T Level Technical Qualification in Engineering, Manufacturing, Processing and Control

Specification

First teaching from September 2025
Version 1.4

Qualification at a glance

T Level route	Engineering and manufacturing
T Level pathway	T Level Technical Qualification in Engineering, Manufacturing, Processing and Control
City & Guilds number	8730 8713
Age group approved	16+
Entry requirements	Formal entry requirements are not set by City & Guilds. However, it is expected that Learners have the appropriate attainment at Level 2 before commencing their studies.
Assessment	Core – knowledge tests are externally assessed Core – employer-set project is externally assessed Occupational specialisms are externally moderated
First registration	September 2022

Title and level	City & Guilds number	Qualification Number (QN)
T Level Technical Qualification in Engineering, Manufacturing, Processing and Control (Level 3)	8730 – Core 8713 – Occupational Specialism	610/0971/4

Version and date	Change detail	Section
1.1 July 2022	Qualification number added	Qualification at a glance
	Amendment to threshold competence	6. Technical qualification grading and result reporting
	Unit 334, criteria 5.4	Amendment to 'range' and 'what the learner needs to know' sections
1.2 January 2023	Alignment of text in relation to ESP Assessment Objective (AO3) with assessment materials	Core component scheme of assessment Pg 29
	Core skill mapping references amended	Unit 300 Engineering common core
1.3 February 2024	Range expanded to include brass	Unit 331, criteria 4.3
		Unit 332, criteria 4.2
	Physical resource lists expanded	Physical Resources Pg 14
	Minor revision to PO weightings	Scheme of Assessment – Machining and Toolmaking Technologies
	Availability of assessment dates amended	Availability of Assessments Pg 41
1.4 February 2025	Unit 333 criteria 4.4 & 4.5	Unit 333 Pg 160

We would like to take this opportunity to thank all the employers, trade associations, professional bodies, providers, subject matter experts and consultants who have dedicated time to review and validate the specifications and TQ documentation. This collaborative work is to ensure that a student studying the Engineering Manufacturing, Processing and Control T level has the best opportunities available to them as they progress through their career with a solid base as a starting point.

- Royal Academy of Engineering
- Xtrac
- Warren Services
- Aeroflex Hose & Engineering LTD
- Nissan
- N&J Lining
- Siemens
- Aerotron
- Safran Nacelles
- Stolle Engineering
- TWI
- National Composites Centre
- Bristol Composites Institute
- The MTC
- Wessex Ducting Services
- Graham Engineering
- Gambica

The Outline Content for the T Level Technical Qualification in Engineering, Manufacturing, Processing and Control (Level 3) has been produced by T Level panels of employers; professional bodies based on the same standards as those used for Apprenticeships. The outline content can be found on the institute website.

Manufacturing, Processing and Control Online Content

City & Guilds has amplified the Outline Content to create the Technical Qualification specification.

Contents

1 Introduction

What is this qualification about?

The following purpose statement relates to the **T Level [1] Technical Qualification in Engineering, Manufacturing, Processing and Control (Level 3)**

Area	Description
OVERVIEW	
What is a T Level?	T Levels are new courses which will follow GCSEs and will be equivalent to three A Levels. These two-year courses have been developed in collaboration with employers and businesses so that the content meets the needs of industry and prepares learners for work. T levels are one of three post 16 options for young people which are: • A Levels • Apprenticeships • T Level
How does the Technical Qualification work within the T Level?	This Technical Qualification specification contains all the required information you need to deliver the qualification in the T Level Technical Qualification in Engineering, Manufacturing, Processing and Control (Level 3) The Technical Qualification forms a significant part of the T Level Technical Qualification in Engineering, Manufacturing, Processing and Control (Level 3). City & Guilds are responsible for the development and ongoing operational delivery of this Technical Qualification. All other parts of the T Level as listed below will need to be achieved by a Learner for the Department for Education to award the successful completion of this T Level. It is important to note that City & Guilds do not have responsibility of delivery for the other parts of the T Level but will continue to support centres where they can on all aspects of T Level delivery. Additional mandatory parts of the T Level that need to be achieved: • An industry placement of 315 – 350 hours (45 – 50 days).
Who is this qualification for?	This qualification is for you if you are a 16-19-year-old learner, who wishes to work within the engineering industry.

[1] T Level is a registered trademark of the Institute for Apprenticeships and Technical Education

	It has been designed to deliver a high level of knowledge about the engineering industry as well as the occupational skills required to enter the industry (known as 'threshold competence'). A learner who completes this qualification is well placed to develop to full occupational competence with the correct support and training.
What does this qualification cover?	The qualification will help you gain an understanding of the engineering industry and the sector, and you will cover topics such as: • Processes of production and manufacturing • Materials used in production, manufacturing, and fabrication environments • Specialist machinery utilised in the production and manufacturing environments • Product and project management • Quality assurance and quality control A learner will have the choice of studying one standalone occupational specialism as listed below: • Fitting and assembly technologies • Machining and toolmaking technologies • Composites manufacturing technologies • Fabrication and welding technologies Centres and providers work with local employers who will contribute to the knowledge and delivery of training. Employers will provide demonstrations and talks on the industry and where possible work placements will also be provided by the employers.
WHAT COULD THIS QUALIFICATION LEAD TO?	
Will the qualification lead to employment, and if so, in which job role and at what level?	This technical qualification focuses on the development of knowledge and skills needed for working in the Engineering industry, which will prepare learners to enter the industry through employment or as an Apprentice. Furthermore, the completion of this qualification gives the learner the opportunity to progress onto higher education courses and training.
Why choose this qualification?	This technical qualification will suit someone who is not yet employed or looking to enter the industry post mainstream education. The structure of the qualification is designed to give learners the breadth of knowledge and understanding across the Engineering industry but also equips them with necessary occupational and core skills to enter the industry. This qualification is designed to support fair access and allows learners to manage and improve their own performance.
WHO SUPPORTS THIS QUALIFICATION?	
Employer route panels	The content of this qualification is outlined by a representative panel of employers from across the industry sector. It therefore prescribes the minimum knowledge and skills required to enter the industry. The content in this specification is approved by the Institute for Apprenticeships and Technical Education (IfATE).

Key information

Below is a summary of the key information provided to centres to support delivery of this technical qualification.

Guided learning hour (GLH) value

This value indicates the average number of guided learning hours a unit will require for delivery to a learner. This includes contact with tutors, trainers or facilitators as part of the learning process, and includes formal learning such as classes, training sessions, coaching, seminars and tutorials. This value also includes the time taken to prepare for, and complete, the assessment for the unit. Guided learning hours are rounded up to the nearest five hours.

Total qualification time (TQT) value

This is the total amount of time, in hours, expected to be spent by a learner to achieve a qualification. It includes both guided learning hours (which are listed separately) and hours spent in preparation and study.

Criteria

This section of the specification outlines the subject or topic that needs to be delivered and assessed. Criteria are often supported by **'range'** which provides the detail of the information required to be delivered as part of that topic. For example, with 'Production processes' as the topic, the range would list the processes that would need to be covered in delivery and assessment.

What do learners need to learn?

The primary purpose of these sections is to support the delivery of the content in the criteria. These sections provide context in relation to the depth and breadth to which a subject or topic needs to be taught.

Skills

This section provides a mapping reference to the core, maths, English and digital skills that are embedded within the technical qualification content.

Example

2.2 Interpret and analyse relevant **technical information**, data, representations and documentation.

Range:

Technical information - drawings, specifications, charts (electrical loading, torque specification), SOP, safe working systems, bills of materials, manufacturing planning sheets.

What do learners need to learn?	Skills
To read, interpret, collate, process and communicate **technical information** and data critical for the successful completion of the job. Accurately interpret drawings, specifications, scales, and technical terms related to production processes and activities. Analyse and report information and data accurately. Use and communicate the analysed information/data to improve quality of products and reliability of the process.	EC1 EC2 EC4 EC5 EC6 MC6 DC1 DC4

T Level structure

To achieve the T Level learners must meet all requirements of the T Level framework of which the technical qualification is one part. Learners have to successfully complete an industry placement and any other requirements set by the Institute for Apprenticeships and Technical Education (IFATE) such as licence to practice qualifications.

Technical qualification structure

The technical qualification is made up of **two** components all of which need to be successfully achieved to attain the technical qualification as well as the full T Level Technical Qualification in Engineering, Manufacturing, Processing and Control (Level 3).

The common core component:
The core content is designed to offer sufficient breadth of knowledge and skills for the learner to apply in a variety of contexts related to the engineering industry and those occupational specialisms linked to this T Level.

The common core content is the building blocks of knowledge and skills that will give a learner a broad understanding of the industry and job roles. At the same time, it will develop the core skills they will need to apply when working within the industry.

Occupational specialisms:
Occupational specialisms develop the knowledge, skills and behaviours necessary to achieve threshold competence in an occupation. Threshold competence is defined as when a learner's attainment against the knowledge, skills and behaviours is of a standard for them to enter the occupation and industry. They must also demonstrate the ability to achieve occupational competence over time with the correct support and training.

To achieve the **T Level Technical Qualification in Engineering, Manufacturing, Processing and Control (Level 3) (delivered by City & Guilds)** learners must complete the **two** components of the Technical qualification. These are known as the core component and the occupational specialism:

- (300) plus one from (331 – 334)

T Level Technical Qualification in Engineering, Manufacturing, Processing and Control (Level 3)					
Programme of Study (POS) number	**City & Guilds component number**	**Component title**	**Component level**	**GLH**	**TQT**
Mandatory					
8730-30	300	Engineering common core	Level 3	680	1000
Choose one standalone Occupational Specialism					
Standalone					
8713-31	331	Fitting and assembly technologies	Level 3	680	1000
8713-32	332	Machining and toolmaking technologies	Level 3	680	1000
8713-33	333	Composites manufacturing technologies	Level 3	680	1000
8713-34	334	Fabrication and welding technologies	Level 3	680	1000

2 Centre requirements

Approval

All eligible providers must obtain Full Provider Approval with City & Guilds prior to delivering any T Level Technical Qualification (TQ).

Provider approval is not equivalent to centre approval; any provider which is already an existing City & Guilds approved centre must still obtain Full Provider Approval in the first instance. There is no fast-track approval for these qualifications.

Once successfully approved, providers can apply for additional TQs or apply to add additional occupational specialisms (OS) during each approval window.

The approval application consists of a comprehensive set of approval criteria agreed with the Institute to ensure an eligible provider is fit and ready to deliver T Level Technical Qualifications.

These criteria seek to ensure the integrity of the qualifications for both City & Guilds and the Institute. They must be adhered to throughout the delivery of the TQ and will be reviewed at the annual self-assessment.

Criteria A Management Systems
Criteria B Industry placement
Criteria C Resources
Criteria D Delivery
Criteria E Assessment and standardisation plan
Criteria F Secure live assessment and administration
Criteria G Conflicts of Interest (COI)

Please refer to our published provider approval and quality assurance information document available on our website here. This document includes information around the approval process, criteria for approval and the timeline for the relevant academic year.

Resource requirements

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

Centre staffing

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

- be occupationally competent and qualified at or above the level they are delivering
- have maths and English at Level 2 or be working towards this level of qualification
- be able to deliver across the breadth and depth of the content of the qualification being taught
- have recent relevant teaching and assessment experience in the specific area they will be teaching, or be working towards this
- demonstrate continuing CPD
- have experience or training in the following to support the delivery of this technical qualification:
    - delivering project-based qualifications
    - preparation for exam-based assessments.

Engineering common core

Staff who are familiar with L3 Engineering and Manufacturing qualifications will be able to teach the core elements.

Occupational specialisms specific requirements

Fitting and assembly technologies

Level 3 or above engineering qualification or equivalent. Industrial experience or relevant CPD that demonstrates the occupational and technical competence to deliver the requirements for this specialism.

Machining and toolmaking technologies

Level 3 or above engineering qualification or equivalent. Industrial experience or relevant CPD that demonstrates the occupational and technical competence to deliver the requirements for this specialism.

Composites manufacturing technologies

Level 3 or above engineering qualification or equivalent. Industrial experience or relevant CPD that demonstrates the occupational and technical competence to deliver the requirements for this specialism.

Fabrication and welding technologies

Level 3 or above engineering qualification or equivalent. Industrial experience or relevant CPD that demonstrates the occupational and technical competence to deliver the requirements for this specialism.

It is recommended that staff assessing these qualifications must meet the above requirements and hold or be working towards a relevant recognised assessor qualification such as a Level 3 Certificate in Assessing Vocational Achievement and continue to practise to that standard.

Assessors who hold earlier qualifications (D32, D33 or TQFE/TQSE) should have CPD evidence that meets current standards.

Assessors must also hold a relevant engineering qualification and/or have 'Eng-Tech' status.

Physical resources

Centres must be able to demonstrate that they have access to the equipment and technical resources required to deliver this qualification and its assessment.

Common resources

- Virtual modelling and CAD software
- Engineering drawing materials
- PPE
- Scientific calculator
- Technical documentation
- Electrical / electronic equipment
- Measurement devices, instrumentation and gauges
- Testing equipment
- Tools and equipment
- Machines
- Materials
- Consumables
- Video camera
- Camera
- Workshop (to include waste disposal facilities)
- ICT equipment and software

Fitting and Assembly Technologies

- Technical documentation – calibration certificates, manufacturers safety specifications, schematic diagrams, BS and ISO standards, drawings (2D, 3D and flat and exploded model views, isometric projections, 1st and 3rd angle orthographic projections, design, tooling, detail, sub-assembly, assembly, general arrangement, installation), Standard operating procedures (SOPs) (Technical, management, types (checklists, step-by-step lists, hierarchical lists, process flowcharts)), circuit diagrams, specifications, design concepts, data sheets, test records, maintenance records, work instructions, flow charts, manufactures manuals, instructions, inspection documentation, risk assessments, Bill of materials (BoM), Statistical process control (SPC), Zeus book (limits and fits, tapping drills), method statements.
- Machines –CNC machinery, lathes, milling machine, drills (hand, pillar, bench), grinder, plasma cutter, laser cutter pillar drill, bench grinder, bending machine, guillotine, bearing puller, compressor, 3D printers, bandsaw.
- Consumables – coolants, lubricants, pipes and tubing, powder, surface treatment.
- Materials – Metals (Ferrous and non-ferrous) - stainless steel, cast-iron, high-speed steel, silver steel, low, medium and high carbon steel, aluminium, alloys, copper, lead, brass, bronze, zinc. Polymers (Thermosets, thermoplastics) - urea formaldehyde, melamine formaldehyde, phenol formaldehyde, epoxy resin, polyester resin, ABS, HIPS, PLA, polycarbonate, polypropylene, PMMA/acrylic, Composites – glass fibre, carbon fibre, aramid fibre, Elastomers – rubber, neoprene.
- Tools and equipment (hand and power) - work holding device (chucks, jigs, fixtures), saws, torque wrenches, spanners, pliers, screwdrivers (electrical and hand), Allen keys, files, tap and die set, engineers square, scriber, center punch, taps, reamers,

hammers, punches, drills (hammer, cordless, mag-base), mag-base drill, compressed air driven tools, sander, rivet gun, metal vice.

- Lifting accessories - sack barrow, pallet truck, scissor jacks, hoist, pulley, lifts, slings (rope or fibre), chains (single or multiple leg), hooks, eyebolts, spreader beams, magnetic and vacuum devices.
- Components/Fasteners – rivets (solid and hollow), anchor units, pins, nuts, bolts.
- Measuring equipment (direct and indirect) – rules, tapes, protractors, micrometres (outside, depth, plug, bore, thread), callipers (vernier), gauges (thread, angle, Go-NoGo, gauge blocks, comparison plates, optical inspection aids, laser projection tool, digital test indicator (DTI).
- Engineering drawing equipment: set square, protractor, compasses.

