features

- Circles
- Radii
- Pitch Circle Diameter (PCD)
- Hole centres
- Angles
- Rectangular profiles
- Curved profiles

### AC1.4 Hand tools and equipment

- Hammers and mallets
- Work holding magnets
- Clamps
- Centre finders
- Punches (centre, dot)
- Drifts and wedges
- Vices
- Anvils

---

### Learning outcome

The learner will:

2 Understand cutting and forming methods used for fabrication

### Assessment criteria

The learner can:

2.1 Describe the principles that underpin cutting by shear methods

- 2.2 Describe equipment used for cutting by shear and their applications
  - 2.3 Describe the principles that underpin chip forming cutting methods
  - 2.4 Describe equipment used for chip forming cutting and their applications
  - 2.5 Describe types of forming equipment available for fabrication and their application
- 

## Range

### AC2.1 Principles

- Purpose of rake angle
- Purpose of shear angle
- Purpose of blade gap
- Influence of shear strength

### AC2.2 Equipment

- Guillotine
- Punching
- Universal steel worker
- Shears (hand, bench, rotary)
- Mechanical nibblers

### AC2.3 Principles

- Purpose of chip formation
- Purpose of rake angle
- Purpose of relief angle

### AC2.4 Equipment

- Drills
- Drill bits (steel, masonry, hole saws)
- Saws (circular, bandsaws, hand)

### AC2.5 Forming equipment

- Bending rolls
  - Folders
  - Press brakes
  - Horizontal bender
- 

## Learning outcome

The learner will:

- 3 Understand the joining and assembly methods for fabrication

## Assessment criteria

---

The learner can:

- 3.1 Describe non-thermal permanent joining methods and their applications
  - 3.2 Describe non-thermal temporary joining methods and their applications
  - 3.3 Describe thermal fusion joining methods and their applications
  - 3.4 Describe thermal non-fusion joining methods and their applications
  - 3.5 Describe assembly methods for fabrication and their applications
- 

## Range

### AC3.1 Non-thermal permanent

- Riveting (hollow (pop), self-piercing)
- Clinching

### AC3.2 Non-thermal temporary

- Screws
- Nuts, bolts and washers

### AC3.3 Thermal fusion

- Welding (MIG/MAG, TIG, MMA, FCAW)

### AC3.4 Thermal non-fusion

- Soldering
- Brazing

### AC3.5 Assembly methods

- Alignment methods (straight edge, levels, laser lines, string lines, dumpy levels, drifts, dogs and wedges)
  - Work holding (tack bolts, tack welding, clamps, fixtures, magnets)
  - Bolt tightening (surface preparation, tightening sequence, torque wrenches, part turn method, bolt locking methods: split pins, castle nuts, adhesives, wiring)
-

## Unit 217

## Fabrication and Welding Principles

### Supporting Information

#### ***Unit guidance***

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

It is recommended that learning is based on engineering information such as engineering drawings and specifications from which learners can interpret the information presented and consider the appropriate tools, equipment and machinery required to create the components. Learners can then consider the operational requirements and processes that will deliver the component in the engineering information.

#### Learning Outcome 3

There is no requirement for learners to have in depth knowledge and understanding of the the welding processes included in the range for AC3.3 as these are covered in other units

## Unit 218

## Manual Welding

<b>Unit level:</b>	Level 2
<b>GLH:</b>	70
<b>Unit aim:</b>	In this unit learners will understand health and safety requirements for arc welding, the equipment and consumables used and the welding parameters. They will also understand weld defects and inspection techniques.

---

### Learning outcome

The learner will:

- 1 Understand safe working practices associated with welding processes

### Assessment criteria

The learner can:

- 1.1 Describe Personal Protective Equipment (PPE) used in welding processes
- 1.2 Describe hazards associated with welding processes and ways of minimising them
- 1.3 Explain the importance of restoring the work area and following correct procedures for waste disposal
- 1.4 Describe post welding activities

---

### Range

#### AC1.1 Personal Protective Equipment

- Headshield
- Filter lens
- Cover lens
- Light reactive filters
- Gauntlets
- Protective footwear
- Eye protection
- Flame retardant overalls
- Leather apron
- Skull cap
- Leather jacket
- Air fed mask

#### AC1.2 Hazards

#### Fume hazards

- Visible (particulate)
- Invisible (gaseous)

#### Minimised by

- Use of extraction (background, local)
- Air fed mask
- Respirator

#### Electrical hazards

- Shock hazards
- Fire
- Burns

#### Minimised by

- Use of electrical insulation

#### Exposure to light hazards

- Visible light
- Infra-red
- Ultra-violet

#### Minimised by

- PPE (types, purpose)
- Screening

#### Fire hazards

- Burns from hot metal
- Fire risks

#### Minimised by

- Use of tools e.g. tongs
- PPE
- Housekeeping i.e. keeping work area clear of flammable materials

#### AC1.3 Restore the work area

- Leave work area free of unused consumables
- Clean work area
- Putting tools and equipment into safe storage

#### AC1.4 Post welding activities

- Cleaning
- Slag removal
- Spatter removal
- Wire brushing
- Removal of excess weld metal where required

---

## Learning outcome

The learner will:

### 2 Understand principles of manual welding

#### Assessment criteria

- 2.1 Describe the function of equipment used for preparing and finishing welded joints
- 2.2 Explain different joint types and welding positions
- 2.3 Explain different welding techniques
- 2.4 Describe assembly and distortion control methods
- 2.5 Describe a weld procedure specification
- 2.6 Describe the weldability of common materials

---

## Range

### AC2.1 Equipment

- Grinders
- Linishers
- Files
- Chipping hammer
- Wire brushes
- Hammer and chisel

### AC2.2 Joint types

- Fillet
- Lap
- Butt

### Welding positions

- Flat – PA position
- Horizontal/vertical – PB position
- Horizontal – PC position
- Vertical upwards – PF position

### AC2.3 Welding techniques

- Stringer beading
- Weaving
- Single-pass
- Multiple-run

### AC2.4 Assembly and distortion control

- Clamping
- Alignment jigs
- Run on/off plates
- Tack welds

- Weld sequence

## AC2.6 Materials

- Carbon and low alloy steel
- High alloy ferritic/martensitic steel
- Austenitic stainless steel
- Nickel and nickel alloys
- Aluminium and aluminium alloys

---

## Learning outcome

The learner will:

- 3 Understand the Manual Metal Arc (MMA) welding process

## Assessment criteria

The learner can:

- 3.1 Describe the major components of welding equipment
- 3.2 Describe different types of electrodes and storage requirements
- 3.3 Describe the parameters for welding

---

## Range

### AC3.1 Components welding equipment

- Power supply
- Welding leads (welding, return, earth)
- Electrode holder
- Return clamp

### AC3.2 Types of electrodes

- Cellulosic
- Rutile
- Basic

### Storage requirements

- Temperature
- Humidity

### AC3.3 Parameters

- Welding current (alternating (A.C.), direct (D.C.), current ranges to electrode sizes: Ø2.5mm, Ø3.2mm, Ø4.0 mm)
- Voltage (open circuit, arc voltage)

---

## Learning outcome

The learner will:

- 4 Understand the Metal Inert Gas/Metal Active Gas (MIG/MAG) welding processes

## Assessment criteria

The learner can:

- 4.1 Describe the major components of welding equipment
- 4.2 Describe different types of filler wire and storage requirements
- 4.3 Identify shielding gases for MIG/MAG welding
- 4.4 Explain the parameters for welding

---

## Range

### AC4.1 Components of welding equipment

- Power supply
- Welding leads: welding, return, earth
- Torch/gun
- Return clamps
- Shielding gas control: regulator, flow meter

### AC4.2 Filler wire

- Solid wires: copper coated, reel sizes
- Cored wire: flux cored, self-shielded

### Storage requirements

- Temperature
- Humidity

### AC4.3 Shielding gases

- argon/ carbon dioxide Ar/CO<sub>2</sub>
- carbon dioxide CO<sub>2</sub>
- argon/oxygen Ar/O<sub>2</sub>
- argon/helium Ar/He

### AC4.4 Parameters

- Welding current: direct (D.C.), electrode positive
- Voltage: open circuit, arc voltage
- Relationship between arc voltage and wire feed speed ranges to filler wire sizes
- Shielding gas flow rates

---

## Learning outcome

The learner will:

5 Understand the Tungsten Inert Gas (TIG) welding process

## Assessment criteria

The learner can:

- 5.1 Describe the major components of welding equipment
- 5.2 Describe types of tungsten electrodes and their sizes
- 5.3 Describe different filler wires and storage requirements
- 5.4 Identify shielding gases for TIG welding process
- 5.5 Describe the parameters for welding

---

## Range

AC5.1 Components of welding equipment

- Power supply
- Welding leads (welding, return, earth)
- Torch/gun
- Return clamps
- Shielding gas control (regulator, flow meter)

AC5.2 Tungsten electrodes

- Types (thoriated, zirconiated, ceriated, lanthanated)
- Sizes (Ø1.6 mm, Ø2.4 mm, Ø3.2 mm)

AC5.3 Filler wires

- Copper coated steel
- Stainless steel
- Aluminium
- Common sizes - Ø1.6 mm, Ø2.4 mm, Ø3.2 mm

Storage requirements

- Temperature
- Humidity

AC5.4 Shielding gases

- argon Ar
- helium He
- argon/helium Ar/He

AC5.5 Parameters

- Welding current
- Voltage (open circuit, arc voltage)

---

### Learning outcome

The learner will:

6 Understand inspection methods for weld defects

### Assessment criteria

The learner can:

- 6.1 Explain the causes of causes of weld defects and how their occurrence can be reduced
- 6.2 Explain quality assessment techniques
- 6.3 Describe workshop destructive testing techniques

---

### Range

AC6.1 Causes of weld defects

- Lack of continuity
- Even or irregular weld profile
- Incorrect weld size or profile
- Undercutting
- Overlap
- Inclusions
- Porosity
- Surface cracks
- Internal cracks
- Lack of fusion: root, side wall, inter-run
- Lack of penetration

AC6.2 Quality assessment methods

- Visual including weld gauges
- Non-destructive testing techniques: dye penetrant, magnetic particle

AC6.3 Destructive testing techniques

- Macroscopic examination
- Nick-break test
- Bend tests

# **Unit 218**                      **Manual Welding**

## Supporting Information

### ***Unit guidance***

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required. The unit will allow learners to develop the knowledge for manual welding processes.

#### Learning Outcome 2

Principles of manual welding is applicable to all manual welding processes and should be taught in the context of each process.

## Unit 219

## Producing Components from Metal Plate

<b>Unit level:</b>	Level 2
<b>GLH:</b>	50
<b>Unit aim:</b>	This unit provides the learner with the knowledge of producing metal plate components. This includes measuring, marking out, cutting to size, forming and joining methods.

---

### Learning outcome:

The learner will:

- 1 Understand tools and equipment used to produce metal plate components

### Assessment criteria

The learner can:

- 1.1 Describe tools and equipment available for marking out and their applications
- 1.2 Explain marking out methods for a range of features
- 1.3 Explain the importance of datums when marking out
- 1.4 Describe metal plate hand tools, equipment and their applications

---

### Range

AC1.1 Marking out tools and equipment, to include

- Scribers
- Scribing blocks
- Centre and dot punch
- Rules
- Tape measures
- Vernier callipers
- Vernier height gauges
- Squares (engineers, adjustable and plate)
- Protractors
- Dividers and trammels
- Laser lines
- Marking out tables

#### AC1.2 Methods

- Direct marking
- Use of templates
- Tracing/transfer method
- Use of datums: line, edge, point

#### Features

- Circles
- Radii
- Pitch Circle Diameter (PCD)
- Hole centres
- Angles
- Rectangular profiles
- Curved profiles

#### AC1.4 Hand tools, equipment

- Hammers and mallets
- Work holding magnets
- Clamps
- Dogs and wedges
- Punches (centre, dot)
- Vices

---

### Learning outcome

The learner will:

2 Understand cutting methods for metal plate

### Assessment criteria

The learner can:

- 2.1 Describe equipment used for cutting by shear and their application
- 2.2 Describe equipment used for chip forming and their application

---

### Range

#### AC2.1 Cutting by shear equipment

- Guillotine
- Punching
- Bench shears
- Rotary shears
- Mechanical nibblers and shears

#### AC2.2 Chip forming equipment

- Drilling machines: hand, pneumatic, battery, pillar, radial arm
  - Drill bits for steel and masonry and hole saws
  - Sawing: circular, bandsaws, reciprocating
- 

### Learning outcome

The learner will:

3 Understand forming methods for metal plate

### Assessment criteria

The learner can:

- 3.1 Describe the process of forming of metals
  - 3.2 Describe forming equipment and their applications
- 

### Range

AC3.1 Forming

- Rolling
- Folding

AC3.2 Forming equipment

- Bending rolls: pinch, pyramid, 4 roll, vertical
  - Folders: universal, box and pan
  - Press brakes
  - Horizontal benders
- 

### Learning outcome

The learner will:

4 Understand joining and assembly methods for metal plate

### Assessment criteria

The learner can:

- 4.1 Describe non-thermal temporary joining methods and their applications
  - 4.2 Describe thermal fusion joining methods and their applications
  - 4.3 Explain assembly methods for fabrication and their applications
- 

### Range

AC4.1 Non-thermal temporary

- Screws: self-tapping, self-drilling
  - Nuts, bolts and washers
-

#### AC4.2 Thermal fusion

- Welding: MIG/MAG, flux cored, TIG, MMA, submerged arc

#### AC4.3 Assembly methods

- Alignment methods: straight edge, levels, laser lines, string lines
- Work holding: tack welding, tack bolts, clamps, fixtures, magnets
- Bolt tightening sequence
- Bolt locking methods: split pins, castle nuts, adhesives, wiring

## **Unit 219**

## **Producing Components from Metal Plate**

### **Supporting Information**

#### ***Unit guidance***

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

For the purpose of this unit metal plate is defined as having a minimum thickness of >3mm

There is no requirement for learners to be taught the principles as part of this unit. They do however need to understand the applications of each welding process.

Learning outcome 4 AC 4.2

The principles of welding processes are covered in Unit 218 – Manual Welding.

## Unit 220

## Producing Components from Sheet Metal

<b>Unit level:</b>	Level 2
<b>GLH:</b>	50
<b>Unit aim:</b>	This unit provides the learner with the knowledge of producing sheet metal components. This includes measuring, marking out, cutting to size, forming, stiffening and joining methods.