Machining and Toolmaking Technologies

- Technical documentation – calibration certificates, specifications, material lists, identification codes, data sheets, manufacturers safety specifications, colour codes, component numbering, schematic diagrams, BS and ISO standards, engineering drawings (design, tooling, detail, sub-assembly, assembly) circuit diagrams, design concepts, test records, maintenance records, work instructions, Standard Operating Procedures (SOPs), flow charts, manufacturers manuals/documentation, instructions, inspection documents, 2D and 3D drawings (solid model exploded views, flat patterns), step-by-step lists, hierarchical lists, Bill of materials (BoM), Zeus book (limits and fits, tapping drills), risk assessments, method statement.
- Machines –
    - Computer Numerical Control (CNC): lathe, milling machine, router, cutter (water, laser, plasma).
    - manual: milling machine, centre lathe, grinder, borer, laser cutter, plasma cutter, water jet cutter, electrical discharge machine, pillar/bench drill.
    - access to machines for broaching, honing, lapping, automated and CNC applications, processing (forging, rolling, stamping, extruding, pressing), joining, plating, powder metallurgy machines (mixing, blending, compacting, sintering).
- Tooling for workshop machinery –
    - milling (face mills, end mills, slot drills, slotting cutters, slitting saws, profile cutters, twist drills, reamers, boring tools).
    - turning (turning tools, facing tools, form tools, parting off tools, single point threading, boring bar, recessing tool, grooving tool, centre drill, twist drill, reamers, tap, dies, knurling tool).
    - drilling (centre drill, drill bit, flat-bottomed drill, counterboring tools, countersinking tools, reamers, taps).
- Materials – ferrous metal (stainless steel, cast iron, high speed steel, silver steel, low, medium and high carbon steel), non-ferrous metal (aluminium, alloys, copper, lead, brass, bronze and zinc), polymers (thermosets (urea formaldehyde, melamine formaldehyde, phenol formaldehyde, epoxy resin, polyester resin) thermoplastics (ABS, HIPS, PLA, polycarbonate, polypropylene, PMMA/acrylic)) elastomers (rubber, neoprene) composites (glass fibre, carbon fibre, aramid fibre).
- Consumables – lubricant, coolant, resins, anti-corrosion surface treatment.
- Tools and equipment (hand and power) – cordless drill, hammer drill, electric screwdriver, compressed air driven tools, centre and edge finders, combination, protractor and depth gauges, deburring tools, dividers, levels, scrapers, scribes, square, straight edges, gauges, vices, punches, rivet setter, screw extractors, bolt grips, clamps, threading tools, files, hammers.

- Access to lifting accessories - sack barrows, pallet trucks, scissor jack, hoist, pulley, lifts, slings (fibre, rope), chains (single, multiple leg), hooks, eyebolts, spreader beams, magnetic and vacuum device.
- Work-holding devices – 3-jaw chuck, 4-jaw chuck, collets, faceplate, centres and drive plates, lathe dog/carrier, steadies, angle plate, magnetic table, vee block, indexing heads, rotary table, jigs, fixtures, clamps, machine vice, bench vice.
- Marking out, measuring and inspection equipment – rule, dividers, scribe, scribing block/surface gauge, height gauge (vernier, digital), combination square, callipers (vernier, digital), micrometers (outside, depth), gauges (feeler, angle, slip, Go- NoGo, dial test indicator (DTI), tape measure, thread gauges, gauge blocks, comparison plates, punches (centre, dot).
- Engineering drawing equipment: set square, protractor, compasses.
- Abrasive/grinding/polishing equipment.

Composites Manufacturing Technologies

- Technical documentation – 2D (1st angle and 3rd angle orthographic projections, isometric projection, assembly, general arrangement, installation drawings) 3D engineering drawings (design, tooling, detail, sub-assembly, assembly)), design concepts, data sheets, material safety data sheets (MSDS) test records, maintenance records, work instructions, flow charts, charts (limits and fit, ply clock) plans, manufacturers manual/documentation, instruction documents, specifications (matrix, core and fibre material) production process plans and records, material supply, storage and handling records, customer specifications, numbers off, time constraints, cost constraints, part tolerances, critical fit and max deflections, service conditions, material specifications, component drawings, risk assessments, Standard operating procedures (SOPs), COSHH compliance, safe working systems, ply lay-up requirements, ply-up and orientation sheets, consumables specification, inspection documents, instructions, checklists, step by steps lists, hierarchical lists, bill of materials (BoM), PAT testing certificates, method statements, calibration certificates.
- Materials:
    - Matrix materials - Thermoset, thermoplastic, ceramic matrix, metal matrix, bio resins.
    - Composites - Fibre material types (glass, carbon, aramid, quartz, bio fibres, thermoplastic), fibre material forms (woven (plain, twill, satin), unidirectional, chopped strand mat (CSM), multi-axial, tapes, 3D stitching, preforms, braiding), natural and synthetic fibres, material combinations.
    - Resins (catalysts, accelerators, hardeners), glass fibre, carbon fibre, particle, fibre and sheet-based composites (natural and synthetic), fillers, gel coats, core material (balsa wood, nomex honey combe, aluminium honey combe, closed cell foam).
    - Assembly equipment - bonding agents and sealants, protective coatings, monolithic and sandwich panels.
- Consumables – release agents, curing agents.
- Tools and equipment - scissors, retractable knife, scalpel, standard hand tools (hacksaws, files), powered hand tools electrical power (full mains, 110v, battery) pneumatic power tools, high-speed cut-off tools, die grinders, power drills, sanders, polishers (hand and power), de-burring tools, safe edger, viscosity measuring cups, square, straight edges, gauges, punches, heat gun, forming tools, dibbers and prodders, resin mixers, clamps, files, scales and balances, sheers, ply cutters, platens, mandrels, jigs.
- Measuring and marking out equipment – pencil, micrometer, depth gauges, engineer's rule, tapes, scales dividers, scriber, templates, set squares, protractors, compasses, combination square, scribing block/surface gauge, callipers, Vernier height gauge, slip

gauges, Dial Test Indicator (DTI), surface table and plates, angle plates, vee blocks, paint pencil (white).

- Lifting accessories - sack barrow, pallet truck.
- Machinery and equipment – freezers, de-gassers, vacuum bags, vacuum pump, mixing station, film, heated press, heat lamps, press/oven/autoclave, heated blankets, resin injection/infusion equipment, vacuum application equipment, mould tools (female, male, matching, multi-part, closed, mandrels), bulk and sheet moulding, additive layer manufacturing, extraction and dust handling system/equipment.
- Equipment and consumables specific for each of the lay-up methods: Hand lay-up, spray lay-up, pre-preg lay-up, resin infusion/transfer, automated lay-up.
- Workshop equipment and machinery - rollers, brushes, spray guns, heat guns, temperature and humidity meter, sanding and finishing equipment, waste disposal.
- Ventilation and fume control.
- First aid kit and eye-wash station.

Fabrication and Welding Technologies

- Technical documentation – calibration certificates, engineering/fabrication/welding drawings (design, tooling, detail, general arrangement, sub-assembly, assembly, installation), drawings (1st and 3rd angle orthographic projections, isometric projections, 2D, 3D, solid model exploded views, flat patterns, isometric symbols, terminology, conventions), circuit diagrams, specifications, design concepts, data sheets, test records, maintenance records, work instructions, flow charts, charts (limits and fits, tilts, tapping drill allowances) manufacturers manual/documentation, standard operating procedures (SOP), instructions, inspection documents, quality documentation specifications (BS EN, ISO), cutting lists, fabrication lists, checklists, step-by-step lists, hierarchical lists, method statements, risk assessments, permits to work (hot works permits), safe systems of work, user guides, standards and legislation (inc. Welding specific), issue logs, bill of materials (BoM).
- Specialist PPE - auto-darkening welding helmet, air-fed welding helmet, welding jacket or apron, welding shoes/boots, gloves, safety glasses, ear plugs or ear defenders, mask or respirator.
- Materials – Ferrous (stainless steel, cast-iron, high-speed steel, silver steel, low, medium and high carbon steel), non-ferrous (aluminium, copper, lead and zinc).
- Tools and equipment (hand and power) - electrical power (full mains, 110v, battery), pneumatic power tools, powered cutters/nibblers, mag base drills, centre & edge finders, combination, protractor & depth gauges, de-burring tools, dividers, levels, scribes, square, straight edges, gauges, vices, punches, rivet setter, bolt grips, taps & dies, vee blocks, clamps, files, hammers, tin snips, spanner, torque wrench, soldering iron.
- Lifting equipment - sack barrows, pallet trucks, scissor jack, hoist, pulley, lifts, slings (fibre, rope), chains (single, multiple leg), hooks, eyebolts, spreader beams, magnetic and vacuum device.
- Components – nuts, bolts, screws, riveting.
- Consumables - adhesives, cleaning agents, anti-spatter spray, solder
- Measuring and marking out equipment - rules, tapes, dividers, scribe, templates, set square, protractors, compasses, combination square, scribe, scribing block/surface gauge, punches (centre and dot). Slip gauge, surface table and plates, angle plates, vee block, clamps, welding gauges, micrometers, thread gauges, gauge blocks, comparison plates.
- Workshop machinery – pillar drill, bench grinder, bending machine, guillotine, hand drill, compressor, plasma cutting, cutting machines, presses.

- Welding equipment - Flux, clamps, magnets, sheet metal gauge, conduit, electrode, wire and electrode feed system (pinch rolls, push-pull, spool on gun), gun, angle grinder, wire brush, cables, fume extractors, local exhaust ventilation systems (LEV), metal inert gas (MIG) rig, gas shielded metal arc (MAG) welding rig, manual metal arc (MMA), resistance/spot welder, tungsten inert gas (TIG) welding, portable welding plant (inverter welders), generator welding plant, oxy fuel cutting equipment, welding table, oven, gas bottles.
- Forging equipment – forge or equivalent, tongs, clamping vice.
- Testing equipment (non-destructive) - dye-penetrant inspection, magnetic particle inspection, visual inspection, ultrasonic testing, radiography.
- Copies of relevant welding standards

Internal quality assurance

Internal quality assurance is key to ensuring accuracy and consistency of tutors and markers. Internal quality assurers (IQAs) monitor the work of all tutors involved with a qualification to ensure they are applying standards consistently throughout assessment activities. IQAs must have, and maintain, an appropriate level of technical competence and be qualified to make both marking and quality assurance decisions through a teaching qualification or recent, relevant experience.

Supervision and authentication of candidate work

The Head of Centre is responsible for ensuring that assessment evidence is conducted in accordance with City & Guilds' requirements.

City & Guilds requires:

- candidates to sign the Declaration of authenticity form to confirm that any work submitted is their own
- tutors to confirm on the record form that the work submitted for assessment is solely that of the candidate concerned and was conducted under the conditions laid down in the assessment documentation

The tutor must be sufficiently aware of the candidate's standard and level of work to make a judgement whether the work submitted is within the expected ability and style of the candidate or whether a further investigation into the authenticity of the work is required.

If the tutor is unable to sign the authentication statement for a particular candidate, then the candidate's work cannot be accepted for assessment.

Learner entry requirements

Centres must ensure that all learners have the opportunity to gain the qualification through appropriate study and training, and that any prerequisites stated in the **What is this qualification about?** section are met when registering for this qualification.

Formal entry requirements are not set by City & Guilds, but it is expected that learners will have qualifications at Level 2 or equivalent. This may include:

- Level 2 vocational qualification or equivalent in a related subject

3 Delivering the technical qualification

Initial assessment and induction

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

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

City & Guilds recommends that centres provide an introduction so that learners fully understand the requirements of the qualification, their responsibilities as learners, and the responsibilities of the centre. This information can be recorded on a learning contract.

Programme delivery

The technical qualification should be delivered through approaches that meet the needs of learners. City & Guilds recommends using a variety of delivery methods, including in classrooms and real work environments. Learners may benefit from both direct instruction in more formal learning environments and taking part in investigative projects, e-learning and their own study and learning through indirect approaches to delivery.

4 Competency frameworks

The technical qualification has been developed to include competency frameworks for T Levels, which demonstrate an array of competencies across maths, English and digital skills as well as five key core skills that have been mapped on to the core content. This can be seen in the skills section for each criterion.

Core skills

By completing the project brief, learners will develop an appreciation of the breadth and diversity of Engineering and Manufacturing and have an opportunity to demonstrate high quality engineering practices, which allow them to work safely and effectively across different engineering contexts and within contemporary workshop environments.

By achieving the assessment objectives and meeting the employer-set brief, students will demonstrate the following core skills to produce quality outcomes, using relevant technology, tools, equipment, systems and components:

i) **Analysing and interpreting -** Evaluate and confirm the brief with reference to context, objectives and constraints (eg requirements, resources, precedents, technical issues, costs, health and safety, regulations, possibilities)

ii) **Planning and preparation -** Propose and plan key activities, stages, methods, processes, techniques, documentation, resources (including types of tools and equipment) and risk assessments.

iii) **Developing responses** - Apply engineering and manufacturing processes to achieve specific objectives and to produce quality outcomes, using relevant techniques and technology, within limits of own authority.

iv) **Evaluating and quality assuring** - Carry out investigations, generate proposals and options, identify standard components and systems at relevant stages to gather and evaluate relevant evidence and data, and to confirm the suitability of plans, processes, actions and outcomes (including quality control and quality assurance activities)

v) **Communication and presentation -** Record, report, communicate and present plans, proposals, processes, issues, risks and outcomes to both technical and non-technical audiences, across a range of suitable formats and media (eg diagrams; physical and digital records; presentations)

In the design, delivery and assessment of the technical qualification, the following core skills are fundamental in the development of the required knowledge, skills and behaviours that learners will need to use when they progress onwards from completing their T level. These core skills have been mapped to the design of the qualification content and developed in consultation with the industry and providers. The mapping identifies opportunities where these core skills can be developed and embedded into teaching and learning. It is not expected that all criteria will develop core skills, but where these skills exist in the core content it has been referenced to support centres.

- **Core skill A (MPC-CSA) Analyse and interpret an Employer Set Brief.** Applying a logical approach to solving problems, identifying issues and proposing solutions e.g. through setting criteria for successful implementation of a design solution, using analysis of the practicality of approaches and the efficiency of any design.

- Identification of key customer requirements and constraints from the project brief
- Identification and use of applicable and established engineering standards, such as British Standards (BS) European Standards (EN) and International Standards (ISO) that may affect the use of standard parts, drawing, communication and documentation systems
- Identification of technical information and resources required for machining techniques
- Recognition and compliance with Health and Safety rules and regulations that affect use of any design and ensure operator wellbeing
- Consideration of human factors such as individual capabilities, and how design affects performance, handling, comfort and productivity
- The application of the principles of material cutting processes
- Show how to analyse, evaluate, synthesise and apply information, data and research findings.

- **Core skill B (MPC-CSB) Plan and prepare suitable responses to the brief.** Primary research e.g. identifying commercially available materials and engineering solutions.
  - Identification of key principles and methodologies in jig and tool design in manufacturing engineering
  - Identifying user requirements and translating them into design options
  - Collecting information and data on standard components that may be incorporated into a design solution.

- **Core skill C (MPC-CSC) Develop response/s using key skills and processes.** Compile responses to the brief, e.g. create designs, using tools, techniques and data.
  - Use of digital engineering tools and techniques to support development of a design solution
  - Use of manufacturer's data and formal engineering standards to develop solutions
  - An understanding of tolerances and the requirement to accommodate potential variation of sizes in both supplied workpieces, standard parts and manufacturing variation
  - Sustainable design solutions
  - Calculation and application of the rules and principles of dimensioning and tolerancing within engineering and manufacturing contexts.