---

### Learning outcome:

The learner will:

1. Understand tools and equipment used to produce sheet metal components

### Assessment criteria

The learner can:

- 1.1 Describe tools and equipment available for marking out and their applications
- 1.2 Explain marking out methods for a range of features
- 1.3 Explain the importance of datums when marking out
- 1.4 Describe sheet metal hand tools, equipment and their applications

---

### Range

AC1.1 Marking out tools and equipment, to include

- Scribers
- Scribing blocks
- Centre and dot punch
- Rules
- Tape measures
- Vernier callipers
- Vernier height gauges
- Squares (engineers, adjustable and plate)
- Protractors
- Dividers and trammels
- Laser lines
- Marking out tables

#### AC1.2 Methods

- Direct marking
- Use of templates
- Tracing/transfer method
- Use of datums (line, edge, point)

#### Features

- Circles
- Radii
- Pitch Circle Diameter (PCD)
- Hole centres
- Angles
- Rectangular profiles
- Curved profiles

#### AC1.4 Hand tools and equipment

- Hammers and mallets
- Stakes
- Work holding magnets
- Clamps
- Punches (centre, dot)
- Vices

---

### Learning outcome

The learner will:

2 Understand cutting methods for sheet metal

### Assessment criteria

The learner can:

- 2.1 Describe equipment used for cutting by shear and their application
- 2.2 Describe equipment used for chip forming and their application

---

### Range

#### AC2.1 Cutting by shear equipment

- Guillotine
- Punching
- Hand shears
- Bench shears
- Rotary shears
- Mechanical nibblers and shears

#### AC2.2 Chip forming equipment

- Drilling machines: hand, pneumatic, battery, pillar
- Drill bits for steel and masonry and hole saws

- Saws: circular, bandsaws, jigsaws
- 

### Learning outcome

The learner will:

3 Understand forming methods for sheet metal

### Assessment criteria

The learner can:

- 3.1 Describe the processes of forming metals
  - 3.2 Describe forming equipment and their applications
  - 3.3 Describe methods of stiffening sheet metal
- 

### Range

AC3.1 Forming

- Rolling
- Folding
- Stretching
- Shrinking

AC3.2 Forming equipment

- Bending rolls: pinch, pyramid, cone rolls
- Folders: universal, box and pan
- Press brakes

AC3.3 Stiffening methods

- Return bends
  - Hems
  - Rolled edges
  - Stiffening ribs
  - Swaged beads
  - Angle bends
- 

### Learning outcome

The learner will:

4 Understand joining and assembly methods for sheet metal

### Assessment criteria

The learner can:

- 4.1 Describe non-thermal permanent joining methods and their applications
  - 4.2 Describe non-thermal temporary joining methods and their applications
  - 4.3 Describe thermal fusion joining methods and their applications
  - 4.4 Describe thermal non-fusion joining methods and their applications
-

## 4.5 Explain assembly methods for fabrication and their applications

---

### Range

#### AC4.1 Non-thermal permanent

- Riveting: hollow (pop), self-piercing
- Clinching

#### AC4.2 Non-thermal temporary

- Screws: self-tapping, self-drilling
- Nuts, bolts and washers

#### AC4.3 Thermal fusion

- Welding: MIG/MAG, TIG, resistance

#### AC4.4 Thermal non-fusion

- Soldering
- Brazing

#### AC4.5 Assembly methods

- Alignment methods: straight edge, levels, laser lines, string lines
- Work holding: tack welding, clamps, fixtures, magnets
- Bolt tightening sequence
- Bolt locking methods: split pins, castle nuts, adhesives, wiring

## **Unit 220**

## **Producing Components from Sheet Metal**

### **Supporting Information**

#### ***Unit guidance***

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

For the purpose of this unit sheet metal is defined as having a maximum thickness of 3mm

There is no requirement for learners to be taught the principles as part of this unit. They do however need to understand the applications of each welding process.

Learning Outcome 4 AC 4.3

The principles of welding processes are covered in Unit 218 – Manual Welding.

## Unit 221

## Principles of Sheet and Plate Metal Work

<b>Unit level:</b>	Level 2
<b>GLH:</b>	50
<b>Unit aim:</b>	This unit provides the learner with the knowledge of basic principles related to sheet and plate metal technology. This includes work organisation, pattern development and cutting and forming

---

### Learning outcome:

The learner will:

- 1 Understand methods of work organisation

### Assessment criteria

The learner can:

- 1.1 Describe preparations before commencing metal work tasks
- 1.2 Explain the use of nesting to minimise waste

---

### Range

#### AC1.1 Preparations

- Health and Safety: work area, protection of others, risk assessment
- Work information: engineering drawings, job instructions, bill of materials, tools
- Material checks
- Equipment checks

---

### Learning outcome

The learner will:

- 2 Understand cutting and forming principles

### Assessment criteria

The learner can:

- 2.1 Explain the principles of cutting by shear

- 2.2 Describe how cutting by shear principles are applied to metal working equipment
  - 2.3 Explain the principles of chip forming
  - 2.4 Describe how chip forming principles are applied to metal working equipment
- 

### Range

#### AC2.1 Principles

- Purpose of rake angle
- Purpose of shear angle
- Purpose of blade clearance
- Influence of material shear strength

#### AC2.2 Equipment

- Guillotine
- Punching
- Bench shears

#### AC2.3 Principles

- Methods of chip formation
- Purpose of rake angle
- Purpose of relief angle

#### AC2.4 Equipment

- Drill bits
  - Sawing machines
- 

### Learning outcome

The learner will:

- 3 Know pattern development techniques

### Assessment criteria

The learner can:

- 3.1 Describe methods of parallel line pattern development
  - 3.2 Describe methods of radial line pattern development
  - 3.3 Describe methods of triangulation pattern development
- 

### Range

#### AC3.1 Parallel line

- Cylinder elbows (900 and 1350)
  - Rectangular elbows (900 and 1350)
  - Cylinder branches (900 and 1350)
-

### AC3.2 Radial line

- Right cones and frustums

### AC3.3 Triangulation

- Rectangular hoppers
- Square to round transformers (on centre only)

## Unit 221

## Principles of Sheet and Plate Metal Work

### Supporting Information

#### ***Unit guidance***

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

It is recommended that learning is based on engineering information such as engineering drawings and specifications from which learners can interpret the information presented and consider the appropriate tools, equipment and machinery required to create the components. Learners can then consider the operational requirements and processes that will deliver the component in the engineering information.

## Unit 222

## Non Fusion Thermal Joining Methods

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<b>Unit level:</b>	Level 2
<b>GLH:</b>	50
<b>Unit aim:</b>	This unit provides the learner with the knowledge of basic principles related to non-thermal joining methods. These include soldering, adhesives and sealants.

---

### Learning outcome:

The learner will:

- 1 Understand the soft soldering method of joining metals

### Assessment criteria

The learner can:

- 1.1 Describe the principles of soft soldering
- 1.2 Describe the consumables used for soft soldering
- 1.3 Describe soft soldering heat sources
- 1.4 Describe the stages required to complete a soft soldered joint

---

### Range

#### AC1.1 Principles

- Capillary attraction
- Inter-metallic compound
- Flux action (wetting, cleaning, oxidation control)

#### AC1.2 Consumables

- Fluxes: active, passive
- Solders: tin lead alloys for general purposes, tin zinc for joining aluminium

#### AC1.3 Heat sources

- Soldering iron
- Gas torch

#### AC1.4 Stages for soft soldered joints

- Joint design: socket, lap
  - Cleaning: mechanical, chemical
  - Flux application
  - Joint assembly
  - Heat application
- 

#### Learning outcome

The learner will:

2 Understand the hard-soldering method of joining metals

#### Assessment criteria

The learner can:

- 2.1 Describe the principles of hard soldering
  - 2.2 Describe the consumables used for hard soldering
  - 2.3 Describe hard soldering heat sources
  - 2.4 Describe the stages required to complete a hard-soldered joint
- 

#### Range

##### AC2.1 Principles

- Capillary attraction
- Inter-metallic compound
- Flux action: wetting, cleaning, oxidation control

##### AC2.2 Consumables

- Fluxes
- Spelters: brass alloys, silver alloys

##### AC2.3 Heat sources

- Gas torch

##### AC2.4 Stages for hard soldered joints

- Joint design: socket, lap
  - Cleaning: mechanical, chemical
  - Flux application
  - Joint assembly
  - Heat application
-

---

## Learning outcome

The learner will:

- 3 Understand the use of adhesives to join materials

## Assessment criteria

The learner can:

- 3.1 Describe the principles of joining using adhesives
  - 3.2 Explain types of adhesives used to join materials and their applications
  - 3.3 Describe the stages to complete an adhesive joint
  - 3.4 Describe the applications of sealants in engineering
- 

## Range

### AC3.1 Principles

- Method of adhesion: solvent, chemical bonding, physical bonding
- Adhesive thickness
- Adhesion strength
- Surface area

### AC3.2 Adhesive types

- Epoxy resin
- Solvent cements
- Cyanoacrylates

### AC3.3 Completion stages

- Joint design
- Cleaning: mechanical, chemical
- Adhesive application
- Joint assembly
- Adhesive activation

### AC3.4 Sealant applications

- Gap sealing
- Marine repair
- Water proofing
- Windscreen bonding

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### ***Unit guidance***

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

It is recommended that learning is based on engineering information such as engineering drawings and specifications from which learners can interpret the information presented and consider the appropriate tools, equipment and machinery required to create the components. Learners can then consider the operational requirements and processes that will deliver the component in the engineering information.

## Unit 223

## Thermal Cutting Techniques

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<b>Unit level:</b>	Level 2
<b>GLH:</b>	40
<b>Unit aim:</b>	This unit provides the learner with the knowledge related to thermal cutting including principles, equipment requirements and related health and safety.

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### Learning outcome:

The learner will:

1. Understand the principle of oxy-fuel thermal cutting

### Assessment criteria

The learner can:

- 1.1 Explain the principle of oxy-fuel thermal cutting
- 1.2 Identify the types of gases available for oxy-fuel thermal cutting
- 1.3 Describe the flame used for oxy-fuel thermal cutting
- 1.4 Describe the equipment used for oxy-fuel thermal cutting
- 1.5 Describe the safe use and applications of oxy-fuel cutting

---

### Range

#### AC1.1 Principle

- Gas combustion
- Ignition temperature
- Exothermic reaction

#### AC1.2 Gases

- Oxygen
- Acetylene
- Propane

#### AC1.3 Flame

- Conditions
  - Neutral
  - Oxidising

- Carburising/reducing
- Parts of the flame: inner cone, outer envelope, hottest point

#### AC1.4 Equipment

- Cylinders: identification i.e. colours and thread type, safe storage
- Regulators
- Flash back arrestors
- Hoses
- Hose check valves
- Torches: controls, mixing chambers
- Nozzles: one-part, two-part, selection related to material thickness
- Component identification: left/right hand threads, notched nuts

#### AC1.5 Safe use

- PPE
- Cylinder handling and storage
- Gas pressures for cutting
- Safe procedures for flame ignition and extinguishing
- Fume particular and gaseous
- Methods of handling of hot metals
- Leak testing

#### Applications including

- Cutting materials to shape: plates, pipes, structural sections
- Piercing
- Bevel cutting: plates, pipes

---

### Learning outcome

The learner will:

2. Understand the principle of plasma cutting

### Assessment criteria

The learner can:

- 2.1 Explain the principle of plasma cutting
- 2.2 Describe the equipment used for plasma cutting

---

### Range

#### AC2.1 Principle

- Definition of plasma
- Pilot arc
- Transferred arc

## AC2.2 Equipment

- Torches: water cooled, air cooled
  - Nozzles
  - Gas baffle
  - Electrodes
- 

### Learning outcome

The learner will:

3. Understand the principle of laser cutting

### Assessment criteria

The learner can:

- 3.1 Explain the principle of laser cutting
  - 3.2 Describe the equipment used for laser cutting
- 

### Range

#### AC3.1 Principle

- Acronym: light amplification by stimulated emission of radiation
- Beam concentration

#### AC3.2 Equipment

- Focus lens
- Nozzle
- CNC control

## **Unit 223                      Thermal Cutting Techniques**

### **Supporting Information**

#### ***Unit guidance***

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

It is recommended that learning is based on engineering information such as engineering drawings and specifications from which learners can interpret the information presented and consider the appropriate tools, equipment and machinery required to create the components. Learners can then consider the operational requirements and processes that will deliver the component in the engineering information.

## Unit 224

## Engineering Maintenance Safety

<b>Unit level:</b>	Level 2
<b>GLH:</b>	40
<b>Unit aim:</b>	This unit is to introduce learners to health and safety within engineering maintenance. In this unit the learners will cover safe working practices associated with a maintenance environment including lifting, moving, working at height and restoring the workplace.

### Learning outcome

The learner will:

1. Understand safe working practices, tools and equipment for maintenance activities

### Assessment criteria

The learner can:

- 1.1 Describe health and safety in engineering maintenance
- 1.2 Describe the hazards associated with maintenance activities
- 1.3 Describe equipment used for working at height
- 1.4 Describe different types of lifting equipment
- 1.5 Describe safe lifting methods/techniques
- 1.6 Describe methods for moving heavy equipment across flat surfaces

### Range

#### AC1.1 Health & Safety

- Legislation/regulation

#### Safe working practices

- Wearing appropriate protective clothing and equipment
- Maintaining a clean and tidy work area
- Use of barriers and/or tapes
- Post warning signs
- Informing personnel of maintenance activities
- System isolation procedures for power and pressure sources
- Permit-to work procedures
- Preparing the work area e.g. Lifting plan
- Leaving the work area in a safe and clean condition

#### AC1.2 Hazards

- Handling of oils and grease
- Misuse of tools
- Misuse of access equipment
- Use of damaged or badly maintained tools
- Not adhering to maintenance procedures

#### AC1.3 Access/egress equipment

- Ladders
- Scaffolding
- Mobile platforms e.g. quick form scaffolding

#### AC1.4 Lifting equipment

- Chains
- Rope and wire slings
- Hooks
- Shackles
- Eye bolts
- Screw and hydraulic jacks
- Overhead gantry cranes
- Forklift trucks
- A frame/tripod
- Pulley blocks
- Pallet truck

#### AC1.5 Safe lifting methods/techniques

- Methods of sling attachment to prevent damage to sling machinery (protective padding, wooden blocks)
- Angle of splay between two leg sling chains not to exceed 120°
- Estimation of approximate weight
- Inspection records for lifting equipment are current
- Centre of gravity of load
- Safe working loads (SWL)

#### AC1.6 Methods

- Rollers and skate
- Crowbars
- Pull-lifts
- Lubricated plates

---

## Learning outcome

The learner will:

2. Know how to clean and restore work areas following maintenance activities

## Assessment criteria

The learner can:

- 2.1 Identify procedures for cleaning work areas following a spillage or leakage
- 2.2 Describe how to restore the work area following maintenance activities

---

## Range

AC2.1 Procedures for cleaning

- Erect warning signs/barriers
- Use approved waste disposal methods
- Absorbent substances
- Use of detergents and solvents

AC2.2 Restore the work area

- Leave the work area free of unused consumables
- Clean the work area
- Put tools and equipment into safe storage

# **Unit 224                      Engineering Maintenance Safety**

## **Supporting Information**

### ***Unit guidance***

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

It is recommended that learning is based on engineering information such as engineering drawings and specifications from which learners can interpret the information presented and consider the appropriate tools, equipment and machinery required to create the components. Learners can then consider the operational requirements and processes that will deliver the component in the engineering information.

<b>Unit level:</b>	Level 2
<b>GLH:</b>	50
<b>Unit aim:</b>	Learners will understand fault diagnostic methods and develop knowledge and understanding of how basic measuring systems and instrumentation to maintain plant and equipment are used.

## Learning outcome

The learner will:

1. Understand fault diagnostic methods

## Assessment criteria

The learner can:

- 1.1 Describe diagnostic methods used for fault finding
- 1.2 Describe diagnostic aids used in fault finding

## Range

### AC1.1 Methods

- Sensory information: sight, sound, smell, touch
- Fault report
- Measurement
- Movement
- Alignment checks
- Instrumentation readings
- Fault location techniques: half-split, input-to-output, function testing, unit substitution, equipment self-diagnostics

### AC1.2 Diagnostic aids

- Manuals
- Flow charts
- Troubleshooting guides
- Maintenance records
- Manufacturers maintenance logs
- Operator experience
- Previous repairs log

- model predictions

---

### Learning outcome

The learner will:

2. Understand measuring systems and instrumentation

### Assessment criteria

The learner can:

- 2.1 Describe how measuring equipment is used for maintenance operations
- 2.2 Identify instrumentation used in maintenance

---

### Range

#### AC2.1 Measuring equipment

- Rules, tapes
- Thermal imager
- Vibration tester
- Insulation resistance tests
- Digital multimeter/clamp meter
- Callipers: Vernier, digital
- Micrometer
- Feeler gauge
- Bore / depth gauge
- Dial test indicator (DTI)
- Deflection gauges

#### AC2.2 Basic instrumentation

- Sensors
- Gauges
- Instrument diagnostics
- Data loggers
- Diagnostic analysis

---

### Learning outcome

The learner will:

3. Understand how plant and equipment is maintained

## Assessment criteria

The learner can:

- 3.1 Explain preparation required for maintenance operations
- 3.2 Describe safe use of tools
- 3.3 Describe joining and bonding processes used in maintenance operations
- 3.4 Describe dismantling and reassembly methods

---

## Range

### AC3.1 Maintenance operations preparation

- Risk assessment
- Permit to work obtained
- Method statements
- Ensure production ceased
- If required cleaning of machinery
- Isolation of equipment from power sources
- Barriers
- Safety locking padlocks
- Removal of guarding

### AC3.2 Safe use of tools

- Inspection of tools before maintenance work
- Sourcing tools for specific operations

### AC3.3 Joining and bonding processes

- Splicing into cables
- Replacement of cables by joining techniques
- Replacement of pipework systems e.g. fixed or flexible
- Joining techniques used in maintenance e.g. welding, soldering, brazing, adhesives

### AC3.4 Dismantling and reassembly

- Removal of access panels to reach parts and components
- Removal of mechanical locking and securing mechanisms
- Release of any stored energy or substances
- Replacement of life limited parts
- Proof marking and appropriate storage of parts as they are removed
- Cleaning or refurbishment of removed parts
- Reporting the activities that were carried out

# **Unit 225                      Engineering Maintenance Techniques**

## **Supporting Information**

### ***Unit guidance***

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

It is recommended that learning is based on engineering information such as engineering drawings and specifications from which learners can interpret the information presented and consider the appropriate tools, equipment and machinery required to create the components. Learners can then consider the operational requirements and processes that will deliver the component in the engineering information.

<b>Unit level:</b>	Level 2
<b>GLH:</b>	50
<b>Unit aim:</b>	In this unit learners will understand different maintenance methods and the techniques. They will understand the considerations required during planning to ensure effective planned maintenance activities that minimise the impact on production.

---

### Learning outcome

The learner will:

- 1 Understand different types of planned maintenance

### Assessment criteria

The learner can:

- 1.1 Describe different types of planned maintenance
- 1.2 Explain the importance of planned preventative maintenance
- 1.3 Describe sources of data used in condition based monitoring

---

### Range

AC1.1 Types of maintenance

- Planned preventative maintenance
- Total productive maintenance (TPM)
- Condition based monitoring
- Cyclical maintenance
- Reactive maintenance

AC1.2 Importance of planned maintenance to

- Reduce downtime
- Maintain production
- Ensure maintenance completed within a fixed period
- Reduce accidents
- Reduce maintenance costs

### AC1.3 Sources of data

- Temperature sensors
  - Sound sensors
  - Pressure sensors
  - Smart technology
  - Visual inspection/operator feedback
- 

### Learning outcome

The learner will:

- 2 Understand health and safety requirements for planning maintenance activities

### Assessment criteria

The learner can:

- 2.1 Describe the purpose of a risk assessment for a maintenance activity
  - 2.2 Identify legislation relevant to planning maintenance activities
- 

### Range

#### AC2.1 Risk assessment

- Identification of hazards
- Evaluation of risk: severity, likelihood, people affected, risk rating
- Recommendation of control measures
- Permit to work

#### AC2.2 Legislation

- Health and Safety at Work Act (HASAWA)
  - Provision and Use of Work Equipment Regulations (PUWER)
  - Personal Protective Equipment Regulations (PPE)
  - Lifting Operations and Lifting Equipment Regulations (LOLER)
  - Control of Substances Hazardous to Health (COSHH)
  - Working at heights regulations
  - Pressure vessels regulations
  - Electrical regulations
- 

### Learning outcome

The learner will:

- 3 Understand the planning of maintenance activities
-

## Assessment criteria

The learner can:

- 3.1 Explain the considerations when planning for maintenance activities
- 3.2 Explain the planning process for maintenance activities
- 3.3 Describe types of resources required for planned maintenance

---

## Range

### AC3.1 Considerations when planning

- Effect on production schedules including planned shutdown, periodic servicing
- Health & Safety requirements including implications for adjacent working areas
- Lead time to procure resources
- Availability of specialist equipment
- Availability of staff including holiday approvals, specialist contractors where required
- Sources of information: (manufacturers' manuals, data sheets, technical drawings)

### AC3.2 Planning process

- Identify sequence of operations required
- Development of method statement
- Contingency planning for delays such as unplanned reactive maintenance
- Methods of monitoring maintenance progress including use of Gantt charts

### AC3.3 Resource requirements

- Fluids: lubricants including oils and greases, coolants
- Consumables: filters, bearings, fuses
- Lifer items: high tensile bolts and washers, nylon insert nuts, locking devices, split pins, seals and gaskets

# **Unit 226                      Engineering Maintenance Planning**

## **Supporting Information**

### ***Unit guidance***

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

<b>Unit level:</b>	Level 2
<b>GLH:</b>	60
<b>Unit aim:</b>	<p>When designing a product, the material that it is to be made from is selected based on the properties needed for the application. Sometimes it is necessary to modify the properties of the material to meet these needs. Further, when designing a product and selecting the material, consideration has to be given to how the product could fail.</p> <p>In this unit learners will come to understand the properties of materials and how these are measured. They will also understand how the properties of a material can be changed and how materials fail.</p>

## Learning outcome

The learner will:

- 1 Understand the properties of materials

## Assessment criteria

The learner can:

- 1.1 Explain the difference between mechanical and physical properties
- 1.2 Describe the relative mechanical properties, physical properties, sustainability and applications of a range of materials
- 1.3 Describe how the mechanical properties of materials are measured
- 1.4 Explain the typical characteristics shown on a load-extension graph during the tensile testing of different types of materials

---

## Range

AC1.1- AC1.2

Mechanical properties

- Tensile strength
- Hardness
- Toughness
- Elasticity

- Plasticity
- Ductility
- Malleability

#### Physical properties

- Density
- Melting point
- Thermal and electrical conductivity
- Corrosion resistance
- Ability to be recycled

#### AC1.2 Materials

- Ferrous metals: cast iron; low carbon steel (<0.30 % carbon); medium carbon steel (0.3-0.7 % carbon); high carbon steel (0.7-1.4 % carbon); stainless steel
- Non-ferrous metals: aluminium and its alloys; copper and its alloys; zinc; nickel
- Thermoplastic polymers: high impact polystyrene (HIPS); polypropylene (PP); acrylonitrile-butadiene-styrene (ABS); acrylic (PMMA); polycarbonates
- Thermosetting polymers: melamine formaldehyde; urea formaldehyde; epoxy resin; polyester resin
- Elastomers: rubber; neoprene
- Engineering ceramics: silicon carbide; concrete
- Composites: glass reinforced plastics (GRP/fibreglass); carbon reinforced plastics (CRP)
- Smart materials: shape memory alloys (SMA), quantum tunnelling composite (QTC), thermochromic materials, photochromic materials

#### AC1.3 Measuring methods

- Tensile testing
- Toughness testing
- Hardness testing

#### AC1.4 Material types

- Ferrous metals
- Non-ferrous metals
- Ceramic
- Composite
- Thermosetting and thermoplastic polymers

#### Characteristics:

- Yield strength/yield point
- Ultimate tensile strength
- Elongation
- Necking
- Fracture

---

## Learning outcome

The learner will:

- 2 Understand methods by which the properties of materials can be changed

## Assessment criteria

The learner can:

- 2.1 Explain the effect of cold working on the mechanical properties of materials
- 2.2 Explain how heat treatment affects the microstructure and properties of metals

---

## Range

AC2.1 Effect of cold working

- Changes in mechanical properties caused by changes in the lattice structure and dislocation movement

AC2.2 Heat treatments

- Case hardening
- Quench hardening
- Tempering
- Normalising
- Annealing
- Precipitation hardening

Influences on the microstructure

- Grain size
- Compositional change
- Phase transformations in steel
- Formation of precipitates

---

## Learning outcome

The learner will:

- 3 Understand failure mechanisms in materials

## Assessment criteria

The learner can:

- 3.1 State the type of process that causes corrosion
- 3.2 Explain how corrosion can cause the failure of a metal part
- 3.3 Explain methods that can be used to manage corrosion in ferrous metals
- 3.4 Explain the causes of fatigue in metals and how the risk of this can be reduced
- 3.5 Explain the causes of material failure due to creep and how the risk of this can be reduced

---

## Range

### AC3.1 Corrosion

- Oxidation of metals: including rusting of ferrous metals
- Formation of surface film of oxide on non-ferrous metals

### AC3.2 Effect of corrosion

- Consumption of material
- Reduction in effective thickness leading to increased stress

### AC3.3 Metals

- Cast iron
- Low, medium and high carbon steel

#### Methods

- Painting
- Plastic coating
- Galvanising
- Electrolytic (galvanic) protection

### AC3.4 Causes of fatigue

- Cyclic loading below the yield stress
- Progressive crack growth
- Influence of stress raisers

### AC3.5 Material fail due to creep

- Three stages of creep
- Influence of temperature and load

# **Unit 227                      Engineering Materials**

## **Supporting Information**

### ***Unit guidance***

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

## Unit 228

# Electrical Installation Methods, Wiring and Circuit Protection

<b>Unit level:</b>	Level 2
<b>GLH:</b>	50
<b>Unit aim:</b>	This unit will provide knowledge and understanding required to install electrical wiring systems and circuits in a domestic or commercial environment. It covers the main principles of circuit wiring, installation and wiring methods and the applications of circuit protection devices.

---

### Learning outcome

The learner will:

- 1 Understand the principles of electrical circuit wiring

### Assessment criteria

The learner can:

- 1.1 State the regulations that apply to electrical installation
- 1.2 Describe the characteristics and applications of cable types
- 1.3 Explain the purpose of documentation required for electrical installations

---

### Range

#### AC1.1 Regulations

- IET (Institution of Engineering and Technology) wiring regulations
- The Electricity at Work Regulations

#### AC1.2 Cable types

- Single core
- Multicore
- Armoured
- Fire resistant

#### AC1.3 Documentation

- Risk assessments
- Method statements
- Permit to work

- Circuit diagrams
  - Wiring diagrams
  - Manufacturers' data sheets
- 

### Learning outcome

The learner will:

- 2 Know electrical installation and wiring methods

### Assessment criteria

The learner can:

- 2.1 Describe the methods used to install electrical circuits, cables and wiring systems
  - 2.2 Describe the tools and equipment used in electrical installations and their purpose
  - 2.3 Describe cable termination methods
- 

### Range

#### AC2.1 Electrical circuits

- Lighting circuits
  - 1-way
  - 2-way
  - intermediate
- Power circuits
  - ring final
  - radial
- Control circuits
- Socket outlet circuits

#### Wiring systems

- Conduit
- Trunking
- Cable tray
- Basket

#### AC2.2 Tools and equipment

- Screwdrivers
- Pliers
- Side cutters
- Drills
- Stripping tools
- Soldering irons
- Power tools

#### AC2.3 Cable termination methods including

- Crimp/compression connections
  - Screw terminals
  - Soldered connections
-

- Cable clamps
  - Cable clips
- 

### Learning outcome

The learner will:

- 3 Understand the applications of electrical circuit protection devices

### Assessment criteria

The learner can:

- 3.1 Explain the purpose and applications of circuit protection devices
  - 3.2 Explain the factors that affect the selection of circuit protection devices.
- 

### Range

AC3.1 Circuit protection devices

- Fuse
- Circuit breaker
- RCD

AC3.2 Factors

- Wire and circuit protection device ratings
  - Fuse blow point
  - Circuit breaker trip value
  - Effects of current heating
-

## **Unit 228**

# **Electrical Installation Methods, Wiring and Circuit Protection**

## Supporting Information

### ***Unit guidance***

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

## Unit 229

# Electrical Circuit Inspection, Testing and Fault Diagnosis

<b>Unit level:</b>	Level 2
<b>GLH:</b>	50
<b>Unit aim:</b>	This unit will provide the knowledge and understanding required to inspect, test and diagnose faults in electrical circuits. It covers safe isolation procedures, methods of inspecting and testing circuits, the symptoms and causes of typical faults and the relevant standards and guidance.

### Learning outcome

The learner will:

- 1 Understand safe electrical isolation procedures

### Assessment criteria

The learner can:

- 1.1 Explain the dangers of electricity and mains voltage
- 1.2 Explain the need to safely isolate circuits
- 1.3 Describe the methods used to safely isolate circuits

### Range

#### AC1.1 Dangers

- Electric shock
  - Burns
  - Muscle damage
  - Neurological damage
  - Heart stoppage
  - Electrocution/death
- Fire
- Arc flash

#### AC1.3 Methods

- Lock out processes
- Use of isolation devices

---

## Learning outcome

The learner will:

- 2 Understand methods of inspecting, testing and fault-finding electrical circuits

## Assessment criteria

The learner can:

- 2.1 Describe preparatory activities required prior to testing electrical circuits
- 2.2 Describe methods of testing electrical circuits
- 2.3 Explain the symptoms and causes of typical faults in electrical circuits
- 2.4 Describe fault diagnosis techniques.