- **Core skill D (MPC-CSD) Evaluate and quality assure processes and outcomes.** Evaluate outcomes of design activity against requirements, information, data and research findings.
  - Production of engineering drawings and documentation to recognised standards
  - Demonstrate understanding of measuring in engineering design and manufacturing context
  - Demonstrate an understanding of data interpretation, validation, evaluation and reporting to support solutions
  - Show an understanding of operational efficiency, and demonstrate purpose of outcome
  - Show a general understanding of the important techniques and processes used including fitting and assembly of components, common production techniques, joining techniques, and jigs and fixtures
  - Reflection of solution and identification of areas where improvement could be made.

- **Core skill E (MPC-CSE) Communicate and present outcomes and evidence.** Report, record and communicate plans proposals and issues to technical and non-technical audiences across a range of suitable formats and media.
  - Application of the principles and standards of communicating engineering information through dimensioned engineering drawings and graphical language

- Production, interpretation, and amendment of drawings, sketches, schematics and diagrams in different contexts, and using different techniques and communications media
- Demonstrate an understanding of evaluation and reporting processes
- Show reflection and evaluation of processes and practices used and identification of potential improvements and refinements.

Maths English and digital skills

Maths, English and digital skills have been mapped across the core content and each of the occupational specialisms. The lists below identify the core competencies which can be found in the skills section of each performance criteria.

General English Competencies

The following outlines a framework of six General English Competences, with no prioritisation or interpretation of order intended:

- EC1. Convey technical information to different audiences
- EC2. Present information and ideas
- EC3. Create texts for different purposes and audiences
- EC4. Summarise information/ideas
- EC5. Synthesise information
- EC6. Take part in/lead discussions

General Mathematical Competencies

The following outlines a framework of ten General Mathematical Competences, with no prioritisation or interpretation of order intended:

- MC1. Measuring with precision
- MC2. Estimating, calculating and error spotting
- MC3. Working with proportion
- MC4. Using rules and formulae
- MC5. Processing data
- MC6. Understanding data and risk
- MC7. Interpreting and representing with mathematical diagrams
- MC8. Communicating using mathematics
- MC9. Costing a project
- MC10. Optimising work processes

General Digital Competencies

The following outlines a framework of six General Digital Competences, with no prioritisation or interpretation of order intended:

- DC1. Use digital technology and media effectively
- DC2. Design, create and edit documents and digital media
- DC3. Communicate and collaborate
- DC4. Process and analyse numerical data
- DC5. Be safe and responsible online
- DC6. Controlling digital functions

5 Scheme of assessment

Assessment methods

Learners must complete:

Two externally set exams covering knowledge from the engineering common core (component 300).

The exams provide sufficient sampling of the content and consist of a mixture of short answer questions (SAQs), some of which will be structured, and extended response questions (ERQs). The balance of questions in assessing across assessment objectives (AOs) 1, 2 and 3 will allow for the appropriate differentiation of learners to support the reliable setting of boundaries.

One employer-set project covering knowledge and core skills from the engineering common core (component 300).

The employer-set project will consist of a well-defined, real industry-style brief. The brief will be complex and non-routine, and will require the use of relevant maths, English and digital skills. The brief will provide a valid context for the Level 3 learner to demonstrate their knowledge and understanding of the core content and their core skills to solve occupationally relevant situations and/or problems.

And

One occupational specialism from (331 – 334)

These assessments will feature a considerable practical element and are composed of a series of holistic practical tasks relating to the specialism at hand. The assessments should be scheduled according to the occupational specialism window identified annually in the key dates schedule published by City & Guilds. By nature of the considerable practical elements, the tasks will generate significant ephemeral evidence and be heavily reliant on Internal Assessor observation notes and records for validation.

Grading and marking

The engineering common core (component 300) is graded overall A*–E plus ungraded (U).

The occupational specialisms (components 331 – 334) are graded overall Distinction, Merit, Pass and Ungraded. Each occupational specialism achieved will receive a grade.

Technical qualification scheme of assessment overview

Core Component – Learners must complete **all** assessment components						
Assessment component	**Method**	**Duration**	**Marks**	**Weighting**	**Marking**	**Grading**
Exam paper 1	Externally set exam	2.5 hours	100	35%	Externally marked	This component will be awarded on the grade scale A* - E
Exam paper 2	Externally set exam	2.5 hours	100	35%	Externally marked	
Employer-set project	Externally set project	15.5 hours	90	30%	Externally marked	
Occupational Specialism Component - Learners must complete **one** assessment component						
Assessment component	**Method**	**Duration**	**Marks**	**Weighting**	**Marking**	**Grading**
Fitting and assembly technologies	Externally set assignment	25 hours 15 minutes	90	100%	Externally moderated	All occupational specialism components will be awarded on the grade scale P, M, D
Machining and toolmaking technologies	Externally set assignment	25 hours 15 minutes	90	100%	Externally moderated	
Composites manufacturing technologies	Externally set assignment	24 hours 15 minutes	90	100%	Externally moderated	
Fabrication and welding technologies	Externally set assignment	26 hours 15 minutes	90	100%	Externally moderated	

Core component scheme of assessment

The assessments for this component consist of two core exams and an employer-set project, which are set against a set of assessment objectives (AOs) used to promote consistency among qualifications of a similar purpose. They are designed to allow judgement of the learner to be made across a number of different categories of performance.

Each assessment for this component has been allocated a set number of marks against these AOs based on weightings recommended by stakeholders of the qualification. This mark allocation remains the same for all versions of the assessments, ensuring consistency across assessment versions and over time. AO weightings for the assessment components related to the core components are detailed below.

AO weightings for the assessment components related to the core components are detailed below.

Core exam

Assessment objective	Description
AO1 Demonstrate knowledge and understanding	All AOs require the ability to recall knowledge. AO1 refers to instances where the learner is required to demonstrate basic recall. In the test, this helps to give confidence in sufficiency of coverage of the content, and recognises that not all knowledge requires further understanding e.g. terminology, number facts etc. AO1 also covers the ability to explain principles and concepts beyond recall of definitions in order to be able to transfer these principles and concepts between contexts. Learners have built connections between related pieces of knowledge. AO1 therefore also covers the ability of the learners to show understanding by summarising or explaining concepts in their own words, exemplifying, or comparing and making inferences in general terms that show e.g. cause and effect.
AO2 Apply knowledge and understanding to different situations and context	Using and applying knowledge and understanding, of processes, procedures, generalisations, principles and theories to specified, concrete situations. AO2 is about being able to take the understanding of generalities and apply them to specific novel situations. It is more granular than the more extended synthesis/creation that may respond to an analysis of a more holistic complex situation/brief.
AO3 Analyse and evaluate information and issues	Learners will be provided with information e.g. in the form of a detailed / complex scenario, problem or data set. Learners analyse the interrelated issues arising, and where appropriate evaluate the approaches or decisions they may take (for example, the strengths and weaknesses or advantages and disadvantages) to achieve a good solution or outcome. Marks will be given for the quality of analysis and evaluation and the range of factors considered.

Assessment objective	Weightings	Description
AO1a Demonstrate knowledge	10%	The ability to demonstrate basic recall of relevant knowledge in response to straightforward questioning e.g. material properties.
AO1b Demonstrate understanding	22%	The ability to explain principles and concepts beyond recall of definitions, but in a general way – i.e. out of a particular context in response to straight forward questioning e.g. simple concepts and terms of description in engineering contexts.
AO2 Apply knowledge and understanding to different situations and context	46%	Using and applying knowledge and understanding taking the understanding of generalities and applying them to specific situations. Questions are likely to ask for application in relation to a straightforward situation – e.g. assessing the application of a single concept and the application of essential mathematical concepts.
AO3 Analyse and evaluate information and issues	22%	The ability to analyse the interrelated issues arising from a complex scenario and to evaluate these to propose a best solution or predict impacts etc e.g. – evaluating materials properties and requirements for engineered products.

Component	Assessment method	Description and conditions
Core exam	Externally marked tests	These tests are **externally set and externally marked** and will be sat through question papers provided by City & Guilds. These tests are designed to assess learners' depth and breadth of understanding across the core component in the qualification at the end of the period of learning and will be sat under invigilated examination conditions. See JCQ requirements for details: **http://www.jcq.org.uk/exams-office/ice---instructions-for-conducting-examinations** Learners who fail either one or both exams in the core component will need to retake both exams and must do so in the same assessment window. These exams will be made up of different question types that include short answer questions, structured questions, and extended response questions. The level of difficulty will increase through the paper with lower demand questions at the beginning of the question paper to higher demand questions at the end of the question paper.

Component	Assessment method	Assessment overview
Paper 1	Externally marked test	Content overview: • Essential mathematics for engineering and manufacturing • Essential science for engineering and manufacturing • Materials and their properties • Mechanical principles • Electrical and electronic principles • Mechatronics
Paper 2	Externally marked test	Content overview: • Working within the engineering and manufacturing sectors • Engineering and manufacturing past, present, and future • Engineering representations • Engineering and manufacturing control systems • Quality management • Health and safety principles and coverage • Business, commercial and financial awareness • Professional responsibilities, attitudes, and behaviours • Stock and asset management • Continuous improvement • Project and programme management

Employer-set project

Component	Assessment method	Assessment weighting
AO1 Plan approach to meet brief	Evidence of a planned approach to work, considered sequence of activity, evidence of prioritisation, review and iterative working. Clearly structured response to brief, cohesive response with ordered sections, logical approach to referencing, research and use of sources, response completed meeting required parameters, sources used effectively and integrated into response, effective use of time allocation available for presentations.	13.3%
AO2 Apply knowledge and skills to contexts	Linking knowledge principles and ideas and applying them in context of the brief when considering compiling response use of materials, concepts etc. Applying core skills e.g. communication, problem solving appropriately throughout tasks within project.	50%
AO3 Select relevant techniques and resources to meet the brief	Selection of techniques and resources in order to support a response to the brief; consideration of the techniques and resources that are most effective and appropriate to use, and accurate and informed use of these.	13.3%
AO4 Use maths, English and digital skills	Use of correct terminology, abbreviations, units of measurement in context, consideration of audience of brief response (technical versus non-technical wording), use of calculations/diagrams etc appropriately, consideration of the use of ICT and digital methods both in brief response and in presentation.	10%
AO5 Realise project outcome and review how well the outcome meets the brief	Considered analysis and evaluation of project outcome, response conclusion or evaluation, identification of solutions in response to brief problem with evidence of evaluation of other options and reasons for rejection of other options where not appropriate.	13.3%

Component	Assessment method	Description and conditions
Employer-set project	Externally marked project	This project is **externally set and externally marked** by City & Guilds and is designed to require the learner to identify and use effectively in an integrated way an appropriate selection of skills, techniques, concepts, theories and knowledge from across the whole of the engineering core content. Projects will be released to centre staff in advance of any of the assessment windows for each task. City & Guilds will provide centres with assessment windows for centres to timetable assessment sessions within, in accordance with the assessment times prescribed in the Employer-set project centre guidance. Centres will be required to maintain the security of all live assessment materials until assessment windows are open. Projects will therefore be password-protected and released to centres through a secure method. Guidance on equipment, resources and duration will be released as appropriate to ensure centres can plan for delivery of the project in advance. Learners who fail the Employer-set project on first submission can retake in any assessment window.

Component	Assessment Method	Assessment overview
Employer-set project	Externally marked project	**Content overview:** The employer-set project samples knowledge drawn from across the core content in relation to the specific project version context. **Assessment overview:** The employer-set project is an assessment made up of several tasks that will take place within controlled conditions, assessing the knowledge and skills learned as part of the core element of the T Level. Each project will be developed together with employers in the industry to reflect realistic types of developments, activities and challenges. The project is made up of a number of tasks which all relate to the same employer-set project brief and tender specification. • Research • Report • Design • Present. The project draws on the content from the core knowledge that sits across all specialisms in Engineering, Manufacturing, Processing and Control (specific knowledge and skills for each specialism will be assessed in the practical assignments). The project is linked to the core skills: • Planning and preparation • Communication • Developing a response • Evaluation.

Scheduling of the Employer-set project assessments

The employer-set project assessment window will occur from March to May annually. Specific dates will be released annually through the key date schedule for the following academic year.

Task	Scheduling	Task duration
1 Research	City & Guilds sets the assessment window for the centre to timetable	3 hours
2 Report	City & Guilds sets the assessment window for the centre to timetable	4 hours
3 Design	City & Guilds sets the assessment window for the centre to timetable	6 hours
4 Present	City & Guilds sets the assessment window for the centre to timetable	2.5 hours

A supporting document and guidance will be shared in advance of the assessment to support timetabling and planning for centres, for example outlining any required resources or conditions. This will be released to centres as part of the Key Dates Schedule.

Occupational specialism component scheme of assessment

What is the occupational specialism component?

The occupational specialism assignment consists of a project brief presented as client requirements or a specification of work that is realistic to the occupational specialism rather than detailed instructions on what to do, to allow the learner to demonstrate that they have the knowledge required to implement the brief. There will be several high-level tasks in every version of the assessment, and these will take the form of planning and carrying out industry relevant practical tasks. Within each high-level task there will be several sub-tasks that learners will need to complete as directed within the assessment documents. The sub-tasks will reflect the project brief for that version of the assignment.

How is the occupational specialism component marked?

Occupational Specialism assessments will be set and marked against a number of assessment themes. Once learner evidence has been marked, Internal Assessors will make a holistic judgement on performance by applying the knowledge and skills that have been demonstrated to assessment themes within the marking grid.

Each learner will receive a total mark for each assessment theme. The total for each assessment theme is accumulated, giving a total mark for the assessment. Assessment themes will be common across every version of the assessment and will assess a similar range of evidence across assessment versions, ensuring comparability of demand between every version of the assessment.

Although evidence from across all tasks can be used to demonstrate performance against an assessment theme, internal assessors will be directed to specific task evidence that must be used to support judgements on performance against the assessment theme. The assessment themes will be broad enough to ensure that all the performance criteria across the specialism are assessed, supporting reliability of the assessment.

In order to ensure reliability, and consistent and accurate judgements on performance, assessment themes may consist of sub-assessment themes due to the potentially wide content coverage and to ensure that the Performance Outcome (PO) is assessed to the appropriate depth and breadth. This still allows for the appropriate base mark to be applied to the assessment theme, but also ensures that the distribution of marks within and across bands is more manageable and increases the reliability of judgements made and marks awarded. Internal assessors will give an appropriate mark in relation to the learner's performance for each individual sub-assessment theme, but this will contribute to the overall mark for that assessment theme. Internal assessors will then need to evidence the decision for the mark awarded for each assessment theme on the Candidate Record Form (CRF).

Component	Assessment method	Overview and conditions
Occupational specialism assignment	Externally set, externally moderated	This assignment is **externally set, internally marked and externally moderated**, and is designed to require the learner to identify and use effectively in an integrated way an appropriate selection of skills, techniques, concepts, theories and knowledge from across the occupational area. Assignments will be released to centre staff towards the end of the learners' programme, usually the week before Easter each year. Centres will be required to maintain the security of all live assessment materials until assessment windows are open. Assignments will therefore be password-protected and released to centres through a secure method. Guidance on equipment, resources and duration will be released as appropriate to ensure centres can plan for delivery of practical assignments in advance. Learners who fail the occupational specialism following the first submission can retake in any assessment window. Please note that for externally set assignments City & Guilds provides guidance and support to centres on the marking process and associated marking grid in the assessment pack for the qualification, and guidance on the use of marking grids.