---

## Range

### AC2.1 Preparatory activities

- Safety checks
- Test instrument calibration checks
- Setting up of test instruments
- Removal of equipment covers / casings
- Mains supply isolation
- Cleaning of modules/components

### AC2.2 Electrical circuits including

- Lighting circuits
- Socket outlet circuits

### Test methods

- Use of measuring instruments
  - Multimeter
  - Continuity tester
  - Oscilloscope
  - Insulation resistance tester
  - Signal generator
- Visual inspection

### AC2.3 Typical faults

- Damaged, faulty or deteriorated circuit parts
- Short circuits
- Ground faults
- Arcing

### AC2.4 Fault diagnosis techniques

- Input to output checks
- Half split method
- Injection and sampling
- Component/unit substitution

- Functional testing
  - Flow charts
- 

### Learning outcome

The learner will:

- 3 Know standards and guidance relating to electrical testing and fault diagnosis

### Assessment criteria

The learner can:

- 3.1 State the regulations and requirements that apply to electrical testing and fault diagnosis
  - 3.2 Describe the markers/labels used to identify wiring and cables
- 

### Range

AC3.1 Regulations and requirements

- IET wiring regulations
- The Electricity at Work Regulations
- HSE guidance: (Safety in electrical testing at work, HSG85 Electricity at work safe working practices)

AC3.2 Markers/labels including

- Wiring/cable colour coding
  - Coded tabs
-

## **Unit 229**

# **Electrical Circuit Inspection, Testing and Fault Diagnosis**

## Supporting Information

### ***Unit guidance***

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

## Unit 230

# Building Services Engineering Pipework Fixing, Bending and Jointing Methods

<b>Unit level:</b>	Level 2
<b>GLH:</b>	50
<b>Unit Aim</b>	This unit introduces knowledge supporting the installation of pipework systems for water. Learners will develop initial understanding of the materials used to make water pipes, and how pipes are bent into shape, joined together and fixed to the fabric of the building. They will also learn about how pipework is tested.

### Learning outcome

The learner will:

- 1 Understand the materials used in domestic pipework applications

### Assessment criteria

The learner can:

- 1.1 State the materials used for domestic pipework applications
- 1.2 Explain the typical applications of pipes made from different materials

---

### Range

AC1.1-1.2 Materials

- Copper: R220 / soft (annealed), R250 / half hard, R290 / hard
- Plastics: acrylonitrile butadiene styrene (ABS), polyethylene (MDPE), polybutylene, polyvinyl chloride (PVC-u, MuPVC), polypropylene (PP).

AC1.2 Types of application

- Hot water supply
- Cold water supply
- Heating systems
- Sanitary pipework

### Learning outcome

The learner will:

- 2 Understand methods of bending pipework

## Assessment criteria

The learner can:

- 2.1 Calculate dimensions and measurements from scaled drawings and diagrams
  - 2.2 Describe methods of producing different types of bends in copper pipes
  - 2.3 Explain techniques used to determine and achieve bend dimensions when using different methods
  - 2.4 Describe methods of bending plastic pipework
- 

## Range

AC2.2-2.3 Types of bend

- 90° bends
- Offset bends

Bending methods

- Hand vice
- Spring bending
- Pipe bender/bending machine
- Use of heat, if required

AC2.3 Techniques

- Distribution of applied force
  - Use of heat
  - Use of templates or jigs
- 

## Learning outcome

The learner will:

- 3 Understand methods of joining pipes

## Assessment criteria

The learner can:

- 3.1 Describe methods used to join copper pipes
  - 3.2 Explain the advantages and disadvantages of the different joining methods used with copper pipes
  - 3.3 Describe fittings used with plastic pipework and their applications
  - 3.4 Describe methods of installing fittings used with plastic pipework
  - 3.5 Describe methods of checking that fittings are sufficiently tight prior to testing
  - 3.6 Identify faults in fittings
- 

## Range

AC3.1, 3.2 Joining methods

---

Types of fitting (including methods of installation)

- Compression: manipulative and non-manipulative, type A and B.
- Capillary: integral and end feed
- Push fit

Thermal joining

- Soldering
- Brazing

AC3.2 Advantages and disadvantages related to:

- Joint integrity
- Joint stability/life
- Need to create a thread
- Use of heat
- Influence on flow characteristics

AC3.3 Types of fitting

- Push fit
- Compression
- Proprietary
- Ring seal
- Solvent welded

---

## Learning outcome

The learner will:

4 Understand methods of fixing pipework to the fabric of a building

## Assessment criteria

The learner can:

- 4.1 Describe fixing devices and their applications
- 4.2 Identify the tools and equipment required to install basic pipework systems
- 4.3 Describe methods of preparing building construction features for the installation of pipework systems
- 4.4 Describe methods of allowing for thermal movement of pipework
- 4.5 Describe methods of marking out for horizontal and vertical clips for copper pipework
- 4.6 Describe methods of fixing clips and brackets
- 4.7 Explain safety considerations when drilling and fixing clips and brackets
- 4.8 Describe methods of restoring the fabric of the building after installation, where required.

---

## Range

AC4.1 Fixing devices

- Clips: horizontal and vertical
- Brackets
- Screws: slotted head, phillips head, pozidrive
- Plastic plugs (for use with screws)
- Coach bolts
- Rawl bolts
- Nails

AC4.7 Considerations to include:

- Use of personal protective equipment (PPE): safety goggles, safety shoes
- Working at heights
- Electrical safety

---

### Learning outcome

The learner will:

- 5 Understand methods of testing domestic pipework

### Assessment criteria

The learner can:

- 5.1 Explain the importance of a visual inspection being carried out prior to filling a pipework system with water
- 5.2 Describe the British standard soundness test
- 5.3 Describe the method used to test a pipework for tightness
- 5.4 Describe the equipment used for pressure testing
- 5.5 Describe the method used to carry out a pressure test on pipework
- 5.6 Explain the actions to be taken if pipework fails a test
- 5.7 Explain how water pressure and flow rate is measured and recorded
- 5.8 Describe the typical water pressures required for domestic premises and problems arising from low water pressure
- 5.9 Explain safety considerations when testing pipework

## Unit 230

# Building Services Engineering Pipework Fixing, Bending and Jointing Methods

## Supporting Information

### ***Unit guidance***

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

#### Learning Outcome 5 AC5.2

The soundness test is as specified in BS 6700 Design, installation, testing and maintenance of services supplying water for domestic use within buildings and their curtilages.

## Unit 231

# Building services engineering pipework fabrication processes and techniques

<b>Unit level:</b>	Level 2
<b>GLH:</b>	50
<b>Unit Aim</b>	This unit will provide knowledge and understanding of engineering pipework fabrication processes and techniques. It covers pipework fabrication and installation methods, methods of supporting domestic pipework and pipework testing methods.

### Learning outcome

The learner will:

- 1 Understand pipework fabrication and installation methods

### Assessment criteria

The learner can:

- 1.1 Describe the purpose and applications of tools used in pipework fabrication and installation
- 1.2 Describe materials used for pipework applications and their typical sizes
- 1.3 Describe functions and applications of pipework fittings
- 1.4 Describe methods of jointing copper pipework
- 1.5 Describe methods of jointing low carbon steel pipework
- 1.6 Describe methods of jointing plastic pipework for different applications
- 1.7 Describe methods of bending pipework made from different materials
- 1.8 Describe methods of preparing construction features for pipework installation

---

### Range

AC1.1 Tools:

- Power tools
  - Drills
  - Pipe threading machines
  - Saws (bandsaws, circular saws, jigsaws)
- Hand tools
  - Bending tools
  - Chisels
  - Grips
  - Hammers

- Hand saws
- Hydraulic benders
- Manual pipe threaders
- Pipe cutters
- Pliers
- Pipe freezing kits
- Spanners
- Spirit levels
- Wrenches

#### AC1.2, 1.7 Materials:

- Copper
  - Soft tube (R220)
  - Half hard tubes (R250)
  - Hard copper tubes (R290)
- Plastic
  - Acrylonitrile butadiene styrene (ABS)
  - Polyvinyl Chloride un-plasticised (PVCu)
  - Polypropylene
  - Medium-density polyethylene (MDPE)
  - Polybutylene
  - Modified un-plasticised polyvinyl chloride (MuPVC)
- Low carbon steel

#### AC1.3 Fittings

- General fittings
  - Bends
  - Elbows
  - Manifolds
  - Tees
  - Reducers
  - Tap connectors
  - Flexible connectors
- Copper pipe fittings
  - Push fit
  - Press fit
  - Compression
  - Capillary
- Low carbon steel pipe fittings
  - Compression
  - Threaded

#### AC1.4 Jointing methods

- Push fit
- Press fit
- Compression
- End feed
- Soldered

#### AC1.5 Jointing methods

- Compression
- Threaded

#### AC1.6 Jointing methods

- Push fit
- Compression
- Proprietary
- Ring seal
- Solvent weld

#### Applications

- Hot
- Cold
- Heating
- Sanitary

#### AC1.7 Bending methods

- Hand vice
- Spring bending
- Pipe bender/bending machine
- Use of heat, if required

#### Types of bends

- 90°
- Passover bends
- Sets and offsets

#### AC1.8 Methods including

- Removal and replacement of floor and subfloor
- Making holes in masonry surfaces
- Drilling holes in and notching floor joists
- Cutting chases

### Learning outcome

The learner will:

- 
- 2 Understand methods of supporting domestic pipework

## Assessment criteria

The learner can:

- 2.1 Describe marking out methods for pipework fixings and brackets
- 2.2 Describe the applications of fixing devices
- 2.3 Describe the purpose and applications of clips and brackets
- 2.4 Describe methods of installing fixings and brackets for pipework

---

## Range

### AC2.2 Fixing devices

- Screws
  - Slotted head
  - Phillips head
  - Pozidrive
- Plastic wall plugs
- Timber nails
- Masonry nails
- Heavy duty fixings
  - Rawlbolts
  - Coach bolts
- Specialist fixings
  - Drive in fixings
  - Cavity fixings

### AC2.3 Applications including

- Supporting pipework
- Attaching radiators to walls
- Fitting and securing sanitary appliances

---

## Learning outcome

The learner will:

- 3 Understand methods of testing domestic pipework

## Assessment criteria

The learner can:

- 3.1 Explain the importance of a visual inspection being carried out prior to filling a pipework system with water
- 3.2 Describe the British standard soundness test
- 3.3 Describe the method used to test a pipework for tightness
- 3.4 Describe the equipment used for pressure testing
- 3.5 Describe the method used to carry out a pressure test on pipework

- 3.6 Explain the actions to be taken if pipework fails a test
- 3.7 Explain safety considerations when testing pipework

## Unit 231

# Building services engineering pipework fabrication processes and techniques

## Supporting Information

### ***Unit guidance***

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

#### Learning Outcome 3 AC3.2

The soundness test is as specified in BS 6700 Design, installation, testing and maintenance of services supplying water for domestic use within buildings and their curtilages

## Unit 232

## Building Services Pipework Systems

<b>Unit level:</b>	Level 2
<b>GLH:</b>	50
<b>Unit Aim</b>	This unit introduces types of pipework systems used in domestic applications. Learners will develop an understanding of hot and cold water supply systems, central heating systems and above ground discharge systems for the disposal of waste water. They will also consider environmental issues arising from energy usage for heating and water use in domestic environments.

### Learning outcome

The learner will:

- 1 Understand hot and cold water supply systems used for domestic plumbing

### Assessment criteria

The learner can:

- 1.1 Outline the main requirements of regulations and standards for domestic water supply
- 1.2 Explain the importance of complying with the regulations and standards
- 1.3 Describe the types of water supply systems used for domestic plumbing
- 1.4 Identify the main components in water supply systems
- 1.5 Describe the layouts of different water supply systems
- 1.6 Identify the symbols used to represent components on system layout drawings
- 1.7 Explain the basic operation of water supply systems, including their advantages and disadvantages

### Range

AC1.1, 1.2 Regulations and standards

- Water Supply (Water Fittings) Regulations
- Building Regulations Approved Document G
- BS 8558 Water use in domestic buildings
- BS EN 806 Specifications for installations inside buildings conveying water for human consumption.

AC1.3 -1.5, 1.7 Types of system

- Hot and cold water supply
- Direct and indirect systems

AC1.4, 1.6 Components to include:

- Indirect water system: cistern, boiler, hot water cylinder, valves, taps
- Direct water system: combi-boiler, valves, taps

---

### Learning outcome

The learner will:

2 Understand the principles of central heating systems

### Assessment criteria

The learner can:

- 2.1 Identify the layouts of central heating systems
- 2.2 Describe the operating principles of central heating systems
- 2.3 Explain the difference between traditional and condensing boilers
- 2.4 Explain the operating principles of controls used on central heating systems
- 2.5 Describe methods of attaching radiators and pipework to walls and boards
- 2.6 Describe methods of bending copper pipe to required angles
- 2.7 Describe methods of joining copper pipes together

---

### Range

AC2.1-2.2 Central heating systems

- Open vented systems for heating only: gravity hot water and fully pumped
- Sealed systems for heating only: fully pumped with motorised zone valve
- Combi-boilers for heating and hot water

AC2.4 Controls

- Mechanical
- Electrical

AC2.5 Attaching radiators and pipework

- Marking out
- Drilling
- Use of horizontal and vertical clips
- Use of brackets

AC2.6 Bending methods

- Spring bending
- Pipe bender
- Use of a template or jig
- Use of heat, if required

AC2.7 Joining methods

- Threaded

- Soldered/brazed

---

### Learning outcome

The learner will:

- 3 Understand above ground discharge systems

### Assessment criteria

The learner can:

- 3.1 Identify the layouts of above ground discharge systems
- 3.2 Explain the advantages and disadvantages of different system types
- 3.3 Explain system design considerations
- 3.4 Explain the causes of issues that can occur in discharge systems and how these can be avoided
- 3.5 Describe the air test used for sanitary pipework including consideration of parameters

---

### Range

AC3.1, 3.2 Discharge systems

- Ventilated
- Unventilated

AC3.3 Design considerations

- Maximum run lengths and gradients of pipes
- Minimum distances from the invert level of the drain to the lowest appliances
- Sizes of soil and waste branch discharge pipes
- Minimum diameter for a discharge stack (75 mm)
- Reductions in stack diameter possible for urinals/waste appliances
- The outcomes of using undersize pipework
- The difference between a socket bend and a long radius bend
- Reasons that bends/offsets should not be used in the wetted section of the stack

AC3.4 Issues

- Hydraulic jump
- Crossflow
- Trap seal loss through self and induced siphonage

AC3.5 Test parameters

- Duration
- Maximum pressure during testing

---

### Learning outcome

The learner will:

- 4 Understand energy and environmental issues arising from heating and water usage

## Assessment criteria

The learner can:

- 4.1 Explain the importance of energy conservation in the home
- 4.2 Describe sources of heat losses from domestic buildings
- 4.3 Identify methods of conserving energy in the home
- 4.4 Describe common insulation methods for buildings
- 4.5 Explain the importance of conserving water
- 4.6 Describe ways to minimise water usage

---

## Range

AC4.2 Sources of heat losses

- Ventilation
- Conduction

AC4.3 Methods of energy conservation

- Heating only occupied areas
- Heating water only when it is required
- Using energy efficient appliances
- Insulation
- Use of heat pumps (water, air, ground source)
- Conversion of waste to energy (biomass)
- Solar panels for water heating and electricity generation

AC4.4 Insulation methods

- Blanket insulation
- Cavity wall (spray foam)
- Foam board
- Double glazing

AC4.6 Minimise water usage

- Eliminate unnecessary use
- Repurposing of waste water
- Use of high efficiency domestic appliances

# **Unit 232                      Building Services Pipework Systems**

## Supporting Information

### ***Unit guidance***

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

## Unit 233

# Building services engineering systems and their layout requirements

<b>Unit level:</b>	Level 2
<b>GLH:</b>	50
<b>Unit Aim</b>	This unit will provide knowledge and understanding of the systems associated with plumbing in building services and their layout requirements. It covers the types of cold and hot water systems used in domestic buildings, the principles of central heating systems, types of sanitary pipework systems and sources of energy used in the building services industry.

### Learning outcome

The learner will:

1. Understand types of cold water systems used in domestic buildings

### Assessment criteria

The learner can:

- 1.1 Outline the main requirements of current regulations and standards for domestic water supply
- 1.2 Explain the importance of complying with the regulations and standards
- 1.3 Describe the requirements of the pipework system between the water main and the main internal stop valve in a domestic building
- 1.4 Explain the importance of correct water pressure
- 1.5 Describe the types of cold water systems used in domestic plumbing and their benefits/limitations
- 1.6 Interpret layout diagrams of cold water systems
- 1.7 Explain the causes of backflow in cold water systems

### Range

AC1.3 Pipework system:

- Connection to the main
- Communication pipe
- Service pipe
- Main external stop valve
- Meter and meter housing
- Below ground level pipework

AC1.5, 1.6 Types of systems

- Direct
- Indirect

### Learning outcome

The learner will:

- 2 Understand types of hot water systems used in domestic buildings

### Assessment criteria

The learner can:

- 2.1 Explain the factors that affect the selection of hot water systems
- 2.2 Describe the types of hot water systems used in domestic plumbing and their benefits/limitations
- 2.3 Interpret layout diagrams of hot water systems
- 2.4 Describe the purpose of pipes used in open vented hot water systems
- 2.5 Explain the causes of backflow in hot water systems

---

### Range

AC2.1 Factors:

- Type of building or property
- Amount of hot water needed
- Distance from hot water source to outlet
- Whether or not a secondary recirculation system is needed
- Safety issues
- Regulations and standards
- Guidance and instructions from manufacturers

AC2.2, 2.3 Types of systems

- Direct
  - Conventional boiler
  - Immersion heater
- Indirect
- Instantaneous water heaters
  - Combination boilers
  - Multipoint heaters
- Vented heaters

AC2.4 Pipes

- Vent pipe
- Cold feed pipe

---

## Learning outcome

The learner will:

- 3 Understand the principles of central heating systems

## Assessment criteria

The learner can:

- 3.1 Identify the layouts of central heating systems  
3.2 Describe the operation of central heating systems  
3.3 Describe the operation and requirements of gas-fired boilers  
3.4 Describe the operation of flues

---

## Range

AC3.1-3.2 Central heating systems

- Open vented systems
  - Gravity fed
  - Fully pumped
- Sealed systems
  - Fully pumped
  - Combination boilers

AC3.3-3.4 Boilers

- Combi
- Condensing
- System

---

## Learning outcome

The learner will:

- 4 Understand types of sanitary pipework systems

## Assessment criteria

The learner can:

- 4.1 Describe the operation and applications of sanitary pipework systems  
4.2 Explain the implications of trap seal loss  
4.3 Describe the system layout features for the wet portion of the discharge stacks  
4.4 Describe the system layout features for branch discharge pipework

---

## Range

AC4.1 Types of system

- Ventilated stack systems
  - Primary
  - Secondary
- Ventilated branch discharge system

#### AC4.3 System layout features

- Size of soil stacks
- Size of waste stacks
- Type and location of bends
- Proximity of low level connections
- Minimum distances from the invert level of the drain to the lowest appliances

#### AC4.4 System layout features

- Maximum lengths and gradients of pipes
- Sizes of soil and waste branch discharge pipes
- Use of traps and self-sealing valves
- Ventilation of branch discharge pipes
- Connection of multiple waste appliances to branch discharge pipes
- Connection of branch discharge pipes into the main stack

---

### Learning outcome

The learner will:

- 5 Understand energy sources used in the building services industry

### Assessment criteria

The learner can:

- 5.1 Describe types of energy sources  
5.2 Explain the benefits and limitations of low and zero carbon energy sources

---

### Range

#### AC5.1 Energy sources

- High carbon
  - Electricity generated from non-renewable sources
- Low carbon
  - Biomass
  - Fuel cells
  - Heat pumps
- Zero carbon
  - Solar (thermal, photovoltaic)
  - Wind
  - Hydroelectric

- Tidal

## Unit 233

# Building services engineering systems and their layout requirements

## Supporting Information

### ***Unit guidance***

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

#### Learning Outcome 1 AC1.1

Learners should know the main requirements of current regulations and standards for domestic water supply including

- Water Supply Regulations
- BS 8558 Water use in domestic buildings
- BS EN 806 Specifications for installations inside buildings conveying water for human consumption.

## Unit 234

# Installation and Servicing of Refrigeration Equipment

<b>Unit level:</b>	Level 2
<b>GLH:</b>	60
<b>Unit Aim</b>	This unit introduces knowledge specific to the refrigeration, air-conditioning and heat pump systems (RACHP) sector, focusing on refrigeration. Learners will develop an understanding of some of the key principles underlying refrigeration, the system controls, how refrigeration systems are installed (including safety considerations), and how refrigeration systems are serviced.

### Learning outcome

The learner will:

- 1 Understand the principles of thermodynamics

### Assessment criteria

The learner can

- 1.1 Convert values between temperature scales
- 1.2 Define the laws of thermodynamics
- 1.3 Describe the concept of heat as energy in transition
- 1.4 Describe how heat is transferred
- 1.5 Describe latent heat processes
- 1.6 Describe sensible heat processes
- 1.7 Calculate the rate of heat transfer
- 1.8 Explain the implications of the ideal gas laws
- 1.9 Describe the impact of changing pressures on saturation temperatures for different substances
- 1.10 Explain the vapour compression cycle in single stage refrigeration
- 1.11 Determine variables using a pressure-enthalpy diagram

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### Range

AC1.1 Temperature scales

- Celsius
- Kelvin

AC1.2 Laws of thermodynamics

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- First law
- Second law

#### AC1.4 Heat transfer mechanisms

- Conduction
- Convection
- Radiation

#### AC1.5 Latent heat processes

- Melting (fusion)
- Freezing
- Sublimation
- Condensation
- Evaporation
- Boiling

#### AC1.6 Sensible heat processes

- Super heating
- Sub-cooling
- Cooling
- Heating

#### AC1.7 Calculations

- $Q = mCt$
- $Q = mL$
- $Q/s = W$

#### AC1.8 Ideal gas laws

- Boyle's law
- Charles' law
- Combined gas law

#### AC1.9 Range of substances

- Water
- Refrigerants

#### AC1.10 Refrigeration cycle

Functions of the compressor, condenser, expansion device, and evaporator

#### AC1.11 Variables

- Work done
- Refrigeration effect
- Total heat rejected
- Coefficient of performance
- Mass flow rate

- Pressure ratio
- Compressor power input
- Specific volume at suction
- Cooling capacity
- Heating capacity

---

### Learning outcome

The learner will:

2 Understand the operating principles and controls for refrigeration systems

### Assessment criteria

The learner can:

- 2.1 Describe the operating principles of refrigeration systems and their application
- 2.2 Describe the range of refrigeration systems in common use
- 2.3 Describe the operating principles of the system controls
- 2.4 Describe the operating principles for defrost systems
- 2.5 Describe control circuits used for refrigeration systems

---

### Range

AC2.1 Operating principles

- Temperature difference
- Defrost methods
- System controls
- 1st and 2nd law of thermodynamics

Applications

- Blast freezing
- Cold storage
- Chill storage
- Liquid chillers

AC2.2 Types of refrigeration system

- Domestic
- Commercial
- Industrial

AC2.3 Operating principles

- Electro-mechanical
- Electrical

Controls

- Pressure

- Temperature
- Time

#### AC2.4 Defrost systems

- Off cycle
- Electric
- Hot gas
- Saturated gas

---

### Learning outcome

The learner will:

3 Understand the principles of installing refrigeration systems

### Assessment criteria

The learner can:

- 3.1 Describe the information required to plan the activities
- 3.2 Describe the roles and responsibilities of persons involved in installation
- 3.3 Explain the safety considerations required for the installation
- 3.4 Identify the services required for the installation
- 3.5 Describe the methods used to form and join pipework
- 3.6 Describe methods of applying insulation to pipework systems
- 3.7 Describe methods of fixing and terminating different types of cabling
- 3.8 Identify test instruments and state their purpose
- 3.9 Describe how installation activities are documented

---

### Range

#### AC3.1 Required information

- Regulatory documents
- Industry codes of practice
- Manufacturers' instructions
- Installation specifications
- Design drawings for the installation

#### AC3.2 Roles

- Self
- Colleagues
- Supervisor
- Client
- General public
- Health and safety officer

#### AC3.3 Safety considerations

- Risk assessment: hazards, risks, control measures

- Method statement
- Permit to work
- Safe isolation of equipment
- Ventilation
- Personal protective equipment (PPE)

#### AC3.4 Services

- Electricity
- Water
- Drainage
- Ventilation
- Gas

#### AC3.5 Methods of forming pipework

- Bend
- Flare
- Swage

#### Methods of joining pipework

- Brazing
- Mechanical and compression joints

#### AC3.6 Methods of insulating pipework

- Pre-insulated
- Cut and glue
- Continuous
- Mitred
- Insulated tape

#### AC3.7 Types of cabling

- Multi-core flex
- Steel wire armoured
- Single conductor
- Twin and earth
- Braided sheath cable
- Screened

#### Termination methods

- Insulated crimps
- Non-insulated crimps

#### AC3.8 Test instruments

- Pressure gauges
- Service manifolds
- Thermometers

- Anemometers
- Sling psychrometers
- Hydrometers
- Scales
- Leak detectors
- Multimeter
- Ammeter
- Voltmeter
- Ohm meter
- Capacitance tester
- Eyes/visual inspection

#### AC3.9 Documentation

- Job sheet/card
- Commissioning sheet
- F gas records

### Learning outcome

The learner will:

- 4 Understand the principles of maintaining and servicing refrigeration systems

### Assessment criteria

The learner can:

- 4.1 Describe maintenance requirements for refrigeration systems
- 4.2 Identify sources of information which aid service and maintenance of refrigeration systems
- 4.3 Identify faults resulting from the failure of components and their symptoms
- 4.4 Describe how maintenance and servicing activities are reported

### Range

#### AC4.1 Maintenance requirements

- Preventative maintenance: cleaning, component replacement, leak testing, visual inspection
- Servicing: cleaning, component replacement, calibration, adjustment, testing
- Reactive maintenance

#### AC4.2 Sources of information

- Service reports and test certificates
- Operations manuals
- Log books
- Customer feedback
- Sensory data

#### AC4.3 Components:

- Compressors
- Condensers
- Evaporators
- Expansion devices
- Storage vessels
- Valves
- Fans
- Ancillary components: line driers, strainers, oil separators

## **Unit 234**

# **Installation and Servicing of Refrigeration Equipment**

## Supporting Information

### ***Unit guidance***

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

## Unit 235

# Installation and Servicing of Air-Conditioning Equipment

<b>Unit level:</b>	Level 2
<b>GLH:</b>	60
<b>Unit Aim</b>	This unit introduces knowledge specific to the refrigeration, air-conditioning and heat pump systems (RACHP) sector, focusing on air conditioning. Learners will develop an understanding of some of the key principles underlying air-conditioning, the system controls, how air-conditioning systems are installed (including safety considerations), and how air-conditioning systems are serviced.

### Learning outcome

The learner will:

- 1 Understand the principles of thermodynamics

### Assessment criteria

The learner can:

- 1.1 Convert values between temperature scales
- 1.2 Define the laws of thermodynamics
- 1.3 Describe the concept of heat as energy in transition
- 1.4 Describe how heat is transferred
- 1.5 Describe latent heat processes
- 1.6 Describe sensible heat processes
- 1.7 Calculate the rate of heat transfer
- 1.8 Explain the implications of the ideal gas laws
- 1.9 Describe the impact of changing pressures on saturation temperatures for different substances
- 1.10 Explain the vapour compression cycle in single stage refrigeration
- 1.11 Determine variables using a pressure-enthalpy diagram

---

### Range

AC1.1 Temperature scales

- Celsius
- Kelvin

AC1.2 Laws of thermodynamics

- First law
- Second law

#### AC1.4 Heat transfer mechanisms

- Conduction
- Convection
- Radiation

#### AC1.5 Latent heat processes

- Melting (fusion)
- Freezing
- Sublimation
- Condensation
- Evaporation
- Boiling

#### AC1.6 Sensible heat processes

- Super heating
- Sub-cooling
- Cooling
- Heating

#### AC1.7 Calculations

- $Q = mCt$
- $Q = mL$
- $Q/s = W$

#### AC1.8 Gas laws

- Boyle's law
- Charles' law
- Combined gas law

#### AC1.9 substances

- Water
- Refrigerants

#### AC1.10 Refrigeration cycle

Functions of the compressor, condenser, expansion device, and evaporator.

#### AC1.11 Variables

- Work done
- Refrigeration effect
- Total heat rejected
- Coefficient of performance
- Mass flow rate

- Pressure ratio
- Compressor power input
- Specific volume at suction
- Cooling capacity
- Heating capacity

---

### Learning outcome

The learner will:

- 2 Understand the operating principles and controls for air-conditioning systems

### Assessment criteria

The learner can:

- 2.1 Describe the operating principles of air-conditioning systems and their application
- 2.2 Describe the range of air conditioning systems in common use
- 2.3 Describe the effect of air conditioning on its moisture content
- 2.4 Describe the operating principles of the system controls
- 2.5 Describe control circuits used for air-conditioning systems

---

### Range

#### AC2.1 Operating principles

- Temperature difference
- Airflow
- System controls
- 1st and 2nd law of thermodynamics

#### Applications

- Air conditioning
- Dehumidifiers

#### AC2.2 Systems

- Human comfort cooling/heating
- Close control
- Data system cooling
- De-humidification

#### AC2.4 Operating principles

- Electro-mechanical
- Electrical

#### Controls

- Pressure
- Temperature (for cooling, for heating)

- Time

---

### Learning outcome

The learner will:

- 3 Understand the principles of installing air-conditioning systems

### Assessment criteria

The learner can:

- 3.1 Describe the information required to plan the activities
- 3.2 Describe the roles and responsibilities of persons involved in installation
- 3.3 Explain the safety considerations required for the installation
- 3.4 Identify the services required for the installation
- 3.5 Describe the methods used to form and join pipework
- 3.6 Describe methods of applying insulation to pipework systems
- 3.7 Describe methods of fixing and terminating different types of cabling
- 3.8 Identify test instruments and state their purpose
- 3.9 Describe how installation activities are documented

---

### Range

#### AC3.1 Required information

- Regulatory documents
- Industry codes of practice
- Manufacturers' instructions
- Installation specifications
- Design drawings for the installation

#### AC3.2 Roles

- Self
- Colleagues
- Supervisor
- Client
- General public
- Health and safety officer

#### AC3.3 Safety considerations

- Risk assessment: hazards, risks, control measures
- Method statement
- Permit to work
- Safe isolation of equipment
- Ventilation
- Personal protective equipment (PPE)