Component	Assessment method	Overview and conditions
Fitting and assembly technologies	Externally set, externally moderated	**Content overview** Learners will be able to: • Analyse projects and specifications, considering the specific requirements, context, resources, tools and equipment, and the suitability of different production technologies, processes, and methods. • Plan and prepare relevant materials, resources, tools, and equipment needed to produce the relevant products and outcomes. • Produce relevant products and outcomes, considering the specified requirements, context and materials, using the relevant fitting and assembly technologies, methods, and processes. • Support the delivery (and the management) by helping to evaluate and review the outcomes to improve the final product, production methods, and work place practices and processes. • Communicate production information, proposals and solutions, producing, recording and explaining relevant technical information, representations, processes and outcomes. **Assessment overview:** Learners will be assessed against the following assessment themes: Health and safety Planning and preparation Production Quality review and evaluation

Component	Assessment method	Overview and conditions
Machining and toolmaking technologies	Externally set, externally moderated	**Content overview** Learners will be able to: • Analyse and interpret engineering and manufacturing requirements, systems, processes, technical drawings and specifications. • Plan and prepare the relevant processes, tools, equipment, and resources, needed to produce relevant products and produce appropriate outcomes. • Produce relevant products and outcomes, considering the specified requirements, context and materials, using the relevant machining and toolmaking technologies, methods and processes. • Support the delivery (and management) of relevant projects and activities, helping to evaluate and review processes and outcomes, and to improve practices. • Communicate production information, proposals and solutions, producing, recording and explaining relevant technical information, representations, processes and outcomes. **Assessment overview:** Learners will be assessed against the following assessment themes: Health and safety Planning and preparation Production Quality review and evaluation

Component	Assessment method	Overview and conditions
Composite manufacturing technologies	Externally set, externally moderated	**Content overview** Learners will be able to: • Analyse and interpret engineering and manufacturing requirements, systems, processes, technical drawings and specifications. • Plan and prepare the relevant processes, tools, equipment, and resources, needed to manufacture relevant products and produce appropriate outcomes. • Produce relevant products and outcomes, considering the specified requirements, context and materials, using the relevant composite manufacturing technologies, methods and processes. • Support the delivery (and management) of relevant projects and activities, helping to evaluate and review processes and outcomes, and to improve practices. • Communicate production information, proposals and solutions, producing, recording and explaining relevant technical information, representations, processes and outcomes. **Assessment overview:** Learners will be assessed against the following assessment themes: Health and safety Planning and preparation Production Quality review and evaluation

Component	Assessment method	Overview and conditions
Fabrication and welding technologies	Externally set, externally moderated	**Content overview** Learners will be able to: • Analyse the tasks, projects and specifications, considering the specific processing requirements, context, resources, materials, tools and equipment, and the suitability of different fabrication and welding technologies, methods and processes. • Plan and prepare the relevant processes, tools, equipment, and resources, needed to produce relevant materials and products. • Produce the relevant product considering the specified requirements and raw materials using the relevant fabrication and welding process and method. • Support the delivery (and the management) of relevant fabrication and welding projects and activities, helping to evaluate and review processes and outcomes, and to improve practices. • Communicate production information, proposals and solutions, producing, recording and explaining relevant technical information, representations, processes and outcomes. **Assessment overview:** Learners will be assessed against the following assessment themes: Health and safety Planning and preparation Production and assembly Quality testing, review and evaluation

Availability of assessments

Scheduled assessment windows will be set annually for the T Level Technical Qualification in Engineering, Manufacturing, Processing and Control (Level 3). Exact key dates for assessment that are externally marked (core exams and the employer-set project) will be communicated to approved providers annually through the key date schedule.

Component	Series	Exam type	Calendar Month/s	Assessment window/set date
Core exam 1	Summer	Written exam	May/June	Set date
	Autumn	Written exam	November	Set date
Core exam 2	Summer	Written exam	May/June	Set date
	Autumn	Written exam	November	Set date
Employer-set project	Summer	Project	March – May	Assessment window
	Autumn	Project	October	Assessment window
Occupational specialism	One series annually	Project	April – May	Assessment window

6 Technical qualification grading and result reporting

Awarding the technical qualification grade

The technical qualification components are awarded as shown below:

Component	Grading
Core	A* – E
Occupational Specialism	Pass, Merit and Distinction

Core component

Calculating the grade of the core component uses the aggregation of points from across all assessment components in the core to calculate the overall grade for the core component.

Core component grade descriptors

Component	Grade	Descriptor
Core	A	To achieve an 'A' grade a candidate will: Show clear ability to demonstrate a comprehensive understanding of the full range of principles that influence engineering activities in routine contexts and allow successful implementation to non-routine contexts. Make links between relevant knowledge and understanding when responding to problems in a logical and methodical format. Legitimate and justified approaches are provided in response to complex engineering briefs and problems. Demonstrate the ability to comprehensively identify and interpret a full range of considerations when analysing complex briefs or problems, including the impacts their decisions have on design, manufacture and maintenance in engineering contexts. There is a meticulous approach in the selection of processes, tools and equipment, materials, methods and health and safety considerations when planning approaches or responses to engineering briefs or problems. Use a range of communication strategies and an ability to adapt their style and format to respond well to audience and stakeholder needs in presenting approaches to solving problems. Demonstrate a high degree of accuracy in knowledge and skills from across the core content and critically evaluate their own performance in meeting a brief or problem, identifying areas for improvement where appropriate.

Component	Grade	Descriptor
Core	E	To achieve an ‘E’ grade a candidate will: Demonstrate a limited understanding some of the key principles and how they influence engineering activities in routine contexts. Make general links in knowledge and understanding when responding to routine engineering problems. The response can sometimes be superficial, not evidence-based and supported by partial reasoning. Respond to engineering briefs or problems with little awareness of the impact their decisions have on design, manufacture or maintenance in engineering contexts. There is some understanding in the selection of processes, tools and equipment, materials, methods and health and safety considerations to meet the requirements of routine engineering briefs or problems. Demonstrate a small range of communication strategies that are sometimes not suitable in language and format for audiences and stakeholders with inaccuracies in technical references. Provide some evaluation of performance and how requirements have been met when addressing an engineering brief, with no reference on how to improve. Candidates need to complete all components to be awarded the Technical Qualification. Any performance determined as not meeting the standard by City & Guilds will receive an unclassified (U) result.

Occupational specialism component

Calculation of the grade for the occupational specialism is based on setting grade boundaries for Pass and Distinction. The setting of grade boundaries is based on judgemental evidence, against the grade descriptors for the occupational specialisms, review of the Guide Standard Exemplification Materials (Grade Standard Exemplification Materials after the first award) and review of statistical evidence.

Pass and Distinction grade descriptors can also be found in both learner and centre occupational assessment materials.

To successfully achieve an occupational specialism the learner needs to be recognised at threshold competence (Pass).

Threshold competence refers to a level of competence that:

- signifies that a student is well placed to develop full occupational competence, with further support and development, once in employment
- is as close to full occupational competence as can be reasonably expected of a student studying the TQ in a classroom-based setting (for example, in the classroom, workshops, simulated working and (where appropriate) supervised working environments)
- signifies that a student has achieved at least a pass in relation to the relevant occupational specialism component

If a learner does not meet the minimum standards as determined by City & Guilds for either/both the core component and occupational specialism they will be issued with an unclassified (U) grade.

Component	Grade	Descriptor
Fitting and assembly technologies	A	To achieve an 'A' grade a candidate will: Competently and thoroughly interpret technical information, applying technical skills to plan, assess risk and follow safe working methods to practical tasks and procedures to an exemplary standard in response to the requirements of the brief, producing an excellent quality of work that meets tolerances, regulations and standards. Thoroughly prepare working area, mitigating potential risks prior to commencing tasks and consistently apply exemplary housekeeping techniques during tasks. Demonstrate exemplary technical practical skills in cutting, shaping, fitting, drilling, assembly and commissioning activities that are in line with industry standards and meet the requirements of the brief. Demonstrate exemplary ability to follow procedures to produce or maintain working components. Work safely and make informed and appropriate use of tools, materials and equipment within the working environments for cutting, shaping, fitting, drilling, assembly and commissioning activities. Identify causes and diagnose problems or common issues related to fitting and assembly and have a thorough understanding and the skills to be able resolve and rectify them. Consistently and accurately use industry and technical terminology across different communication methods with full consideration of technical and non-technical audiences.

Component	Grade	Descriptor
Fitting and assembly technologies	E	To achieve an 'E' grade a candidate will: Interpret information, plan, assess risk and follow safe working methods when applying practical skills to an acceptable standard in response to the requirements of the brief. Adequately prepare working areas, acknowledging potential risks and applying acceptable housekeeping techniques during tasks. Demonstrate the basic technical practical skills in cutting, shaping, fitting and drilling to install components that are in line with industry standards and meet the requirements of the brief. Demonstrate adequate ability to follow procedures to produce or maintain working components. Demonstrate basic knowledge and understanding of the principles and processes required for fitting and assembly activities. Work safely showing an understanding in the selection and use of relevant tools and equipment and demonstrate a basic awareness of straightforward preparation and application processes within the working environments for cutting, shaping, fitting, drilling, assembly and commissioning activities. Identify causes of problems or common issues related to production control, operating procedures and quality control and have some knowledge and skills in how to rectify them. Mostly use general industry and technical terminology accurately across different communication methods with some consideration of technical and non-technical audiences. Candidates need to complete all components to be awarded the Technical Qualification. Any performance determined as not meeting the standard by City & Guilds will receive an unclassified (U) result.

Component	Grade	Descriptor
Machining and toolmaking technologies	A	To achieve an 'A' grade a candidate will: Competently and thoroughly interpret technical information, applying technical skills to plan, assess risk and follow safe working methods to practical tasks and procedures to an exemplary standard in response to the requirements of the brief, producing an excellent quality of work that meets tolerances, regulations and standards. Thoroughly prepare working area, mitigating potential risks prior to commencing tasks and consistently apply exemplary housekeeping techniques during tasks. Demonstrate exemplary technical practical skills in machining materials to produce components and products using a range of manual and automated equipment and machinery activities that are in line with industry standards and meet the requirements of the brief. Demonstrate exemplary ability to follow procedures to produce or maintain working components. Work safely and make informed and appropriate use of tools, materials and equipment within the working environments for machining and commissioning activities. Identify causes and diagnose problems or common issues related to production control, operating procedures and quality control and have a thorough understanding and the skills to be able resolve and rectify them. Consistently and accurately use industry and technical terminology across different

Component	Grade	Descriptor
Machining and toolmaking technologies	E	To achieve an 'E' grade a candidate will: Interpret information, plan, assess risk and follow safe working methods when applying practical skills to an acceptable standard in response to the requirements of the brief. Adequately prepare working areas, acknowledging potential risks and applying acceptable housekeeping techniques during tasks. Demonstrate the basic technical practical skills in machining materials to produce components and products using a range of manual and automated equipment and machinery, which are in line with industry standards and meet the requirements of the brief. Demonstrate basic knowledge and understanding of the principles and processes required for machining and toolmaking activities. Work safely showing an understanding in the selection and use of relevant tools and equipment and demonstrate a basic awareness of straightforward preparation and application processes within the working environments for machining and commissioning activities. Identify causes of problems or common issues related to production control, operating procedures and quality control and have some knowledge and skills in how to rectify them. Mostly use general industry and technical terminology accurately across different communication methods with some consideration of technical and non-technical audiences. Candidates need to complete all components to be awarded the Technical Qualification. Any performance determined as not meeting the standard by City & Guilds will receive an unclassified (U) result.

Component	Grade	Descriptor
Composites manufacturing technologies	A	To achieve an 'A' grade a candidate will: Competently and thoroughly interpret technical information, applying technical skills to plan, assess risk and follow safe working methods to practical tasks and procedures to an exemplary standard in response to the requirements of the brief, producing an excellent quality of work that meets regulations and standards. Thoroughly prepare working area, mitigating potential risks prior to commencing tasks and consistently apply exemplary housekeeping techniques during tasks. Demonstrate exemplary technical practical skills in preparing moulds, shaping composite materials and cores, laying-up, debulking, consolidating, curing and de-moulding, assembling and finishing that are in line with industry standards and meet the requirements of the brief. Demonstrate exemplary ability to follow laminating and assembly procedure to produce composite components to meet the requirements of the brief. Demonstrate exemplary knowledge and understanding of the principles and processes required for composite engineering to produce a product that meets the required tolerances within the brief Work safely and make informed and appropriate use of tools, materials and equipment within the working environments for preparing moulds, shaping composite materials and cores, laying-up, debulking, consolidating, curing and de-moulding, assembling and finishing composite assemblies. Identify causes and diagnose problems or common issues related to composites manufacturing and have a thorough understanding and the skills to be able resolve and rectify them. Consistently and accurately use industry and technical terminology across different communication methods with full consideration of technical and non-technical audiences.

Component	Grade	Descriptor
Composites manufacturing technologies	E	To achieve an 'E' grade a candidate will: Interpret information, plan, assess risk and follow safe working methods when applying practical skills to an acceptable standard in response to the requirements of the brief. Adequately prepare working areas, acknowledging potential risks and applying acceptable housekeeping techniques during tasks. Demonstrate basic technical practical skills in preparing moulds, shaping composite materials and cores, laying-up, debulking, consolidating, curing and de-moulding, assembling and finishing that are in line with industry standards and meet the requirements of the brief. Adequately demonstrate ability to follow laminating and assembly procedures to produce composite components to meet the requirements of the brief. Demonstrate basic knowledge and understanding of the principles and processes required for composite engineering to produce a product that meets the required tolerances within the brief. Work safely showing an understanding in the selection and use of relevant tools and equipment and demonstrate a basic awareness of straightforward preparation and application processes within the working environments for preparing moulds, shaping composite materials and cores, laying-up, debulking, consolidating, curing and de-moulding, assembling and finishing composite assemblies. Identify causes of problems or common issues related to production control, operating procedures and quality control and have some knowledge and skills in how to rectify them. Mostly use general industry and technical terminology accurately across different communication methods with some consideration of technical and non-technical audiences. Candidates need to complete all components to be awarded the Technical Qualification. Any performance determined as not meeting the standard by City & Guilds will receive an unclassified (U) result.

Component	Grade	Descriptor
Fabrication and welding technologies	A	To achieve an 'A' grade a candidate will: Competently and thoroughly interpret technical information, applying technical skills to plan, assess risk and follow safe working methods to practical tasks and procedures to an exemplary standard in response to the requirements of the brief, producing an excellent quality of work that meets regulations and standards. Thoroughly prepare working area, mitigating potential risks prior to commencing tasks and consistently apply exemplary housekeeping techniques during tasks. Demonstrate exemplary technical practical skills in marking out, cutting, forging, fabricating and welding that is in line with industry standards and meet the requirements of the brief. Demonstrate exemplary knowledge and understanding of the principles and processes required for fabrication and welding technologies. Work safely and make informed and appropriate use of tools, materials and equipment within the working environments for marking out, cutting, forging, fabricating and welding activities. Identify causes and diagnose problems or common issues related to fabrication and welding and have a thorough understanding and the skills to be able resolve and rectify them. Demonstrate exemplary technical skills and understanding in the use of non-destructive testing methods to ensure quality welds are produced to recognised industry standards. Consistently and accurately use industry and technical terminology across different communication methods with full consideration of technical and non-technical audiences.

Component	Grade	Descriptor
Fabrication and welding technologies	E	To achieve an 'E' grade a candidate will: Interpret information, demonstrate planning, assess risk and follow safe working methods when applying practical skills to an acceptable standard as recognised by industry. Adequately prepare working areas, acknowledging potential risks and applying acceptable housekeeping techniques during tasks. Demonstrate basic technical practical skills in marking out, cutting, forging, fabricating, welding that is in line with industry standards and meet the requirements of the brief. Demonstrate basic knowledge and understanding of the principles and processes required for fabrication and welding technologies. Work safely showing an understanding in the selection and use of relevant tools and equipment and demonstrate a basic awareness of straightforward preparation and application processes within the working environments for marking out, cutting, forging, fabricating and welding activities. Identify causes of problems or common issues related to fabrication and welding and have some knowledge and skills in how to rectify them. Demonstrate basic technical skills and understanding in the use of non-destructive testing methods to ensure quality welds are produced to recognised industry standards. Mostly use general industry and technical terminology accurately across different communication methods with some consideration of technical and non-technical audiences.

Candidates need to complete all components to be awarded the Technical Qualification. Any performance determined as not meeting the standard by City & Guilds will receive an unclassified (U) result.

Awarding the T Level programme grade

To achieve a T Level Technical Qualification in Engineering, Manufacturing, Processing and Control (Level 3) a learner must complete all elements of the T Level framework set by the Institute for Apprenticeships and Technical Education (IfATE). This includes the technical qualification and the industry placement.

In meeting the above requirements, the learner will be eligible to be awarded an overall qualification grade for the T Level Technical Qualification in Engineering, Manufacturing, Processing and Control (Level 3). The overall qualification grade will be based on performance in the core component and occupational specialism, as set out below.

T Level Qualification Grade				
	Occupational specialism grade			
Core component grade		Distinction	Merit	Pass
	A*	Distinction*	Distinction	Distinction
	A	Distinction	Distinction	Merit
	B	Distinction	Merit	Merit
	C	Merit	Merit	Pass
	D	Merit	Pass	Pass
	E	Pass	Pass	Pass

7 Administration

Factors affecting individual learners

If work is lost, City & Guilds should be notified immediately of the date of the loss, how it occurred, and who was responsible for the loss. Centres should use the JCQ form, JCQ/LCW, to inform City & Guilds Customer Services of the circumstances.

Learners who move from one centre to another during the course may require individual attention. Possible courses of action depend on the stage at which the move takes place. Centres should contact City & Guilds at the earliest possible stage for advice about appropriate arrangements in individual cases.

Malpractice

Please refer to the City & Guilds guidance notes *Managing cases of suspected malpractice in examinations and assessments*. This document sets out the procedures to be followed in identifying and reporting malpractice by candidates and/or centre staff and the actions which City & Guilds may subsequently take. The document includes examples of candidate and centre malpractice and explains the responsibilities of centre staff to report actual or suspected malpractice. Centres can access this document on the City & Guilds website.

Examples of candidate malpractice are detailed below (please note that this is not an exhaustive list):

- falsification of assessment evidence or results documentation
- plagiarism of any nature
- collusion with others
- copying from another candidate (including the use of ICT to aid copying), or allowing work to be copied
- deliberate destruction of another's work
- false declaration of authenticity in relation to assessments
- impersonation.

These actions constitute malpractice, for which a penalty (e.g. disqualification from the assessment) will be applied.

Where suspected malpractice is identified by a centre after the candidate has signed the declaration of authentication, the Head of Centre must submit full details of the case to City & Guilds at the earliest opportunity. Please refer to the form in the document *Managing cases of suspected malpractice in examinations and assessments*.

Accessibility

In the design of the Technical Qualification and its assessments the following principles have been applied:

- In the development of content, tasks and assessments, **all** learners are considered
- Well-designed materials that do not create barriers to attainment. This will include content being presented logically and uncluttered
- No particular characteristic or group of learners are disadvantaged by features of a qualification
- Language is appropriate including carrier language which is presented in its simplest for fair access to all learners
- In the design of content and assessments the impact on learners social, behavioural and emotional well-being will be considered
- Physical and sensory needs of learners in accessing content and assessments.

Access arrangements

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.

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 *JCQ access arrangements and reasonable adjustments and Access arrangements - when and how applications need to be made to City & Guilds* for more information. Both are available on the City & Guilds website: http://www.cityandguilds.com/delivering-our-qualifications/centre-development/centre-document-library/policies-and-procedures/access-arrangements-reasonable-adjustments

In the design of the technical qualification and its assessments the following principles have been applied:

- In the development of content, tasks and assessments, **all** learners are considered.
- Materials are well designed and do not create barriers to attainment. This includes content being presented logically and in an uncluttered way.
- No particular characteristics or groups of learners are disadvantaged by features of the qualification.
- Language is appropriate and presented in its simplest form to provide fair access to all learners.
- In the design of content and assessments, the impact on learners' social, behavioural and emotional wellbeing are considered.
- Physical and sensory needs of learners in accessing content and assessments are considered

Special consideration

We can give special consideration to candidates who have had a temporary illness, injury or indisposition at the time of the examination. Where we do this, it is given after the examination.

Applications for either access arrangements or special consideration should be submitted to City & Guilds by the Examinations Officer at the centre. For more information, please consult the current version of the JCQ document, *A guide to the special consideration process*. This document is available on the City & Guilds website: http://www.cityandguilds.com/delivering-

our-qualifications/centre-development/centre-document-library/policies-and-procedures/access-arrangements-reasonable-adjustments

Informing candidate of pre-moderated marks

Centres are required to inform candidates of their marks **before** external moderation. It is important that candidates are informed of their pre-moderated marks are provisional and allow sufficient time for them to appeal if felt necessary while still allowing their agreed centre marked work to be available for external moderation on time.

Centres must also provide candidates with a copy of their marked work and the centre's internal appeals procedures on request.

Internal appeals procedure

For internally marked assessments, all centres must have an internal appeals procedure for candidates, which gives them the opportunity to appeal the centre mark for their work, before moderation takes place. The procedure must ensure:

- the person completing the appeal is competent and did not mark the work originally
- that any marking errors are identified and corrected
- the candidate is informed of the outcome, reason and any change in mark.

The City & Guilds appeals process also covers access arrangements, special consideration, and malpractice. Applications are not accepted directly from candidates, but the centre can apply on a candidate's behalf. Where relevant, centres must tell candidates how to request this. The centre can refuse to make the application to City & Guilds, but the candidate must be given the opportunity to appeal this decision. This information must be included in the centre's internal appeals procedure.

Centres must provide candidates and City & Guilds with a copy of their internal appeals procedure, on request.

Results reporting

The Institute for Apprenticeships and Technical Education (IFATE) will certificate Learners who have successfully completed all elements of the T Level Technical Qualification in Manufacturing, Processing and Control (Level 3)

T Level results will be released on the Level 3 results day in August.

Post-results services

The services available include a review of marking and review of moderation. Requests must be submitted within the specified period after the publication of results for individual assessments.

For further details of enquiries about results services, please visit the City & Guilds website at **www.cityandguilds.com.**

8 Components

Content of components

The components in this qualification are written in a standard format and comprise the following:

- City & Guilds reference number
- Title
- Level
- Guided learning hours (provisional)
- Assessment method
- Introduction section
- Underpinning knowledge outcome – including range and ‘what learners need to learn’ sections
- Skills outcomes – including range and ‘what learners need to learn’ sections
- Links to maths, English and digital skills
- Guidance for delivery
- Suggested learning resources.

300 Engineering common core content

Level:	3
GLH:	680
Assessment method:	Externally set exam Employer-set project

What is this component about?

An introduction to Engineering and Manufacturing, designed to help learners choose a specific pathway and specialism once the common core is delivered.

It covers the theoretical knowledge of the Engineering and Manufacturing industry and various disciplines across all sectors that are indicative to the industry.

Learners gain an understanding of what theoretical principles and practices integral to the industry and sector are required to work in it.

Learners will develop their knowledge and understanding of, and skills in:

- Knowledge of working within the engineering and manufacturing sectors and the professional responsibilities, attitudes, and behaviours required to do so.
- Knowledge of the essential mathematics and science for engineering and manufacturing.
- Knowledge of mechanical, electrical and mechatronic principles.
- Knowledge of health and safety principles.
- An understanding of the business management required within the sector to provide a product or service with success.
- Skills in project management and delivery of a project.

Learners may be introduced to this component by asking themselves questions such as:

- What are the different sectors in engineering and manufacturing?
- What does the future look like for this sector, where could it take me?
- What mathematics and science are involved in engineering and manufacturing?
- How do I read engineering diagrammatic representations?
- How do I manage and present a project?

Underpinning knowledge outcomes

On completion of the Common Core component, learners will understand

1 Working within the engineering and manufacturing sectors
2 Engineering and manufacturing past, present, and future
3 Engineering representations
4 Essential mathematics for engineering and manufacturing
5 Essential science for engineering and manufacturing
6 Materials and their properties
7 Mechanical principles
8 Electrical and electronic principles
9 Mechatronics
10 Engineering and manufacturing control systems
11 Quality management
12 Health and safety principles and coverage
13 Business, commercial and financial awareness
14 Professional responsibilities, attitudes, and behaviours
15 Stock and asset management
16 Continuous improvement
17 Project and programme management

Completion of the Engineering and Manufacturing Common Core will give learners the opportunity to develop their Maths, English and Digital Skills. Details are presented in the skills section of each criterion.

Content

1 Working within the engineering and manufacturing sectors

1.1 Key **principles** and methodologies in engineering and manufacturing design.

Range:
Principles
Types of manufacturing process (wasting, forming, shaping, joining, finishing, casting, additive).
Fitness for purpose (influences on design and manufacture, functional requirements, environmental requirements).
User requirements (design brief, specification, needs to be met).
Approaches to design (linear design, iterative design, inclusive design, user centred design, anthropometric data (ergonomic design), design for manufacture, design for assembly, sustainable design, 6Rs (reduce, refuse, rethink, repair, reuse, recycle)).
Research and testing methodologies.
Methods of communicating design requirements to technical and non-technical audiences.

What do learners need to learn?	Skills
How different types of manufacturing processes influence the design of engineered products. How different requirements affect the user and designs related to the manufacture of products. The steps of the linear and iterative design processes and the contribution that testing makes to achieve a suitable and effective design. How to interpret anthropometric data.	MPC-CSA, MPC-CSB, MPC-CSE.

1.2 The role of **maintenance, repair and installation** in engineering.

Range:
Maintenance, repair and installation
Types of maintenance activity (planned, reactive, preventative, condition-based monitoring).
Roles and functions (machine operator, maintenance engineer, maintenance manager).
Operations (monitoring, repair, shutdown, servicing).
Tools and equipment (mechanical (hand tools, portable power tools), electrical/electronic (hand tools, soldering irons).
Measurement devices, instrumentation and gauges).
Installation requirements (provision of services, commissioning).
developments in maintenance (influence of new technologies, environmental influences).

What do learners need to learn?
The role and purpose of maintenance, repair and installation.
The advantages and disadvantages of different approaches to maintenance.
The responsibilities of the different roles involved in maintenance.
Approaches to monitoring and the reasons for carrying out monitoring.
The reasons for, and implications of shutdown and servicing.
An overview of the types of tools and equipment used.
The reasons for commissioning activities.

How effective maintenance reduces impact on the environment and the safe and environmentally friendly disposal of waste.

1.3 Approaches to **manufacturing**, processing and **control**.

Range:

Manufacturing – Scale of manufacture (one off, batch, mass, continuous), infrastructure (functional, product and matrix arrangements, cellular manufacture, production lines), level of automation (manual, computer aided manufacture (CAM), fully automated, robotic).

Control – Infrastructure (monitoring of performance, quality assurance, quality control).

What do learners need to learn?

How the scale of manufacture affects the level of automation.

Examples of products made at different scales of manufacture.

Different types of manufacturing infrastructure, their purpose and relative advantages and limitations.

The purpose and application of CAM systems and software.

The advantages and limitations of different levels of automation.

2 Engineering and manufacturing past, present, and future

2.1 **Sectors** of the engineering industry.

Range:
Sectors – Aerospace, rail, agriculture, automotive, chemical, structural, materials, logistics, defence, electrical and electronic, control, medical, manufacturing, marine, petrochemical, power generation (renewables, non-renewables, nuclear), telecommunications, water and waste management.

What do learners need to learn?
An overview of the main activities, the products and/or services provided by the stated sectors.

2.2 Significant **technological advances** in engineering from a historical perspective.

Range:
Technological advances – Development of materials, electrical power and electrical sources of artificial lighting, the internal combustion engine, electric motors, replaceable parts and mass production, television (valves, cathode ray, LED, OLED, curved screens, 4K/5K), radio, automated machines, computers and the internet.

What do learners need to learn?
How technology advances and their operations have evolved and contributed to engineering, and social and economic development, to include transportation, healthcare, housing, employment and sustainability.

2.3 **Areas of innovation and emerging trends** in engineering.

Range:
Areas of innovation and emerging trends – Artificial intelligence (AI), virtual reality (VR), augmented reality (AR), digitalisation, robotics, drones, autonomous systems, distributed energy, hybrid technologies, cyber-physical systems, the internet of things (IOT), cloud computing, sustainability (product life cycle, circular economy, exploring alternatives, renewables, waste and disposal).

What do learners need to learn?
How innovation and emerging trends are evolving and could influence manufacturing, environmental considerations, social and economic development.

3 Engineering representations

3.1 **Drawings** and **information** conveyed by drawings.

Range:

Drawings – Computer aided design models, freehand sketching, isometric, orthographic projection (first angle, third angle, section, assembly, general arrangement), exploded views, block diagrams, flowcharts, circuit diagrams, schematics (wiring diagrams, pneumatics, hydraulics).

Information – Scale, title block, view (elevation, plan, end, section, auxiliary), types of line (outlines, hidden detail, centre line, projection, dimension, leader, construction), surface finish, manufacturing detail, standard features (screw threads, nuts, bolts, pins, repeated items, counterbore, countersink, centre mark), abbreviations (across flats AF, centre line CL, diameter DIA, drawing DWG, material MTL, square SQ, chamfer CHAM, countersunk CSK, hexagon head HEX, radius R, thread THD, undercut UCUT, pitch circle diameter PCD), graphical symbols used on drawings (projection symbols, diameter, surface finish).

What do learners need to learn?	Skills
The characteristics of, purposes of, and audience for different drawing types. The purpose and application of CAD systems and software. How to interpret and present information, symbols, conventions and annotations on engineering drawings in accordance with the conventions of BSEN8888 and BS3939.	MPC-CSA, MPC-CSD, MPC-CSE, MC3, DC4.

3.2 **Dimensions and tolerancing** on engineering drawings.

Range:

Dimensions and tolerancing – Dimensions (linear, diameter, radius, angular), tolerances, limits and fits, geometric dimensioning and tolerancing (GDT) symbols (datum, parallelism, perpendicularity, concentricity, straightness).

What do learners need to learn?	Skills
How to interpret dimensions and related drawing symbols. How to calculate tolerances, limits and fits.	MPC-CSC, MC4, MC8.

4 Essential mathematics for engineering and manufacturing

4.1 Applied **mathematical theory** in engineering applications.

Range:

Mathematical theory

Standard arithmetic – Ordering, integers, decimals, standard forms, fractions, percentages, ratios.

Algebra – Factorising and manipulating equations, solving quadratics, using indices and logarithms, determining numbers in a sequence, standard matrices and determinants.

Geometry – Calculation of areas and volumes.

Calculus – Graphs and charts relevant to engineering and manufacturing contexts, differentiation and integration.

Trigonometry – Pythagoras' theorem, triangle calculations, circular measure, trigonometric functions and graphs of trigonometric functions, sine and cosine rules, common trigonometric identities and values, applications of vectors and coordinates, scalars.

Statistical analysis – Analysis of data and calculation of probabilities in engineering contexts, estimation.