#### AC3.4 Services

- Electricity
- Water
- Drainage
- Ventilation
- Gas

#### AC3.5 Methods of forming pipework

- Bend
- Flare
- Swage

#### Methods of joining pipework

- Brazing
- Mechanical and compression joints

#### AC3.6 Methods of insulating pipework

- Pre-insulated
- Cut and glue
- Continuous
- Mitred
- Insulated tape

#### AC3.7 Types of cabling

- Multi-core flex
- Steel wire armoured
- Single conductor
- Twin and earth
- Braided sheath cable
- Screened

#### Termination methods

- Insulated crimps
- Non-insulated crimps

#### AC3.8 Test instruments

- Pressure gauges
- Service manifolds
- Thermometers
- Anemometers
- Sling psychrometers
- Hydrometers
- Scales
- Leak detectors
- Multimeter

- Ammeter
- Voltmeter
- Ohm meter
- Capacitance tester
- Eyes/visual inspection

#### AC3.9 Documentation

- Job sheet/card
- Commissioning sheet
- F gas records

---

### Learning outcome

The learner will:

- 4 Understand the principles of maintaining and servicing air-conditioning systems

### Assessment criteria

The learner can:

- 4.1 Describe maintenance requirements for air-conditioning systems
- 4.2 Identify sources of information which aid service and maintenance of air-conditioning systems
- 4.3 Identify faults resulting from failure of components and their symptoms
- 4.4 Describe how maintenance and servicing activities are reported

---

### Range

#### AC4.1 Maintenance requirements

- Preventative maintenance: cleaning, component replacement, leak testing, visual inspection
- Servicing: cleaning, component replacement, calibration, adjustment, testing
- Reactive maintenance

#### AC4.2 Sources of information

- Service reports and test certificates
- Operations manuals
- Log books
- Customer feedback
- Sensory data

#### AC4.3 Components

- Compressors
- Condensers
- Evaporators
- Expansion devices

- Storage vessels
- Valves
- Fans
- Ancillary components: line driers, strainers, oil separators

## **Unit 235**

# **Installation and Servicing of Air-Conditioning Equipment**

## Supporting Information

### ***Unit guidance***

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

## Unit 236

## Design of Security Systems

<b>Unit level:</b>	Level 2
<b>GLH:</b>	60
<b>Unit Aim</b>	This unit introduces knowledge specific to the design of security systems. Learners will develop an initial understanding of different types of security system, their wiring and transmission paths, the installation of components and how systems are tested.

### Learning outcome

The learner will:

- 1 Understand types of security systems

### Assessment criteria

The learner can:

- 1.1 Describe security systems and their applications
- 1.2 Describe the operating principles of access control systems relating to the functional system elements
- 1.3 Describe the methods used for access control
- 1.4 Describe formats used for detection in alarm systems
- 1.5 Explain the applications of CCTV

### Range

#### AC1.1 Security systems

- Access control
- Intruder alarm
- Hold up alarm
- Closed circuit television (CCTV)
- Fire detection and alarm systems

#### AC1.2 Elements

- Door controller
- Reader interface
- Administration reader
- Administration pc/server

#### AC1.3 Methods of access control

- Proximity

- Smart card
- Magnetic strip
- Bar code
- Biometric types: fingerprint, voice, retina

#### AC1.4 Formats used for detection

- Fixed
- Moveable
- Trap
- Perimeter

#### AC1.5 Applications

- Private property
- Retail business
- Office premises
- Transport authorities
- Public places
- Events
- Perimeter surveillance

---

### Learning outcome

The learner will:

- 2 Understand circuit wiring and transmission paths

### Assessment criteria

The learner can:

- 2.1 Explain the information needed about the site to support system design
- 2.2 Explain the requirement for primary and secondary power supplies
- 2.3 Describe the operation of power supplies
- 2.4 Describe the transmission of power in a security system
- 2.5 Explain the difference between bonding and earthing
- 2.6 State the practical applications of different cable types including limitations on their use
- 2.7 Describe methods for overcoming the problems of induced noise (rfi/emi) in system cables
- 2.8 Explain the advantages and disadvantages of linking system components to the system using different transmission methods
- 2.9 Describe methods for cable fixing and containment

---

### Range

#### AC2.1 Information

- Site survey

- Site/building plans
- Specification documents

#### AC2.3 Power supplies

- Full wave
- Rectification
- Smoothing
- Switched mode
- Constant current

#### AC2.4 Power transmission

- Voltage regulators
- Mains suppression filters
- Safety earth
- Functional earth

#### AC2.6 Cable types

- Thermoplastic or thermosetting insulated (non-sheathed)
- Flat multicore thermoplastic or thermosetting insulated and sheathed
- Mineral insulated copper conductors and sheath
- Multi-core thermoplastic (pvc)
- Data/communication cables
- Pvc single wire armoured
- Co-axial
- Twisted pair
- Fibre optic
- HDMI

#### AC2.7 Methods for overcoming noise

- Cable routing and installation
- Use of shielded cable
- Use of twisted pair cable
- Correctly configured functional earthing
- Avoidance of ground loops

#### AC2.8 Transmission methods

- Direct: hardwired, USB connection
- Ethernet
- Wifi/wireless connection
- Modems (GPRS, PSTN, GSM)
- Radio (RF)
- Integration with smart devices

---

## Learning outcome

The learner will:

- 3 Understand the design considerations of security systems

## Assessment criteria

The learner can:

- 3.1 State the basic principles of shock protection, circuit overload and short-circuit protection
- 3.2 State the function of circuit protection devices
- 3.3 Describe how a self-latching relay can be used as a means of switching higher currents
- 3.4 Describe the operating principles of the lock types used in access control systems
- 3.5 Describe the purpose of detection devices in an alarm system and their output characteristics
- 3.6 Explain the purpose of detection methods in an alarm system
- 3.7 Identify the purpose of control and indicating equipment (CIE) in an alarm system
- 3.8 Explain the requirements of standards and building regulations for the location of the CIE
- 3.9 State the influence of legislation, standards and regulatory bodies on CCTV
- 3.10 Explain the function of the main system elements of a CCTV system
- 3.11 Describe the operating principles, location and siting for the sensors used in fire detection systems
- 3.12 Describe the operating principles of common alarm output devices

---

## Range

### AC3.2 Protection devices

- In-line fuses
- On-board self-resetting protection devices
- Suppression diodes
- Metal oxide varistor (MOV)

### AC3.4 Lock types

- Maglock
- Shear mag
- Electric strike
- Shoot bolt
- Rim latch
- Solenoid handle lock
- Motorised lock

### AC3.5 Detection devices

- Foil on glass
- Closed circuit wiring

- Contacts: roller shutter, door and window
- Magnetically operated switches
- Mechanically operated switches

#### AC3.6 Detection methods

- Active movement detection
- Passive movement detection
- Acoustic vibration detection (glass break)
- Structural vibration detection (impact)

#### AC3.9 Legislation and regulatory bodies

- Human Rights Act
- Data Protection Act and GDPR
- The Freedom of Information Act
- BS EN 50132
- The Information Commissioners Office

#### AC3.10 System elements

- Camera and lens
- Housing
- Control/switching equipment
- Display equipment
- Recording equipment
- Transmission system
- Composite video signal
- Scene lighting

#### AC3.11 Sensor types

- Manual call point
- Automatic detectors: point type heat (fixed temperature and rate of rise)
- Linear heat sensing cable
- Point type smoke (ionisation and optical)
- Linear optical beam smoke
- Aspirating
- Video image processing
- Combustion gas (carbon monoxide)
- Flame (infra-red and ultra-violet)

#### AC3.12 Output devices

- Bells
- Beacons
- Electronic sounders and sirens
- Voice sounders
- Radio pagers
- Pillow alarms

---

## Learning outcome

The learner will:

4 Understand the testing requirements of security systems

## Assessment criteria

The learner can:

4.1 State the purpose of test equipment and its applications

4.2 Describe the techniques for testing movement detection

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## Range

AC4.1 Test equipment

- Multimeter
- Insulation resistance tester
- Mains polarity tester
- Battery tester
- Network (ethernet) cable tester
- Oscilloscope

## Unit 236

## Design of Security Systems

### Supporting Information

#### ***Unit guidance***

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

The focus of this unit is the design aspect of security systems including different types of security system, wiring and transmission paths, installation of components and system testing.

This links closely with unit 237 where the content is specific to the installation of security systems including site planning, safety considerations and installation procedures.

This unit could also be studied either after or concurrently with units 228 and 229, which cover electrical installation methods, circuit inspection and testing and fault diagnosis.

## Unit 237

## Installation of Security Systems

<b>Unit level:</b>	Level 2
<b>GLH:</b>	40
<b>Unit Aim</b>	This unit introduces knowledge specific to the installation of security systems. Learners will develop an initial understanding of site planning requirements, safety considerations when installing a system, installation procedures and handover procedures.

### Learning outcome

The learner will:

- 1 Understand site planning for a security system

### Assessment criteria

The learner can:

- 1.1 Describe the information needed prior to starting installation
- 1.2 Calculate dimensions and measurements from scaled drawings and diagrams
- 1.3 Interpret schematic diagrams of security systems
- 1.4 Identify electro technical symbols from working drawings and specifications
- 1.5 Identify services which may be required for the installation

---

### Range

#### AC1.1 Information

- Manufacturers' instructions
- Installation specification documents
- Site/building plans
- Design drawings for the installation
- Schematic diagrams
- Permits to work
- Job cards

#### AC1.5 Services

- Electricity
- Water
- Drainage
- Ventilation
- Gas

---

## Learning outcome

The learner will:

- 2 Understand safety considerations for installation

## Assessment criteria

The learner can:

- 2.1 Describe the main stages of the risk assessment process
- 2.2 Explain the purpose of a method statement and permit to work
- 2.3 Identify types of electrical supply systems and their features
- 2.4 State the risks of electric shock when using extension leads and electrical tools/equipment
- 2.5 Describe the basic principles of shock protection, circuit overload and short-circuit protection
- 2.6 Describe methods of verifying and securing (locking off) isolation
- 2.7 Describe safety precautions for working at heights
- 2.8 Describe safety considerations and precautions for lifting and handling
- 2.9 Describe procedures for safe storage of tools and equipment
- 2.10 Describe how to dispose of waste appropriately

---

## Range

AC2.1 Stages of risk assessment

- Hazards
- Risks
- Control measures

---

## Learning outcome

The learner will:

- 3 Know methods of installing security systems

## Assessment criteria

The learner can:

- 3.1 Identify cable types and their applications
- 3.2 Describe methods of terminating cables
- 3.3 Describe methods for cable fixing and containment
- 3.4 State the requirements for installing wiring complete with specified mechanical protection between the control and indicating equipment (CIE) position and the point of detection

- 3.5 Identify the tools and fixings required to locate, install and connect enclosures and equipment to various types of surface
  - 3.6 Describe the methods of installing different sensor devices
  - 3.7 Describe the methods of installing and protecting closed circuit wiring
  - 3.8 Describe the methods of restoring building fabric on completion of installation
- 

## Range

### AC3.1 Cable types

- Thermoplastic or thermosetting insulated (non-sheathed)
- Flat multicore thermoplastic or thermosetting insulated and sheathed
- Mineral insulated copper conductors and sheath.
- Multi-core thermoplastic (PVC)
- Data/communication cables
- PVC single wire armoured
- Co-axial
- Twisted pair
- Fibre optic

### AC3.2 Termination methods

- Insulated crimps
- Non-insulated crimps

### AC3.3 Containment

- Trunking
- Cable basket work
- Conduit

### AC3.5 Surface types

- Wood
- Brick
- Plastic
- Plastic board
- Concrete

### AC3.6 Sensors

- Surface mounted contacts on windows and doors including positioning
- Metal foil and take off blocks on glass including the types of interconnection used
- Movement detection sensors including testing

### AC3.7 Methods of installing including

- Attaching directly to the surface
- Protection from mechanical damage by hardboard, plywood and metal sheet covering

---

## Learning outcome

The learner will:

- 4 Understand procedures for commissioning and handover

## Assessment criteria

The learner can:

- 4.1 List the typical documentation required to perform system commissioning and system handover
- 4.2 State the stages and tests involved in electrical installation testing
- 4.3 Identify test instruments and their purpose
- 4.4 Describe the procedures for demonstrating and handing over a system to a customer

---

## Range

### AC4.2 Stages and tests

Dead testing (supply not connected)

- Continuity of protective conductors including main and supplementary equipotential bonding
- Continuity of ring final circuit conductors
- Insulation resistance
- Protection by SELV, PELV or electrical separation
- Basic protection by a barrier or enclosure provided during erection
- Insulation resistance/impedance of floors and walls
- Polarity
- Earth electrode resistance

Live testing (supply connected)

- Protection by automatic disconnection of the supply
- Earth fault loop impedance
- Additional protection
- Prospective fault current
- Check of phase sequence
- Functional testing
- Verification of voltage drop

### AC4.3 Test instruments

- Multimeter
- Insulation resistance tester
- Mains polarity tester
- Battery tester
- network (Ethernet) cable tester
- Oscilloscope



# Unit 237                      Installation of Security Systems

## Supporting Information

### ***Unit guidance***

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

The focus of this unit is the installation of security systems including site planning, safety considerations, methods of installation, handover and commissioning procedures.

This links closely with unit 236 where the content is specific to the design aspect of security systems including different types of security system, wiring and transmission paths, installation of components and system testing.

This unit could also be studied either after or concurrently with units 228 and 229, which cover electrical installation methods, circuit inspection and testing and fault diagnosis.

<b>Unit level:</b>	Level 2
<b>GLH:</b>	60
<b>Unit aim:</b>	<p>Project management is the skill of being able to plan, co-ordinate and control the tasks involved in turning an idea or activity into a required outcome.</p> <p>In this unit learners will understand why project management is important and develop knowledge and understanding of how to plan, monitor and control projects.</p>

## Learning outcome

The learner will:

- 1 Understand the importance of project management

## Assessment criteria

The learner can:

- 1.1 Explain the principles of project management
- 1.2 Explain the benefits of project management

---

## Range

### AC1.1 Principles

- Defined objectives
- Identification of constraints and resources
- Defined roles and responsibilities
- Resource management
- Management by stages/task
- Management by exception/addressing deviations from plan
- Risk management

### AC1.2 Benefits

- Completion on schedule

- Compliance with the requirements of the initial brief
  - Efficiency of resource use
  - Customer satisfaction
  - Improved risk assessment
  - Learning from experience
  - Development of staff in the project team
- 

### Learning outcome

The learner will:

- 2 Understand how to plan, monitor and review a project

### Assessment criteria

The learner can:

- 2.1 Explain the potential constraints to a project
  - 2.2 State the types of resources needed to carry out a project
  - 2.3 Describe the roles and responsibilities within projects
  - 2.4 Explain the methods used to plan projects and their advantages and disadvantages
  - 2.5 Explain risks associated with project management and risk mitigation actions
  - 2.6 Describe methods of monitoring projects
  - 2.7 Explain the reasons for reviewing projects on completion
- 

### Range

#### AC2.1 Constraints

- Time
- Money
- Materials
- Tools and processes
- Personnel
- Authority
- Competition for resources

#### AC2.2 Resources

- Time
- Money
- Materials
- Tools and processes
- Personnel

#### AC2.3 Roles & responsibilities

- Project manager
-

- Specialist knowledge from different areas of the organisation

#### AC2.4 Planning methods

- Gantt charts
- Critical path analysis
- Budget planning and control

#### AC2.5 Risks

- Unrealistic time and cost estimates
- Unexpected costs
- Changing requirements
- Equipment failure/breakdowns
- Safety issues
- Inadequate communication
- Inadequate project management
- Contingency planning

#### AC2.6 Monitoring methods

- Monitoring of task completion
- Progress reports
- Budget monitoring reports
- Rescheduling uncompleted tasks

#### AC2.7 Project reviewing

- Compare outcomes against original objectives
  - Identify areas for improvement
  - Learn from experience
  - Improve future projects
  - To identify key resources for future projects
-

## Unit 238

## Project Management in Engineering

### Supporting Information

#### ***Unit guidance***

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

This unit could be taught effectively using a variety of relevant case studies. Learners could also develop understanding by carrying out simulated projects.

<b>Unit level:</b>	Level 2
<b>GLH:</b>	70
<b>Unit aim:</b>	<p>Engineers often use mathematical methods to calculate information needed to design effective products, manufacture parts, and solve engineering problems.</p> <p>In this unit learners will apply mathematical principles of algebra, calculus, trigonometry and statistics to solve engineering problems.</p>

### Learning outcome

The learner will:

- 1 Apply principles of algebra to solve engineering problems

### Assessment criteria

The learner can:

- 1.1 Use equations to solve engineering problems requiring calculations
- 1.2 Manipulate equations and change the subject
- 1.3 Simplify equations and functions

---

### Range

AC1.1-AC1.3 Equations

- Compound areas made up of squares, rectangles, triangles, circles
- Volumes and mass of cuboids, cylinders, spheres, compound shapes
- Materials: (calculation of stress, strain, Young's modulus)
- Electrical systems, Ohm's law, electrical power, values of resistors in series and parallel

---

### Learning outcome

The learner will:

- 2 Apply principles of calculus and use graphs to solve engineering problems

## Assessment criteria

The learner can:

- 2.1 Interpret graphs used in engineering systems
- 2.2 Plot and use graphs to represent variables in engineering systems
- 2.3 Determine the equation of the relationship shown in a straight-line graph
- 2.4 Differentiate simple functions
- 2.5 Determine maximum and minimum values of functions using differentiation

---

## Range

AC2.1-AC2.2

Graphs showing straight line, trigonometrical and exponential relationships

AC2.3

$$y = mx + c$$

AC2.4-AC2.5

Limited to functions using addition, subtraction, division, multiplication and powers

---

## Learning outcome

The learner will:

- 3 Apply principles of trigonometry to solve engineering problems

## Assessment criteria

The learner can:

- 3.1 Apply trigonometric relationships to determine the dimensions in a triangle
- 3.2 Select and use appropriate principles of trigonometry to solve engineering problems
- 3.3 Convert between Cartesian and polar co-ordinates

---

## Range

AC3.1

Tangent, sine and cosine

AC3.2

Tangent, sine, cosine, cosecant, secant, cotangent

AC3.3

Cartesian (x,y) co-ordinates

Polar (r,θ) co-ordinates where angles are in degrees

---

## Learning outcome

The learner will:

- 4 Apply statistics to solve engineering problems

## Assessment criteria

The learner can:

- 4.1 Determine averages and standard deviation for data sets
  - 4.2 Explain how statistical data is used in quality control
  - 4.3 Explain the benefits and limitations of using statistical process control, relative to quantity of parts being manufactured
- 

## Range

AC4.1

Mean, median and modal averages, cumulative frequency and standard deviation

AC4.2-AC4.3

Statistical process control

Nominal values, upper and lower action (warning) limits, upper and lower control limits

---

# **Unit 239**                      **Applied Mathematics in Engineering**

## Supporting Information

### ***Unit guidance***

Centres may provide a formula sheet to support the assessment for this unit.

## Unit 240

## Leading an Engineering Team

<b>Unit level:</b>	Level 2
<b>GLH:</b>	40
<b>Unit aim:</b>	In this unit, learners will develop an understanding of the approaches used in leading a team and the roles of team members. They will also understand the importance of effective communication and conflict resolution.

---

### Learning outcome

The learner will:

- 1 Understand approaches to leading a team

### Assessment criteria

The learner can:

- 1.1 Describe the roles and responsibilities of a team leader
- 1.2 Explain different leadership styles and their advantages and disadvantages
- 1.3 Explain the different roles that exist within a team
- 1.4 Explain how to work effectively within a team

---

### Range

#### AC1.1 Roles and responsibilities

- Setting objectives
- Resource allocation
- Managing workloads
- Motivating staff
- Conflict resolution
- Monitoring performance
- Communication
- Problem solving
- Meeting health and safety requirements

#### AC1.2 Leadership styles

- Autocratic
- Participative
- Delegative

### AC1.3 Team roles as defined by Belbin

- Co-ordinator
- Shaper
- Completer/finisher
- Implementer
- Monitor evaluator
- Plant
- Resource investigator
- Specialist
- Team worker

### AC 1.4 Work effectively

- Personal development
- Participation in group discussions and decision making
- Suggesting solutions to problems
- How to give and receive constructive criticism
- When to be assertive
- Respond to feedback from others
- Time management

---

## Learning outcome

The learner will:

- 2 Understand types of communication used in engineering businesses

## Assessment criteria

The learner can:

- 2.1 Explain the principles of communication
- 2.2 Describe types of business documentation and their typical uses
- 2.3 Describe types of ICT applications

---

## Range

### AC2.1 Principles of communication

- Two-way process
- Types of communication (oral, written, non-verbal)
- Formal/informal

### AC2.2 Types of business documentation

- Gantt charts
- Bill of Materials (BoM)
- Technical Reports

- Job cards
- Risk assessments
- Emails

### AC2.3 ICT applications

- Word processing
- Spreadsheets
- Databases
- Presentation
- CAD/CAM
- Mobile apps

---

## Learning outcome

The learner will:

- 3 Understand how to resolve problems and conflict in the workplace

## Assessment criteria

The learner can:

- 3.1 Explain the difference between the root cause and symptoms of a problem
- 3.2 Describe methods used to resolve problems and conflict
- 3.3 Explain the reasons for conflict in work situations and ways to avoid them

---

## Range

### AC3.2 Methods

- Negotiation
- Persuasion
- Compromise
- Mediation
- Arbitration

### AC3.3 Reasons for conflict

- Differences of opinion
- Unpopular team leader decisions
- Working within time constraints
- Team member aspirations and/or ambitions
- Individual skill levels
- Team member personalities

Avoid conflict situations by:

- Enquiring politely

- Timeliness when seeking advice or assistance
- Avoiding conflict and knowing when to withdraw from the situation
- Listening carefully
- Following reasonable requests from supervisors
- Offering help when colleagues are in need of assistance

## **Unit 240**

## **Leading an Engineering Team**

### Supporting Information

#### ***Unit guidance***

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

<b>Unit level:</b>	Level 2
<b>GLH:</b>	50
<b>Unit aim:</b>	This unit will provide learners with an understanding of how to prepare for manufacturing operations processes, types of manufacturing operation and how these are monitored. They will also understand the factors that affect the efficiency of manufacturing.

## Learning outcomes

The learner will:

1. Understand how to prepare for manufacturing operations
- 

## Assessment criteria

The learner can:

- 1.1 Explain considerations for preparing and maintaining work areas
  - 1.2 Describe checks required on receipt of materials
  - 1.3 Describe methods of material handling
  - 1.4 Describe safety factors when handling materials
- 

## Range

### AC1.1 Prepare and maintain work areas

- Health and safety requirements
  - Identify and check equipment prior to use
  - Housekeeping
  - Protecting others
- Identify and check availability of materials
- Waste disposal

### AC1.2 Checks

- Materials are as specified on the documentation
  - Materials are stored safely
-

- Materials are in a suitable condition

#### AC1.3 Methods to transfer materials

- Manual
- Hand operated e.g. pallet trucks, push conveyors
- Power operated e.g. power operated cranes, forklift trucks

#### AC1.4 Safety factors

- Manual handling methods and restrictions
- Load does not exceed the safe lifting capacity of the equipment
- Load is secure
- There are no restrictions or obstacles preventing handling of materials

---

### Learning outcome

The learner will:

- 2 Understand the principles of manufacturing operations

### Assessment criteria

The learner can:

- 2.1 Describe the types of manufacturing process
- 2.2 Describe the different scales of production
- 2.3 Describe the types of instructions used to undertake manufacturing operations
- 2.4 Describe ways of monitoring and controlling the manufacturing processes

---

### Range

#### AC2.1 Types

- Wasting
- Forming
- Shaping
- Additive
- Finishing
- Joining

#### AC2.2 Scales of production

- One off/prototype
- Batch
- Mass
- Continuous/flow

#### AC2.3 Instructions

- Job cards

- Engineering drawings
- Process planning documentation
- Manufacturers' instructions

#### AC2.4 Monitoring and controlling

- Quality of finished product
- Dimensional accuracy
- Raw material use
- Consumable material use
- Machinery condition
- Equipment or tool condition
- Output/production targets

---

### Learning outcome

The learner will:

- 3 Understand factors that affect the efficiency of manufacturing

### Assessment criteria

The learner can:

- 3.1 Describe the "Eight Wastes" that affect manufacturing
- 3.2 Describe methods of minimising the "Eight Wastes"
- 3.3 Explain manufacturing issues and ways in which they may be minimised

---

### Range

#### AC3.1 Eight wastes

- Defects
- Overproduction
- Waiting
- Motion
- Transporting
- Extra-processing
- Inventory
- Untapped human potential

#### AC3.3 Issues

- Productivity
- Material faults
- Material use
- Operation safety
- Quality of product
- Shortages

# **Unit 241                      Engineering Manufacturing Techniques**

## Supporting Information

### ***Unit guidance***

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

<b>Unit level:</b>	Level 2
<b>GLH:</b>	50
<b>Unit aim:</b>	In this unit learners will learn about the factors that influence the design of new products. They will understand the key information included within design briefs and product design specifications and the stages that make up both linear and iterative approaches to designing products. Learners will understand strategies and techniques used to develop design solutions and how these are evaluated.

## Learning Outcome

The learner will:

1. Understand the factors that affect the development of a product design specification (PDS)

## Assessment Criteria

The learner can:

- 1.1 Describe the information included in a design brief
- 1.2 Describe factors that influence new designs
- 1.3 Describe the stages of the linear design process
- 1.4 Describe the stages of the iterative design process
- 1.5 Describe the information included in a PDS

## Range

AC1.1 Information in a design brief

- Purpose of the product
- User/client
- Constraints (manufacturing methods, functional properties)
- User wants (material, size, weight, shape)
- Quantity to be produced
- Environmental impact
- Cost

AC1.2 Factors

- Market pull
- Technology push
- Changes in legislation and standards
- Sustainability
- Avoiding design fixation

#### AC1.3 Stages of the linear design process

- Analyse brief
- Research
- Specification
- Ideas generation
- Ideas development
- Production planning
- Production
- Testing
- Evaluation

#### AC1.4 Stages of the iterative design process

- Modelling and prototyping
- Testing
- Evaluating
- Refining/creating a new iteration
- Repeating stages in a cyclical process

#### AC1.5 Information included in a PDS

- Product function
- Size, weight, physical dimensions
- Environmental factors
- Costs
- Health & Safety requirements
- Maintenance requirements
- Aesthetics
- Ergonomics
- Relevant industry standards
- Materials
- Manufacturing methods
- Sustainability requirements

---

### Learning outcome

The learner will:

2. Understand strategies and techniques used to develop design solutions

### Assessment criteria

The learner can:

- 2.1 Describe the characteristics and applications of different design strategies
- 2.2 Explain how ergonomics influence the design of products
- 2.3 Explain modelling techniques and their benefits/limitations

---

## Range

### AC2.1 Design strategies

- User-centred design (UCD)
- Inclusive design
- Systems approach
- Collaborative design

### AC2.3 Modelling techniques

- Virtual modelling
- Block modelling
- Rapid prototyping
- Using modular kits
- Breadboarding – electrical circuits

---

## Learning outcome

The learner will:

3. Understand the factors that affect the evaluation of a product design

## Assessment criteria

The learner can:

- 3.1 Describe techniques used to evaluate designs
- 3.2 Explain the considerations when evaluating a final design from proposals

---

## Range

### AC3.1 Techniques

- Feasibility study
- Design matrix
- Market research
- Product analysis
- Comparison with brief and specification

### AC3.2 Considerations

- Product design specification
- Cost

- Quality requirements
- Availability of materials
- Manufacturing processes
- Environmental impact

# **Unit 242                      Engineering Design Techniques**

## **Supporting Information**

### ***Unit guidance***

This unit should be delivered within a classroom/training environment. Learners could be given access to case studies of existing products to analyse how they were designed and the approaches/strategies used.

## Unit 243

## Marketing Engineered Products

<b>Unit level:</b>	Level 2
<b>GLH:</b>	50
<b>Unit aim:</b>	In this unit the learners will understand the principles of marketing, the main considerations when marketing an engineered product and method of communicating with potential customers.

---

### Learning Outcome

The learner will:

1. Understand the principles of marketing

### Assessment Criteria

The learner can:

- 1.1 Explain the difference between marketing and sales
  - 1.2 Explain what is meant by a “market” and “market segments”
  - 1.3 Explain the basic concept of marketing
  - 1.4 State the advantages and disadvantages of establishing a brand identity
  - 1.5 Explain how the 5Cs of marketing influence the marketing of products
- 

### Range

AC 1.3 Concept

- Message
- Branding
- Position

AC 1.5 The 5C's

- Company
  - Customers
  - Competitors
  - Collaborators
  - Climate
-

---

## Learning outcome

The learner will:

2. Understand the marketing process for an engineered product

## Assessment criteria

The learner can:

- 2.1 Explain the reasons for developing a new product
- 2.2 Describe what is meant by a unique selling proposition (USP)
- 2.3 Explain the stages of a product lifecycle and their effect on marketing
- 2.4 Describe the key considerations in a marketing plan

---

## Range

AC2.1 Reasons for new product

- Profit
- Technology push
- Market pull
- Changes to legislation and standards

AC2.3 Stages of a product lifecycle

- Introduction
- Growth
- Maturity
- Decline

AC2.4 Marketing plan: 7P's

- Product
- Price
- Promotion
- Place
- Positioning
- Packaging
- People

---

## Learning outcome

The learner will:

2. Understand marketing as a communication method
-

## Assessment criteria

The learner can:

- 3.1 Describe communication methods used for marketing
  - 3.2 Describe types of marketing materials
- 

## Range

### AC3.1 Communication methods

- Word of mouth
- Print media
- Television and radio
- Trade shows
- Telesales
- Direct
- Social media
- Email/letters
- Meetings
- Websites

### AC3.2 Materials

- Product data sheets
- Brochures
- Advertisements
- Mailshots
- Leaflets

# **Unit 243                      Marketing Engineered Products**

## **Supporting Information**

### ***Unit guidance***

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

This unit can be taught using a range of case studies of engineered products.