What do learners need to learn?	Skills
Perform arithmetic operations on integers, decimal numbers and numbers in standard form using rules of arithmetical preference: brackets indices division multiplication adding and subtraction (BIDMAS).	MC2, MC3, MC4, MC5, MC6, MC7, MC8.
Work to a specified number of decimal places or significant figures.	
Carry out calculations using fractions, percentages, ratios and scale.	
Simplify, factorise and manipulate equations to change the subject.	
Solve simultaneous and quadratic equations.	
Apply rules of indices.	
Apply laws of logarithms (base 10 and natural) - problem solving including problems involving growth and decay.	
Determine numbers in a sequence using arithmetic and geometric progression, power series.	
Addition, subtraction and multiplication of matrices in engineering contexts.	
Calculate the area of 2D shapes (square, rectangle, triangle, circle) and the volume of 3D shapes (cube, cuboid, cylinder, cone).	
Interpret and express changes in an engineering system from a graph (straight line, trigonometrical and exponential relationships).	
Determine the equation of a straight line from a graph (y = mx + c).	
Determine standard differentials and integrals (basic arithmetic operations, powers/indices, trigonometric functions).	
Calculate maximum and minimum values in engineering contexts using differentiation.	
Use of Pythagoras' theorem and triangle measurement.	
Circular measure including conversion between radians and degrees.	
Application of trigonometric functions (sin, cos, tan), their common values, rules and graphical representation.	
Determining dimensions of a triangle using sine and cosine rules.	
Common trigonometric identities (sec, csc, cot).	
Use of vectors including addition, dot and cross product.	
Calculation of range, cumulative frequency, averages (mean, median and mode) and standard deviation for statistical data in an engineering context.	
Determination of probabilities in practical engineering situations.	

4.2 **Number systems** used in engineering and manufacturing.

Range:
Numbering systems – Decimal, binary, hexadecimal.

What do learners need to learn?	**Skills**
How to identify and convert between numbering systems. The applications of numbering used in engineering and manufacturing.	MC5, MC6.

5 Essential science for engineering and manufacturing

5.1 **Units of measurement** used in engineering.

Range:

Units of measurement –

SI units: Metre (m), kilogram (kg), second (s), newton (N), metre cubed (m^3), metre per second ($m\ s^{-1}$), metre per second squared ($m\ s^{-2}$), newton metre (N m), Pascal (Pa or $N\ m^{-2}$), mass per unit volume ($kg\ m^{-3}$), unit multiples and submultiples (tera, giga, mega, kilo, milli, micro, nano, pico).

Imperial units: Foot (ft), inches (in), yard (yd), ounce (oz), gallon (gal).

What do learners need to learn?	Skills
The difference between base and derived units. The units applicable to different properties. How to convert between SI units and comparable imperial units. How to convert between different multiples and submultiples.	MC4.

5.2 **Vector and coordinate** measuring systems.

Range:

Vector and coordinate – Vectors and scalar quantities (distance, displacement, speed, velocity, acceleration), polar coordinates, Cartesian coordinates.

What do learners need to learn?	Skills
The definitions of, and differences between, scalar and vector coordinates. How to convert between Cartesian and polar coordinates where angles are in degrees.	MC4, MC7, MC8.

5.3 Scientific methods and approaches to scientific inquiry and research.

What do learners need to learn?	Skills
The concept of the scientific method (observation, questioning, making a hypothesis, prediction / simulation, testing, conclusion, iteration). How to analyse, evaluate, synthesise and apply information, data, research findings, deliberation, and the processes, results and outcomes of testing, modelling and experimenting (accuracy, reliability, precision and replication).	MPC-CSA, MPC-CSB, MPC-CSC

5.4 Measurement **equipment**, techniques and **principles**.

Range:

Equipment – Rule, callipers (digital, Vernier), micrometers (inside, outside, depth), gauges (angle, slip, go/no-go), dial test indicator (DTI), coordinate measuring machines (CMM).

Principles – Precision, accuracy, uncertainty, resolution, calibration, tolerance.

What do learners need to learn?	Skills
What can be measured by each item of equipment. The techniques used to carry out measurements using the stated equipment. The accuracy and relative limitations and benefits of the listed devices. How the principles and techniques are used in measuring and problem solving.	MC1, MC5, MC6, MC8, DC1, DC4.

5.5 **Chemical composition** and **behaviours**.

Range:

Chemical composition – Atomic structure (atom, nucleus, electron, proton, neutron, valence, valence shell, ion, element, molecule), chemical structure (solutions, suspensions, solubility, compound and mixture), periodic table.

Behaviours – Chemicals in electricity (cells (simple, primary and secondary), cell capacity, power capacity, internal resistance), electrolysis (anode, cathode, electrolyte, anion, cation, dissociation, plating, galvanic protection), reactions of metals and alloys with weak and strong acids and alkalis.

What do learners need to learn?	Skills
The definitions of the term atom, element, molecule, compound and mixture. The applications, characteristics, management and control of chemical interactions and reactions used in engineering (chemical etching, surface finishing, bonding, applications for oils and lubricants, high-risk operations).	EC4, MC3, MC5, MC6, DC1, DC4.

5.6 **Forces and motion** in engineering.

Range:

Forces and motion – Types of motion (rotary, linear, reciprocating, oscillating), pressure, vector representation of forces, balanced and unbalanced forces, moments about a force, torque, conditions for equilibrium, coplanar forces.

What do learners need to learn?	Skills
The application of theory and calculations to solve practical engineering problems involving forces and motion.	MC4, MC5, MC6, MC7, MC8, DC1, DC4.

5.7 **Fluid dynamics** in engineering.

Range:

Fluid dynamics – Hydrostatic pressure ($p = r\ g\ h$), hydrostatic thrust on an immersed plane surface ($F = \rho\ g\ A\ x$), centre of pressure, viscosity, Bernoulli's principle, immersion of a body, flow characteristics around a two-dimensional shape (laminar, turbulent, vortices, separation points), principles of aerodynamics (drag, thrust, lift).

What do learners need to learn?	Skills
The application of theory and calculations to solve practical engineering problems involving fluids. The key differences between liquid flow and aerodynamics.	MC4, MC5, MC6, MC7, MC8, DC1, DC4.

5.8 **Thermodynamics** in engineering.

Range:

Thermodynamics – Heat transfer mechanisms (conduction, convection, radiation), systems (open, closed, temperature, pressure, volume), sensible heat, latent heat of fusion, latent heat of vaporisation, expansivity, coefficient of heat transfer, equations (absolute temperature, absolute pressure, volume, mass, density, Boyle's law (pV = constant), Charles' law (V/T = constant), general gas equation (pV/T = constant), characteristic gas equation (pV = mRT)).

What do learners need to learn?	Skills
The application of theory and calculations to solve practical engineering problems involving thermodynamics.	MC4, MC5, MC6, MC7, MC8, DC1, DC4.

6 Materials and their properties

6.1 **Physical** and **mechanical** properties of materials.

Range:
Physical properties – Density, melting point, thermal and electrical conductivity (resistivity), thermal expansivity, corrosion resistance, specific heat capacity, hardenability, weldability, permeability, permittivity, ability to be recycled.
Mechanical properties – Strength (tensile, compressive, shear, torsion), hardness, toughness, brittleness, ductility, elasticity, plasticity, malleability.

What do learners need to learn?
The difference between physical and mechanical properties.
The definitions of the stated properties.
Calculation of density.

6.2 **Types** of material and their **structures**.

Range:
Types –

- Ferrous metals (cast iron, low carbon steel, medium carbon steel, high carbon steel, stainless steel).
- Non-ferrous metals (aluminium and alloys, copper, brass and bronze, nickel, zinc).
- Thermoplastic polymers (ABS, HIPS, PLA, sheet and polystyrene foam, polycarbonate, polypropylene, PMMA/acrylic).
- Thermosetting polymers (urea formaldehyde, melamine formaldehyde, phenol formaldehyde, epoxy resin, polyester resin).
- Elastomers (rubber, neoprene).
- Composites (GRP, CRP, MDF).
- Engineering ceramics (silicon carbide, glass).
- Timber (soft wood, hard wood, engineered wood).
- Smart materials: shape memory alloys, quantum tunnelling composite, thermochromic materials, photochromic materials, piezoelectric crystals.

Structures – Atomic structure (atoms, compound), bonding mechanisms (metallic, covalent, ionic, van der Waal's forces), microstructure (grains), lattice structure in metals (dislocation movement and pinning), crosslinking of polymers, ceramic structures (crystalline and non-crystalline (amorphous) materials), composite (particulate, fibrous, laminated).

What do learners need to learn?
The common forms of supply, relative properties, applications and methods of disposal of the listed materials.
The differences between: pure metals and alloys, ferrous and non-ferrous metals, thermoplastic and thermosetting polymers, composites and alloys.
The definition of a smart material, the characteristics and typical applications of smart materials.
The relationship between the structure of a material and its properties.
The difference between crystalline and non-crystalline materials.

6.3 The effects of processing **techniques** on materials.

Range:
Techniques –

Metals – forming (rolling, forging, moulding/press forming), welding, brazing, casting, sintering, coating, hot working, cold working.

Thermoplastic polymers – temperature, mould/injection pressure.

Thermosetting polymers – curing.

Ceramics – sintering pressing force and firing temperature.

Composites – influence of alignment of reinforcement on anisotropy of properties, influence of matrix/reinforcement ratio on tensile strength.

What do learners need to learn?

How the stated processes affect the structure, physical and mechanical properties of materials.

6.4 **Heat treatments** and **surface treatments**.

Range:
Heat treatments – Case hardening, quench hardening, tempering, normalising, annealing and precipitation hardening.
Surface treatments – Painting, plastic coating, galvanising and electrolytic (galvanic) protection.

What do learners need to learn?

How heat treatment and surface treatment processes affect the structure and properties of materials.

Common applications of each method.

6.5 **Causes** of material fand their **prevention**.

Range:
Causes – Corrosion (oxidation of metals including rusting of ferrous metals, chemical composition and attack, stress corrosion), aging, physical (deformation, fracture, fatigue, creep, erosion).
Prevention – Coatings, sacrificial anodes and cathodes, galvanising.

What do learners need to learn?

Materials fail due to corrosion as a result of material consumption, chemical composition and attack, reduction in thickness and perforation.

The factors that contribute to fatigue failure and the three stages of creep.

The different methods of preventing corrosion and their relative benefits and limitations.

6.6 Materials testing **methods** and **interpretation of results**.

Range:
Methods – Visual inspection, tensile testing, toughness testing, hardness, corrosion resistance, wear resistance, fatigue (Wohler), electrical conductivity.

Interpretation of results – Hooke's law, load-extension graphs (tensile strength, elastic limit, ultimate tensile strength, maximum plastic deformation, calculation of stress, strain and Young's modulus), characteristic graphs of different materials, necking and transition zone in steel.

What do learners need to learn?	Skills
The advantages and limitations of different testing methods. The steps involved in the materials testing methods and how these determine the material properties. How to interpret load extension graphs.	MC4, MC7.

7 Mechanical principles

7.1 Principles of **motion and mechanics** in engineering and manufacturing systems.

Range:
Motion and mechanics – Newton's three laws of motion, types of forces (concurrent, non-concurrent, co-planar, non-contact), simply supported beams (loading, load distribution (point, uniformly distributed, combination of point and uniformly distributed), reaction forces, loaded components, shear force, bending moments).

What do learners need to learn?	Skills
The practical application of Newton's three laws of motion, including appropriate calculations. Calculation of stated variables for simply supported beams.	MC2, MC4, MC7, MC8.

7.2 Principles of **forces and energy**.

Range:
Forces and energy – Principle of conservation of momentum, principle of conservation of energy, D'Alembert's principle, potential and kinetic energy, gravitational force, frictional resistance, mechanical work, power, types of power sources (mechanical, electrical, renewable).

What do learners need to learn?	Skills
Calculations using equations of motion to determine displacement, velocity and uniform linear acceleration relating to falling objects and collisions between two objects in line. Explanation and examples of tractive effort, braking force, frictional resistance, rotational kinetic energy, moment of inertia, mechanical work, power in practical applications (fly wheels, springs, height, pressurised fluids). The function and relative advantages of the alternative power sources and examples of their use, including solar, hydro, wind, biofuel, geothermal, electric motors, internal combustion, fossil fuels, nuclear.	MC2, MC4, MC7, MC8.

8 Electrical and electronic principles

8.1 **Principles** of electrical and electronic systems.

Range:

Principles –

Basic principles of electricity and electronics – flow of electrons, charges, energy, power, networks, force, current, capacitance, waves, conduction, magnetism (flux density, field strength), electromagnetism, inductance, measurements of electrical quantities in electrical systems (standard units of measure, multimeters).

Electric circuit theories – voltage, current (alternating current (AC), direct current (DC)), power, resistance, potential difference and dividers, basic electrical elements, Ohm's law (series, parallel and combination circuits), Kirchhoff's current and voltage laws, phasor diagrams, protection systems (lightning arrestors, time graded over current protection, distance protection), residual current devices (RCD)).

DC circuit networks – resistors, capacitors and inductors in series, parallel circuits, combined circuits, semiconductors (forward and reverse bias, N-type and P-type), hierarchical design.

Signals – types (analogue, digital), waveforms (sinusoidal, square, rectangular, triangular, sawtooth), signal processing, signal conditioning, fan in and fan out.

What do learners need to learn?	**Skills**
The physical principles underpinning electrical and electronic systems and devices. The basic properties and principles of magnetism and electromagnetism and their common applications. The relationship between flux density and field strength. The definitions of terms used in electric circuit theory and their applications. The use of Ohm's law and electric circuit theories to calculate values in circuits, such as voltage, current and resistance. The relationship between voltage, current and power in AC circuits and how to represent them in graphs and phasor diagrams. Factors affecting the operation and applications of high-power electrical equipment and electronic devices. How differential protection schemes work to protect transmission lines. How transformer protection schemes work for common faults. The characteristics of DC circuit networks comprising resistors, capacitors and inductors in various arrangements, including time constants. The properties and applications of semiconductor diodes and transistors. The characteristics of the different concepts related to signals. The characteristics of analogue and digital systems, including their waveforms and applications.	EC1, EC2, MC2, MC4, MC5, MC7.

9 Mechatronics

9.1 The key **components** of a mechatronics system.

Range:
Components – Mechanical (gears, cams, linkages, levers, pulleys), electrical/electronic (sensors and transducers, microprocessors, microcontrollers, actuators), common drive devices (standard electrical motors, servo motors, stepper motors).

What do learners need to learn?
Mechatronics is the integration of mechanical and electronic systems to produce a functioning system.
The purpose and function of the mechanical and electrical components.

9.2 The **operation**, **function** and **applications** of **programmable logic controllers (PLC)** in mechatronic systems.

Range:
Programmable logic controllers – Types (unitary, unitary with modular features, modular), architecture.
Operation – Sensor signal conditioning, programming.
Function – Process blocks, motor driver integrated circuits, interface devices.
Applications – Robotic arms, conveyor belts, packaging, supervisory control and data acquisition (SCADA), remote technical units, animatronics.

What do learners need to learn?	Skills
The differences between the types of PLCs. An overview of how a PLC operates. An overview of the functions. The advantages and limitations of using PLCs for the applications given, compared to the alternatives (dedicated integrated circuits, computer-based systems).	DC1

9.3 The basic **principles** of hydraulics and pneumatics.

Range:
Principles – Transmission of power, fluid compressibility, components (valves, pumps, actuators, cylinders, compressors).

What do learners need to learn?
The differences between hydraulic and pneumatic systems, and their advantages and limitations.
The purpose and function of the stated components and how they are they are represented on schematic diagrams.

10 Engineering and manufacturing control systems

10.1 **Principles** and **applications** of control system theory.

Range:

Principles – Input, process (logic gates (AND, OR, NOT), timer, comparator, pulse unit, counter, latch), output, signal, feedback, open and closed loop systems, transfer function, summing points, analogue, digital, pulse width and amplitude modulation, how control systems are represented in diagrams.

Applications – Electrical, pneumatic, hydraulic, measured parameters (pressure flow, temperature, speed, position).

What do learners need to learn?	Skills
How to produce a system diagram with multiple inputs, outputs, a combination of process blocks and feedback, and explain its operation. Applications of open and closed loop control systems (under or over-damped, and time dependency). The advantages and disadvantages of open and closed loop control systems. The relationship between input and output (steady rate error). The relative advantages and disadvantages of analogue and digital signals in control systems. Applications of control systems in industry, including effective and efficient networked communication and data transmission.	MC5, DC1, DC4, DC6.

10.2 How **sensors and actuators** are **used in automation** control systems.

Range:

Sensors and actuators – Types (analogue, digital, active, passive), applications (switches, proximity sensors, laser, vision systems), power sources, hard-wired, wireless.

Uses in automation – Position and volume of objects being processed, mechanised lifting and moving of objects, measurement applications (electrical, mechanical, thermal, chemical, biological, optical, acoustic, radiation).

What do learners need to learn?	Skills
The purpose and function of the different types of sensors and actuators. Applications and uses of sensors and actuators.	DC1, DC4, DC6.

11 Quality management

11.1 Quality **standards**, **assurance, control** and **improvement**.

Range:
Standards – British standards, ISO standards, CE, engineering bodies (Engineering Council, Institution of Engineering and Technology (IET), Institution of Mechanical Engineers (IMechE), Society of Operations Engineers (SOE), Chartered Institution of Building services Engineers (CIBSE), Institute of Agricultural Engineers (IAgrE), Institute of the Motor Industry (IMI), The Welding Institute (TWI)).
Assurance and control – Culture of quality, right first time, quality standards (ISO9001), inspection and testing, traceability, document management and version control, process capability, statistical process control (SPC), six sigma, total quality management (TQM).
Improvement – Failure mode effect analysis (FMEA), Pareto analysis, cause and effect diagrams, quality circles.

What do learners need to learn?	**Skills**
The function, purpose and value of standards (safety, quality, compliance) and how to access this information. The roles and responsibilities of the engineering bodies. The main principles, purposes and outcomes of quality assurance, quality control, inspection and testing. The difference between quality control and quality assurance. The main requirements of quality standards. The reasons for document management and version control. The advantages and disadvantages of 100% sampling compared to statistical process control (SPC). The use of six sigma for high volume manufacture. The main principles, purposes, advantages and disadvantages of different approaches to quality improvement.	MPC-CSD, MC4, MC5, MC7.

11.2 **Types and applications** of Standard Operating Procedures (SOPs) and their **purposes**.

Range:
Types and applications – Manufacturing, quality, maintenance.
Purposes – Standardisation of activity, customer satisfaction, safety, training.

What do learners need to learn?	**Skills**
The typical format and content of SOPs. How SOPs are used in the different applications. The reasons for using SOPs (consistency, conformance to standards). How SOPs are produced, implemented and evaluated.	MPC-CSE, EC1, EC3.

12 Health and safety principles and coverage

12.1 The main requirements of key health and safety **legislation** applicable to engineering activities.

Range:
Legislation –

The Health and Safety at Work Act (HASAWA)
Management of Health and Safety at Work Regulations
Provision and Use of Work Equipment Regulations (PUWER)
Personal Protective Equipment (PPE) Regulations
The Control of Noise at Work Regulations
Manual handling operations regulations
Lifting operations and lifting equipment regulations (LOLER)
Work at Height Regulations
Electricity at Work Regulations
The Control of Electromagnetic Fields at Work Regulations (CEMFAW)
Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR)
Control of Substances Hazardous to Health (COSHH)

What do learners need to learn?	**Skills**
The main requirements of the current key legislation, how to access it and how it affects their own activities in the workplace. That the legislation should be satisfied by their company's safe systems of work and other procedures, and they therefore do not need to know every detail of the law. The purpose of legislation within the engineering industry: · why there is a need for the legislation · that there is legislation to cover every aspect of the workplace · how the legislation keeps them safe in the workplace · who is responsible for compliance with current regulations and legislation · health and safety culture, training and information	MPC-CSA.

12.2 The importance of health and safety practices within the workplace.

What do learners need to learn?
How health and safety legislation affects the frequency of accidents and related incidents. The importance of mental health and wellbeing in the workplace. The persons responsible for ensuring compliance – employer, employee, Health and Safety Executive (HSE). Implications of non-compliance.

12.3 **Responsibilities** for health and safety.

Range:

Responsibilities – Individual, employee and employer obligations, local, national, and global requirements.

What do learners need to learn?

Health and safety responsibilities of employees, including:

- work safely so as not to cause injury to self and others in the vicinity
- not to attempt any work task unless trained and authorised to do so
- co-operate with the employer to enable the duties placed on the employer to be performed
- have regard of any duty or requirement imposed upon the employer or any other person under any of the statutory provisions
- not interfere with or misuse anything provided in the interests of health, safety or welfare

Health and safety responsibilities of employers, including:

- minimising risks in the handling, storage and transport of articles and substances
- instruction, training and supervision to maintain high standards of health and safety at work
- maintaining the workplace and its environment to be safe and minimising risk to health
- to provide a statement of general health and safety policy
- provide arrangements for safety representatives and safety committees
- ensure the safety of visitors, contractors and members of the public

Differences between local, national and global requirements.

12.4 **Risk assessment**.

Range:

Stages of **risk assessment** – Identification of hazards (hazard and operability study (HAZOP), hazard identification (HAZID)), evaluation of risks (likelihood, severity, number of people affected), implementation of control measures (hierarchy of control: elimination, reduction/substitution, isolation, controls, administration/training/safe system of work, PPE).

What do learners need to learn?

The hazards associated with engineering and manufacturing contexts (equipment, stored energy, tools, electricity, harmful substances including gases, environments).

Common industrial injuries that can occur without appropriate precautions.

Methods of identifying hazards.

How to evaluate risks.

The hierarchy of control for control measures.

Types of control measures typically used in engineering (guarding, machine isolation, PPE (eye protection, safety shoes, ear protection, gauntlets, helmets).

12.5 Health and safety **considerations** in specific engineering **contexts**.

Range:

Considerations – Safe systems of work, oxygen use in the workplace, asphyxiation hazards, heat, moving parts, fire and explosion hazards, fire safety, guarding, manual handling, permit to work, lock out tag out (LOTO), maintenance.

Contexts – Chemicals, equipment with moving parts, confined spaces, electrical testing, high voltage electrical (generation, distribution, isolation and storage).

What do learners need to learn?

The different considerations appropriate to a range of engineering contexts.

12.6 Principles and practices relating to environmental **legislation** and **considerations**.

Range:

Legislation –

- Environmental Protection Act
- Pollution Prevention and Control Act
- Clean Air Act
- Radioactive Substances Act
- Controlled Waste Regulations
- Dangerous Substances
- Hazardous Waste Regulations

Considerations – ISO 14001, waste disposal.

What do learners need to learn?

The main requirements of the current key environmental legislation, how to access it and how it affects their own activities in the workplace.

That the legislation should be satisfied by their company's environmental policies and other procedures, and they therefore do not need to know every detail of the law.

The purpose of legislation within the engineering industry:

· why there is a need for the legislation

· who is responsible for compliance with the regulations

ISO 14001: Aims, benefits and consequences.

Methods of waste disposal (landfill, reuse, recycling, controlled waste) and their implications.

13 Business, commercial and financial awareness

13.1 **Principles** of commercial operations and **markets**.

Range:
Principles – Commercial priorities (profit, addressing stakeholder needs), efficiency, value added, non-value added, competition, supply and demand.
Markets – Customers, local, national, international.

What do learners need to learn?
The goals of commercial operations and how these are addressed.
How organisations address the needs of different customers and markets.
How organisations evaluate activities in terms of quality, cost and time.
The role of research and development and innovation to address changing customer needs.

13.2 Business and commercial **practices**.

Range:
Practices – Legal (tendering, contracts, warranties, force majeure, indemnity clauses, liabilities), management (resource allocation and planning, staffing, training and development), business models (traditional, agile), company management systems, policies and procedures.

What do learners need to learn?
How business practices influence the operation of engineering organisations.
The legislation affecting tendering and contracts.

13.3 Financial and economic **concepts**.

Range:
Concepts – Financial responsibility, recording financial transactions, sources of finance (loans, shares, capital), budgets, transactions, costs (direct, indirect, overheads), payment terms, revenue, creditors and debtors, cash flow, profit and loss, break even, assets (depreciation), liabilities, solvency, taxes, rates.

What do learners need to learn?
The meaning of the stated financial concepts and their implications for the operation of a business.

14 Professional responsibilities, attitudes, and behaviours

14.1 Professional **conduct and responsibilities** in the workplace.

Range:
Conduct and responsibilities – Job descriptions, behaviours required in the workplace, personal conduct (reputation, ethical responsibilities), levels of accountability in organisational structures (apprentice, operator, management, director), equality, diversity, accessibility, inclusion.

What do learners need to learn?

Purpose, function and typical content of job descriptions.

How behaviour and personal conduct in the workplace influence interactions with people.

How to seek advice and guidance, where necessary.

Expectations for reputation and ethical behaviour in the workplace.

The main responsibilities of the different roles in an organisation and how they affect the business in terms of accountabilities and inter-dependencies.

The main duties of an organisation regarding equality, diversity, accessibility and inclusion.

14.2 Continuous professional development (**CPD**) and professional recognition.

Range:
CPD – Training courses, industry placement, academic study, events and seminars.

What do learners need to learn?

What is CPD and how it motivates staff and improves performance.

Professional standards for engineering, as set out by the Engineering Council.

14.3 **Human factors** within engineering and manufacturing contexts.

Range:
Human factors – Human characteristics (physical, mental), workplace design (considerations, assessment criteria), human error.

What do learners need to learn?

How human characteristics, capabilities and limitations affect the company and production.

How the design of the workplace affects safety, comfort and productivity.

Causes of human error (insufficient training, fatigue, workload, stress) and methods to reduce these.

15 Stock and asset management

15.1 Stock and inventory management **principles** and **practices**.

Range:
Principles – Demand, stock turnover, cost of inventory, redundant stock / write down, obsolescence, minimum stock levels, supply chain, packaging/storage.
Practices – Just in time, made to stock, made to order, material requirements planning.

What do learners need to learn?
The purpose of effective stock and inventory management and control.
Key issues, risks, advantages and disadvantages associated with the different practices.

15.2 Asset management and control **principles**.

Range:
Principles – Capacity management (manufacturing resource planning, bottleneck), key stages of asset life cycle management (planning, acquisition, operation and maintenance, disposal), budgetary control practices (life cycle, whole life approach, depreciation).

What do learners need to learn?
The purpose and methodology of effective asset management.
Advantages and disadvantages associated with methods of capacity management.

16 Continuous improvement

16.1 Continuous improvement **principles** and **practices**.

Range:

Principles – Reflection and evaluation of processes, incremental change and improvement, key performance indicators (KPIs), implementation (plan, do, check, act – PDCA), 8 wastes (transportation, inventory, motion, waiting, excess production, overprocessing, defects, unused talent), lean, Kaizen.

Practices – Value stream mapping, visual management, 6S (sort, set in order, shine, standardise, sustain, safety), single minute exchange of dies (SMED), operation effective efficiency (OEE), total productive maintenance (TPM), kanban.

What do learners need to learn?	**Skills**
Methods of gathering feedback and evidence about performance, including types of KPIs and how these can be used to evaluate continuous improvement activities. How the 8 wastes affect the performance of engineering activities. Purpose, methodology, benefits and limitations of the different practices.	MPC-CSD.

17 Project and programme management

17.1 **Principles** of project management.

Range:
Principles – Project brief, project goals, success criteria, project life cycle (initiation, planning, implementation, monitoring, reporting, evaluation), constraints, risk management (budget, cost, quality, time, safety, resource availability, communication, reputation, changing requirements), collaborative working (matrix working, collaborative technologies).

What do learners need to learn?	Skills
How projects are defined and structured. The management practices, processes and documentation needed at each stage of the project. Types of risk and how these are managed throughout the life of the project, including the role of research and development. The benefits and limitations of collaborative working.	MPC-CSB.

17.2 **Roles** and **responsibilities** in projects.

Range:
Roles – Stakeholders (clients, regulators), project manager, team members.
Responsibilities – Communication, monitoring, planning, finance, reporting.

What do learners need to learn?
The responsibilities of the different roles and how they contribute to a project.

17.3 Project **planning** and **control**.

Range:
Planning – Resource requirements (time, budget, human resources, training needs, communication needs, production facilities), Gantt charts, critical path analysis (CPA), project evaluation review technique (PERT), management of interdependencies, contingency planning.
Control – Monitoring reports (budget, quality, cost, time), manage by stages, manage by exception.

What do learners need to learn?	Skills
How to identify the resources required to carry out a project. The benefits and limitation of the different planning methods. How to plan projects using the different methods. How to monitor and evaluate the progress of projects. The reasons for reviewing and evaluating of projects to improve subsequent projects.	MC9.

Guidance for delivery

A variety of active teaching and learning activities should be used to engage learners in this common core. Opportunities for visits/engagement with local industry, employers and manufacturers should be provided throughout the delivery of the content – where appropriate, local employers could present details of recent projects, problems faced and how they were overcome. Learners' work placement experiences could be presented to peers detailing where knowledge and skills within the content was seen in practice.

Formative assessment for the content may include verbal Q&A, presentations to peers, observation of stock control activities etc. Reinforcement of learning can be encouraged through revisiting learning, group discussions, and the establishment of a peer support system within the cohort.

Providers must ensure content is delivered in line with current, up to date industry practices which will require:

- Current industry legislation, regulations, and technical information.
- Teaching coverage representing the type of equipment currently available and accepted for use in the UK industry.

Suggested learning resources

Books

- T F Waters, *Fundamentals of Manufacturing For Engineers*, CRC Press, 2017, ISBN: 113843485X
- Christoph Roser, *Faster, Better, Cheaper in the History of Manufacturing: From the Stone Age to Lean Manufacturing and Beyond*, Productivity Press, 2016, ISBN: 9781498756303
- Colin H Simmons, Dennis E Maguire, *Manual of Engineering Drawing: Technical Product Specification and Documentation to British and International Standards*, 3rd Edition, Butterworth-Heinemann, 2009, ISBN: 9780750689854
- Paul Clayton, *Essential Math Skills for Engineers*, John Wiley & Sons, 2009, ISBN: 9780470405024
- Millard F Beatty, *Principles of Engineering Mechanics: Volume 2 Dynamics - The Analysis of Motion (Mathematical Concepts and Methods in Science and Engineering)*, Springer, 2005, ISBN: 0387237046
- Gerardus Blokdyk, *Stock Management A Complete Guide - 2020 Edition*, 5STARCooks, 2021, ISBN: 1867301091
- Jeffrey Liker, *The Toyota Way, Second Edition: 14 Management Principles from the World's Greatest Manufacturer*, McGraw-Hill Education, 2020, ISBN: 1260468518
- David Shonnard, David Allen, *Sustainable Engineering: Concepts, Design and Case Studies*, Pearson, 2011, ISBN: 0132756544

Websites

- Engineering Industry Trends for 2020 - blog.v-hr.com/blog/engineering-industry-trends-for-2020
- Introduction to Engineering Mechanics - youtu.be/ksmsp9OzAsI
- Research Trends in Sustainable Manufacturing - link.springer.com/article/10.1007/s40684-019-00113-5
- Innovation Engineering - www.innovation-engineering.net/
- Principles of Sustainable Engineering - www.e-education.psu.edu/eme807/node/688
- ISO management standards in Engineering and Manufacturing - www.nqa.com/en-za/certification/sectors/engineering-manufacturing
- List of Environmental Laws - www.field.org.uk/list-of-environmental-laws
- Application of Newton's Laws - engineeringlibrary.org/reference/application-of-newtons-laws-doe-handbook
- Management: Drivers of Behavior - courses.lumenlearning.com/boundless-management/chapter/drivers-of-behavior

331 Fitting and assembly technologies

Level:	3
GLH:	680
Assessment method:	Practical assignment

What is this specialism about?

The purpose of this specialism is to engage with the technical expertise, technology, methods, and skills involved in producing items or assemblies (generally on an industrial scale), using specialist tools, equipment and machinery.