## Unit 244

## Additive Manufacturing (3D Printing)

<b>Unit level:</b>	Level 2
<b>GLH:</b>	40
<b>Unit aim:</b>	<p>Additive manufacturing processes, such as 3D printing, are revolutionising how products are designed and manufactured. With the push of a button, anyone can make a physical prototype from a CAD model.</p> <p>In this unit learners will understand the principles of additive manufacturing, the range of processes available and their advantages and limitations. In particular, they will develop knowledge and understanding of the operation of 3D printing.</p>

---

### Learning outcome:

The learner will:

1. Understand the principles of additive manufacturing

### Assessment criteria

The learner can:

- 1.1 Explain the difference between additive and subtractive approaches to manufacturing
- 1.2 Describe the method by which additive manufacturing processes make products
- 1.3 Describe different types of additive manufacturing processes
- 1.4 Explain the advantages and limitations of additive manufacturing

---

### Range

AC1.3 Types of additive manufacturing processes

- 3D printing/fused deposition modelling
- Selective laser sintering
- Stereolithography

AC1.4 Advantages and limitations relating to:

- Shape and internal geometry of the product
- Materials used
- Mechanical and physical properties
- Product dimensions
- Processing times

- Sustainability

---

### Learning outcome

The learner will:

2. Understand the set-up and operation of 3D printing

### Assessment criteria

The learner can:

- 2.1 Describe the main parts of a 3D printer and their functions
- 2.2 Describe the materials that can be used with a 3D printer
- 2.3 Explain the design limitations on the CAD model to be used for 3D printing
- 2.4 Explain the methods used to communicate a 3D CAD model to a 3D printer
- 2.5 Explain the safety considerations needed when 3D printing
- 2.6 Describe the manufacture of a product using a 3D printer
- 2.7 Explain the effect of the process parameters on the features and properties of the manufactured item
- 2.8 Explain defects that arise when 3D printing and how they may be resolved
- 2.9 Explain maintenance requirements for a 3D printer

---

### Range

#### AC2.1 Parts of a 3D printer

- Controller board
- Print head
- Stepper motors
- Threaded rod
- Belts
- End stops
- Power supply unit
- Print bed
- Feeder system
- Bed levelling system
- Filament
- Casing

#### AC2.2 Materials

- Polylactic acid (PLA)
- Acrylonitrile butadiene styrene (ABS)
- Polyamide (nylon)
- Glass filled polyamide

### AC2.3 Design limitations

- Bridging
- Overhangs
- Need for support structures
- Infill density and form

### AC2.4 Methods of communication

- .stl file
- USB cable
- SD card
- USB flash drive
- Ethernet

### AC2.5 Safety considerations

- Fume and vapours
- Hot parts and components
- Entanglement in mechanical parts
- Use of a cabinet
- Electrical safety

### AC2.7 Process parameters

- Layer thickness
- Build orientation
- Raster width
- Print speed

### AC2.8 Defects

- Poor surface finish
- Layer misalignment
- Stringing (filaments bridging empty spaces)
- Warping
- Z-wobble
- Excessive base layer
- Product not attaching to print bed
- Voids
- Delaminations or separations in the surface

### AC2.9 Maintenance

- Cleaning the nozzle
- Levelling and cleaning the print platform
- Preheating the bed and nozzle
- Checking that belts and screws are tight
- Lubrication requirements

# **Unit 244                      Additive Manufacturing (3D Printing)**

## **Supporting Information**

### ***Unit guidance***

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

## Unit 245

# Effective Working Practices in an Engineering Environment when Working on Military Vehicles and Equipment

<b>Unit level:</b>	Level 2
<b>GLH:</b>	30
<b>Unit aim:</b>	This unit will provide the knowledge and understanding required to work on military vehicles and equipment. Learners will develop an understanding of how to plan and execute a variety of maintenance tasks on military vehicles and equipment, drawing on a range of technical drawings and support documentation.

### Learning outcome

The learner will:

- 1 Understand the procedures for carrying out an engineering activity on military vehicles and equipment.

### Assessment criteria

The learner can:

- 1.1 Describe task requirements for an engineering activity
- 1.2 Describe a works programme for specific tasks
- 1.3 Describe the procedure for completion of an engineering activity
- 1.4 Describe how to complete appropriate documentation to organisational requirements

### Range

AC1.1 Task requirements

- Identify sources of information
- Information from single or multiple sources
- Task details
- Task outputs

AC1.2 Works programme

- Identify key stages
- Produce a scope of works

- Identify quality control measures  
For engineering activities

---

### Learning outcome

The learner will:

- 2 Understand data used for engineering activities

### Assessment criteria

The learner can:

- 2.1 Describe sources of documentation and / or data to complete engineering tasks
- 2.2 Describe required documentation and / or data to meet task outputs
- 2.3 Describe how to use correct data for an engineering activity
- 2.4 Describe how to interpret engineering drawings
- 2.5 Identify technical support structure

---

### Range

AC2.1 Sources of documentation e.g.

- Army Equipment Support publications (AESP)
- Manufacturers publications
- Technical literature
- Drawings, sketches and components
- Written briefings
- Verbal briefings

AC2.4 Engineering drawings could include

- engineering drawing standards
- essential drawing information
  - Scales
  - Dimensions
  - Issue number
  - Tolerances
  - Symbols
  - Notes
  - Materials
  - Parts list
- different projection types
  - Oblique
  - Isometric

- Orthographic
  - 1<sup>st</sup> angle
  - 3<sup>rd</sup> angle
  - drawing layouts
    - Freehand sketches
    - Sectional view
    - Component drawings
    - Exploded views
    - General assembly
    - Schematic
  - datums
- 

### Learning outcome

The learner will:

3 Understand the importance of quality control

### Assessment criteria

The learner can:

3.1 Describe the procedures for record keeping

3.2 Describe the potential consequence of not following quality procedures

3.3 Identify the procedure for reporting faults

---

### Range

AC3.1 Record keeping procedures

- equipment documentation
  - Data recording and Corrective Action Systems
  - Job cards
  - Who can sign off job cards as complete and to standard required
- user documentation and details required
  - Oil / lubricants used
  - Fuel consumption / drawn
  - Hours run

AC3.3 Fault reporting procedures

- Following organisation specific processes
  - Using organisation specific forms
-

## **Unit 245**

# **Effective Working Practices in an Engineering Environment when Working on Military Vehicles and Equipment**

## Supporting Information

### ***Unit guidance***

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

It is recommended that learning is based on engineering information such as engineering drawings and specifications from which learners can interpret the information presented and consider the appropriate tools, equipment and machinery required.

Assessment of outcomes could be through presentation of documents used when carrying out tasks and by short written answers.

## Unit 246

# Principles of Military Vehicle and Equipment Maintenance

<b>Unit level:</b>	Level 2
<b>GLH:</b>	60
<b>Unit aim:</b>	This unit will provide the knowledge and understanding of the principles required to carry out maintenance on military vehicles and equipment. Learners will understand the types of maintenance and the reasons for them and they will learn how to prepare and carry out a maintenance activity safely

---

### Learning outcome

The learner will:

- 1 Understand the different types of maintenance

### Assessment criteria

The learner can:

- 1.1 Explain the purpose of maintenance
- 1.2 Describe different types of maintenance
- 1.3 Describe types of routine maintenance
- 1.4 Explain time and usage maintenance
- 1.5 Explain special maintenance
- 1.6 Explain the Health and Safety considerations when planning and undertaking maintenance tasks on Military vehicles and equipment

---

### Range

AC1.1 Purpose of maintenance

- To rectify faults to return equipment to service
- To service components to prolong service life of equipment
- To prevent breakdowns

AC1.2 Types of maintenance

- Planned maintenance
- Reactive maintenance

AC1.3 Types of routine maintenance

- Pre and post use checks
- Planned or scheduled maintenance

#### AC1.4 Time and usage

- Hours run
- Time bound
- Operating environment

#### AC1.6 Health and Safety considerations

- COSHH
- Hydraulic pressure
- Manual handling
- Lifting equipment
- Other equipment fitted to vehicle

---

### Learning outcome

The learner will:

- 2 Understand the procedures for maintenance on military equipment in line with the technical literature available

### Assessment criteria

The learner can:

- 2.1 Describe how to prepare for maintenance activities
- 2.2 Describe how maintenance activities are undertaken
- 2.3 Describe how post maintenance functional tests are carried out
- 2.4 Describe the handover procedure following completion of maintenance activities

---

### Range

#### AC2.1 Preparation

- Establish resource requirements
- Conduct a risk assessment for task
- Establish a safe working area

#### AC2.3 Post maintenance functional tests to confirm functionality in line with technical literature

- Off load tests
- On load tests

---

### Learning outcome

The learner will:

- 3 Understand the procedure for removing and replacing components

### Assessment criteria

The learner can:

- 3.1 Describe the procedure for removing and replacing components
- 3.2 Explain the extent of own authority and reporting procedures for problems that cannot be resolved

---

### Range

AC3.1 Procedure

- Support publication requirements
  - Manufacturers technical literature
-

## Unit 246

# Principles of Military Vehicle and Equipment Maintenance

## Supporting Information

### ***Unit guidance***

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

It is recommended that learning is based on engineering information such as engineering drawings and specifications from which learners can interpret the information presented and consider the appropriate tools, equipment and machinery required to create the components. Learners can then consider the operational requirements and processes to carry out the activities.

## Unit 247

# Procedures and Processes for Fault Identification on Military Vehicles and Mechanical Systems

<b>Unit level:</b>	Level 2
<b>GLH:</b>	70
<b>Unit aim:</b>	<p>This unit will provide the knowledge and understanding required to describe the major components of a military vehicle or system. Learners will be able to describe the purpose of major components and their function.</p> <p>They will be able to identify faults on these components using a range of methods and information sources and identify how to rectify the fault and carry out functional tests before returning the equipment to service</p>

### Learning outcome

The learner will:

- 1 Understand the function of military vehicles and mechanical systems

### Assessment criteria

The learner can:

- 1.1 Describe the purpose of the main components of vehicle systems
- 1.2 Describe the operation of vehicle systems

### Range

AC1.1 Components/systems

- Power source
- Transmission
- Wheels
- Tracks
- Hydraulic systems
- Engine
- Cooling
- Steering system
- Braking system
- Electrical system

- Organisation specific equipment mounted on vehicle

#### AC1.2 Operation of vehicle systems

- Power source could include:
  - Petrol engine (Spark Ignition)
  - Diesel Engine (Compression Ignition)
- Transmission could include:
  - Mechanical
  - Hydraulic

---

### Learning outcome

The learner will:

- 2 Understand how to identify the symptoms of a fault

### Assessment criteria

The learner can:

- 2.1 Explain how sensory methods are used to identify faults
- 2.2 Describe the system instruments / gauges available to identify faults
- 2.3 Describe symptoms that indicate the system is faulty
- 2.4 Explain the process for identification and location of faults

---

### Range

#### AC2.1 Sensory methods

- Sight
- Touch
- Smell
- Sound

#### AC2.2 System instrument gauges

- Vehicle specific warning lamps
- Alarms and gauges
- Diagnostic equipment supplied with the vehicle (if applicable)

#### AC2.3 Symptoms

- Reduced performance
- Breakdown

#### AC2.4 Identification process

- User report
- Malfunction indicator lamp / alarm

- On board diagnostics
- Data link
- Sensory evidence
  - Visual
  - Sound
  - Smell

To include faults on one or more of the following components/systems:

- Engine
- Cooling
- Transmission
- Hydraulics
- Tracks
- Wheels
- Steering system
- Braking system
- Electrical system
- Organisation specific equipment mounted on vehicle

---

### Learning outcome

The learner will:

- 3 Understand procedures for rectifying / remedying faults

### Assessment criteria

The learner can:

- 3.1 Describe the procedures for rectifying / remedying faults
- 3.2 Describe the different levels of repair tasks as stipulated in the equipment supporting documentation
- 3.3 Explain who is authorised to carry out different levels of repair

---

### Range

AC3.2 Levels of repair tasks

- User maintenance / pre use checks e.g. lights, oil, fluid levels (level 1)
- Field Maintenance / repair (level 2)
- Workshop maintenance / repair (level 3)
- Base workshop repair (level 4)

---

## Learning outcome

The learner will:

- 4 Understand the process for testing / checking the function of equipment following repair

## Assessment criteria

The learner can:

- 4.1 Describe the process for testing / checking equipment for serviceability
  - 4.2 Explain the extent of own authority and reporting procedures for problems that cannot be resolved
  - 4.3 Identify functional test requirements to be carried out before handover in accordance with organisational procedures
-

## **Unit 247**

# **Procedures and Processes for Fault Identification on Military Vehicles and Mechanical Systems**

## Supporting Information

### ***Unit guidance***

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

It is recommended that learning is based on practical activities on vehicles or equipment where learners can use available information from a range of sources to identify faults and how to rectify them

## Appendix 1 Sources of general information

The following documents contain essential information for centres delivering City & Guilds qualifications. They should be referred to in conjunction with this handbook. To download the documents and to find other useful documents, go to the **Centre document library** on **www.cityandguilds.com** or click on the links below:

### **Centre Handbook: Quality Assurance Standards**

This document is for all approved centres and provides guidance to support their delivery of our qualifications. It includes information on:

- centre quality assurance criteria and monitoring activities
- administration and assessment systems
- centre-facing support teams at City & Guilds/ILM
- centre quality assurance roles and responsibilities.

The Centre Handbook should be used to ensure compliance with the terms and conditions of the centre contract.

### **Centre Assessment: Quality Assurance Standards**

This document sets out the minimum common quality assurance requirements for our regulated and non-regulated qualifications that feature centre-assessed components. Specific guidance will also be included in relevant qualification handbooks and/or assessment documentation.

It incorporates our expectations for centre internal quality assurance and the external quality assurance methods we use to ensure that assessment standards are met and upheld. It also details the range of sanctions that may be put in place when centres do not comply with our requirements or actions that will be taken to align centre marking/assessment to required standards. Additionally, it provides detailed guidance on the secure and valid administration of centre assessments.

### **Access arrangements: When and how applications need to be made to City & Guilds**

provides full details of the arrangements that may be made to facilitate access to assessments and qualifications for candidates who are eligible for adjustments in assessment.

The **Centre document library** also contains useful information on such things as:

- conducting examinations
- registering learners
- appeals and malpractice.

### **Useful contacts**

Please visit the **Contact us** section of the City & Guilds website.

## City & Guilds

For almost 150 years, we have worked with people, organisations and economies to help them identify and develop the skills they need to thrive. We understand the life-changing link between skills development, social mobility, prosperity and success. Everything we do is focused on developing and delivering high-quality training, qualifications, assessments and credentials that lead to jobs and meet the changing needs of industry.

We partner with our customers to deliver work-based learning programmes that build competency to support better prospects for people, organisations and wider society. We create flexible learning pathways that support lifelong employability because we believe that people deserve the opportunity to (re)train and (re)learn again and again – gaining new skills at every stage of life, regardless of where they start.

The City & Guilds community of brands includes Gen2, ILM, Intertrain, Kineo and The Oxford Group.

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