Learners will examine a range of production processes, systems, and facilities, investigating factors such as scale, efficiency and demand, the application of quality management, and the analysis and optimisation of conditions, processes and practices when producing high-quality products for a variety of purposes.

Learners will develop their knowledge and understanding of, and skills in:

- Scientific and mathematical principles along with production and materials awareness.
- Suitable tools and equipment, machines and technology widely used in production along with fault finding and diagnosis.
- General workplace practices and production standards.
- Regulatory and legal requirements, specifically health and safety and employment.
- Project and programme management principals incorporated into general business and commercial aspects of production.
- Production quality aspects and communications in the workplace.
- Drawings and tools used in production.
- The planning, preparation, and production of products.
- Communications and supporting production activities.

Learners may be introduced to this specialism by asking themselves questions such as:

- Do I enjoy coming up with ideas and thinking about how I could turn them into a physical product?
- Am I a team player? Do I like working with others in a team environment towards a common goal?
- Am I a planner? Do I like planning things out and trying to decide how a sequence of events will work together to deliver a product?
- Do I get enjoyment from assembling and taking things apart to see how they work and then putting them back together?

Underpinning knowledge outcomes

On completion of this specialism, learners will understand:

1. Fitting and assembly technologies knowledge criteria.

Performance outcomes

On completion of this specialism, learners will be able to:

2. Analyse projects and specifications, considering the specific requirements, context, resources, tools and equipment, and the suitability of different production technologies, processes, and methods.
3. Plan and prepare relevant materials, resources, tools, and equipment needed to produce the relevant products and outcomes.
4. Produce relevant products and outcomes, considering the specified requirements, context, and materials, using the relevant fitting and assembly technologies, methods, and processes.
5. Support the delivery (and the management) by helping to evaluate and review the outcomes to improve the final product, production methods, and workplace practices and processes.
6. Communicate production information, proposals, and solutions, producing, recording, and explaining relevant technical information, representations, processes, and outcomes.

Completion of this specialism will give learners the opportunity to develop their maths, English and digital skills. Details are presented at the end of the specification.

Specialism content

Knowledge criteria for performance outcomes

1.1 Planning, preparing and implementing manufacturing and processing activities.

Range:

Plan - Location, types of facility needed, space requirements, equipment requirements (types, costs, operational processes), people (skilled, unskilled), materials, processes, costs, timescales, quantity, quality control/assessment, finished product (design/finish).

Technical information - Engineering drawings (design, tooling, detail, sub-assembly, assembly), circuit diagrams, specifications, design concepts, data sheets, test records, maintenance records, work instructions, flow charts, plans, manufacturer's manual/documentation. standard operating procedures (SOP), instructions, inspection documents.

Scale of work - Prototype, batch, mass production, continuous production.

Cost break points and other factors - Revenue, costs, profit and loss, average rate of return, investment (jigs, fixtures, automation).

What do learners need to learn?	**Skills**
The difference between the scale of work in production, manufacturing and processing activities. How to plan and prepare for the activities. The **technical information** needed to achieve specific outcomes. How to interpret information to create a manufacturing production **plan**. How to produce a plan to the correct **scale of work.** **Cost break points and other factors** for selecting assembly and manufacturing methods.	N/A

1.2 Common **production machines** and their applications.

Range:

Types - Manual, Computer Numerical Control (CNC).

Machines - Lathes, milling, drills, grinding, welding, 3D printers.

Purpose - Cut, rout, drill, turn, press, bend, slot, grind, join, turn, erode.

Parameters - Positional (position of workpiece, position of tool in relationship to workpiece), dynamic (tooling, workpiece or cutter revolutions per minute), pressure, linear feed rate, depth of cut for roughing and finishing, swarf clearance.

Consequences - Poor quality product, product does not meet specification, out of tolerance, material wastage, injuries to operator, damage to machinery/working parts.

Work holding devices - Chucks, jigs and fixtures.

What do learners need to learn?	Skills
The **types** of **machines** used in production. The **purpose** of each type of machine and their primary use. How the machines operate to remove material to produce semi or fully finished parts. The **parameters** of the machines. The use of guarding on exposed parts of the machinery. **Consequences** of a poorly set up machine and the risks the operator could be exposed to. The correct set up and use of **work holding devices** for a variety of machines. The use of additive manufacturing and 3D printing as lineside tools.	N/A

1.3 **Measurement techniques.**

Range:

Measurement techniques - Direct measurement; rules, tapes, micrometres, Vernier callipers and CMM machines; indirect measurement; thread gauges, gauge blocks, and comparison plates, optical and laser.
Estimation - Standard time calculation, engineering time standards.

What do learners need to learn?	Skills
The purpose of, and uses of a range of **measuring techniques**, devices, accuracy levels and practical applications that they may be used for measurement activities. Factoring used in **estimation**, the application of standard times to production. tasks to estimate costs and durations. How to apply correct **measurement techniques**. How to apply measurement to the stages of the manufacturing process from estimating material quantity and costs through to dimensional inspection, with regard to product or process specification. Imperial and metric measuring conventions and units of measurement. The importance of calibration and the importance of re-calibration.	N/A

1.4 **Component classification, numbering** and **referencing systems**.

Range:

Component classification - Passive, active.
Numbering - Part numbers, identification numbers, material lists, labelling, specifications, traceability.
Referencing systems - Identification codes and technical data, manufacturers data sheets, manufacturers safety specifications, colour codes, component numbering, schematic diagrams, BS and ISO Standards.

What do learners need to learn?	Skills
The purposes and applications of **component classification, numbering** and **referencing systems**. How to interpret current BS and ISO standards related to production activities, including classification, numbering and referencing. The purposes and applications of electronic systems that measure performance.	N/A

1.5 **Classification, application** and **disposal requirements** of materials.

Range:

Properties - Ductility, malleability, hardness, toughness, tensile strength, elasticity, compressive and shear and modulus of rigidity.

Classification - Ferrous, non-ferrous, ceramics, polymer and composites.

Materials:

Metals - Ferrous (stainless steel, cast iron, high speed steel, silver steel, low, medium and high carbon steel), non-ferrous (aluminium, alloys, copper, lead, brass, bronze and zinc).

Polymers – Thermosets (urea formaldehyde, melamine formaldehyde, phenol formaldehyde, epoxy resin, polyester resin), thermoplastics (ABS, HIPS, PLA, polycarbonate, polypropylene, PMMA/acrylic).

Composites - Glass fibre, carbon fibre, aramid fibre.

Elastomers - Rubber, neoprene.

Considerations – Corrosion, degradation, interaction of dissimilar materials.

Disposal - General waste, recycling, re-use, hazardous and non-hazardous waste.

Waste - Used materials, used liquids, off cuts, swarf, shavings, hazardous and non-hazardous materials.

Legislation - Environmental Protection (Duty of Care) Act 1990, Hazardous Waste (England and Wales) Regulations 2005, Waste Management (England and Wales) Regulations 2006, Control of Pollution (Applications, Appeals and Registers) Regulations 1996, Trade Effluent (Prescribed Processes and Substances) Regulations 1989.

Forms of supply - Loose bulk materials, sacks, bags, pallets, sheet materials, bars, ingots, castings, plate, pipes and tubing, wire, rolled sections, powders, liquids (resins, coolants, lubricants).

What do learners need to learn?	Skills
The **classification** and types of common materials. The **properties** of the different material and the material **considerations** prior to selection for a given application. The **forms of supply** for common materials used in the manufacturing and production process. The considerations that must be made for **disposal** of various materials and **waste** in accordance with organisational policies and environmental **legislation.**	N/A

1.6 Standard technical **documentation**.

Range:

Documentation - Engineering drawings (design, tooling, detail, sub-assembly, assembly), circuit diagrams, specifications, design concepts, data sheets, test records, maintenance records, work instructions, flow charts, plans, manufacturer's manual/documentation. standard operating procedures (SOP), instructions, inspection documents.

Standard Operating Procedures - Technical, management, types (checklists, step-by-step lists, hierarchical lists, process flowchart).

Drawings - 2D, 3D, solid models exploded views, flat patterns.

What do learners need to learn?	**Skills**
The purposes and types of a selection of standard technical **documentation**. How technical **documentation** is produced and who is responsible for its production. How to interpret technical **documentation** and who or what to refer to for guidance. How amendments are made to technical **documentation**, who is responsible and who to refer to for authorisation. Overview of all types of manufacturing documents used in a wide range of manufacturing sectors. How to read and interpret the **drawings.** The correct representations, symbols, annotations, and conventions used, as outlined in BS 8888. How to identify specific **requirements** and extract information to form material or cutting lists. Different types of **Standard Operating Procedures (SOP).** How Computer Aided Production Planning (CAPP) is being used to convey instructions in the workplace.	N/A

1.7 **Hand tools, power tools** and **measuring equipment**.

Range:

Hand tools - Saw, wrench, spanner, pliers, screwdrivers, allen keys, files, engineers square, scriber, center punch, taps, reamers, hammer, punch.

Measurement equipment - Rule, callipers (vernier, digital), micrometres (outside, depth), gauges (angle, slip, go/no-go), dial test indicator (DTI), coordinate measuring machines (CMM).

Power tools - Cordless drill, hammer drill, mag-base drill, electric screwdriver, band saw, angle grinder, bench grinder, sander, compressed air driven tools, portable welding plant (MMA, MIG and TIG).

Maintain - Cleaning, lubricating, sharpening, charging.

Regulations, guidelines and instructions - Work instructions, operating procedures, health and safety legislation and regulations (HASAWA, PUWER), risk assessments, maintenance records, manufacturer's manuals.

What do learners need to learn?	Skills
How to correctly select **hand tools and power tools** and **measuring equipment** that are the most appropriate for various production tasks. How to correctly prepare tools and equipment making adequate and reasonable checks on their condition prior to use. How to adequately **maintain** the tools and equipment after use. How to suitably record and report any faults identified in the condition or performance of the tools. The process/procedure to take damaged or faulty equipment out of service until returned to a suitable condition. Who the authorised and most appropriate person is to ask for advice and guidance. The relevant **regulations, guidelines and instructions** that must be checked and followed when preparing, using, or maintaining tools and equipment.	N/A

1.8 Using **specialist machinery** and technology.

Range:

Specialist machinery - CNC machines (router, plasma cutter, laser cutter, milling machine, lathes, drilling machines, grinding machine).

Problems - Risk, issue, unexpected activity, excessive noise, heat, vibration, smell.

Faults - Visual, vibration, noise, power failure (electrical, pneumatic, hydraulic) leaks, jams, blockages.

Detection - Sensory (noise, vibration, visual, smell).

Isolation - Mechanical, electricity, gas, air, fluids.

Resolution - Six-point technique, quantitative, qualitative.

Parameters - Positional (position of workpiece, position of tool in relationship to workpiece), dynamic (tooling, workpiece or cutter revolutions per minute), pressure, linear feed rate, depth of cut for roughing and finishing, swarf clearance.

What do learners need to learn?	Skills
How to safely set up a range of **specialist machinery** and technology to the correct **parameters**. How to use a range of **specialist machinery** effectively to meet specification requirements. The importance of following guidelines and instructions. The risks to quality, cost and health and safety of non-compliance. Who the appropriate person is to ask for advice and guidance, if and when necessary. The **detection** and identification of **problems** or **faults** with **parameters**, machinery and **isolation** methods. Methods of **resolution** or escalation of issues.	N/A

1.9 Compliance with standard **workplace practices**.

Range:

Standard Operating Procedures - Technical, management, types (checklists, step-by-step lists, hierarchical lists, process flowchart).
Workplace practices - Safe systems of work, permits to work, risk assessments, work instructions, standard operating procedures (SOP), user guides, operational instructions.
Practices - Health and safety, regulations, legislation (PUWER).
Activity - Planning, preparing tools/equipment, using tools/machinery, maintaining tools/machinery.

What do learners need to learn?	**Skills**
The various formats of **Standard Operating Procedures** (SOP) and how to interpret and work to them. The typical **safe workplace practices** contained in an SOP and how the importance of **compliance** with them and any specific instructions. Health and safety documentation including risk assessments, permits. How to comply with standard workplace practices for the relevant **activity**. The consequences of non-compliance on self and others.	N/A

1.10 Engineering **standards**.

Range:

Standards - Quality management (BS4500, ISO 9000, 9001), environmental management (ISO 14000, 14001), risk management (ISO 31011), social responsibility (ISO 26000).
Application - Quality, environmental, risk, social responsibility.
Sector - Aerospace, nuclear, power, utilities, automotive.

What do learners need to learn?	**Skills**
The purpose of a range of **standards.** The types of **standards** used in engineering and a variety of manufacturing **sector** workplaces. The **application** of the **standards** in a manufacturing workplace. The systems and procedures put in place to ensure they are adhered too.	N/A

1.11 Legal and regulatory frameworks, documentation and authoritative information.

Range:

Standards - British (BS), European (EN), International (ISO) ISO 9001, ISO 8062.
Health and safety procedures - Health and safety policy, risk assessments, emergency procedures.
Consequences - Improvement and enforcement notices, prosecution (fines, imprisonment, compensation claims), organisation reputation damaged .
Sources – Websites (Gov.UK, HSE, Equalities Commission), e-books, printed texts/matter.

What do learners need to learn?	Skills
The key points of health and safety legislation that provide a framework for more specific, task-focused activities. The company's **health and safety procedures**, specifically those related to the learner's role, responsibilities and functions. The importance of complying with legislation and **standards.** The **consequences** of breaches in legislation and standards on the individual and the organisation. How to access **sources** of authoritative information.	N/A

1.12 Site and process **safety, environment and risk management systems and practices.**

Range:

Safety, environment and risk management systems and practices - Health and safety management system (HSG65) generic risk assessment, COSHH, manual handling, young people, PUWER assessments, Environmental Management System (EMS).

What do learners need to learn?	Skills
The role of individuals and the impact they can have when upholding health and safety and organisational policies in a workplace. The purpose and function of **safety, environment and risk management systems and practices.** The typical emergency systems and procedures that would be in place for a manufacturing and processing environments. Reporting procedures and who to inform. How to interpret a health and safety management system (HSG65). How to interpret information from an Environmental Management System (EMS).	N/A

1.13 Completing and recording relevant **quality processes** in production contexts.

Range:

Quality processes - Policies, procedures, guidance, second line verifications, organisational systems and requirements, sensory checks, checklists, maintenance instructions, data, reports, measurement, analysis of systems.

Documents - Maintenance logs, defect logs, reports, statements, checklists, equipment.

Inspection parameters - Functional (mating parts), dimensional (overall sizes, hole tolerances, mass), comparative (surface roughness), completeness, colour.

Inspection documents - Checklists, documents for quantitative and qualitative information.

What do learners need to learn?	Skills
The purpose of quality inspection, testing and recording through **quality processes.** The range of typical **inspection parameters** measured and checked during a production run. A range of typical **documents** used in production to record data and inspections. How **inspection documents** are configured and what data needs to be recorded, how often, and in what format.	N/A

1.14 Business improvement through project management.

Range:

Job performance - Developing own skills, learning existing and new work methods, training, participating in performance review meetings, professional institution membership, professional accreditations, continuing professional development (CPD).

Research - New supply chains, comparing against similar competitors projects, new technologies.

Evaluation - Project review, lessons learned, PDCA cycles.

Improvements - Identification of process improvements, investment in machinery and equipment, increased training of employees, workplace efficiencies, future opportunities.

What do learners need to learn?	Skills
How their individual **job performance** and quality of the end product can be improved. Methods for individuals to improve their own performance. How projects can lead to continuous **improvement** for a business. The prospects of project success increased by continually seeking to develop own skills, learn existing and new work methods, processes, techniques and developing the capability to offer solutions to problems. The use of Key Performance Indicators (KPI). How **research**, evidence and **evaluation** of projects can identify future **improvements** and improved performance. The types of data that can be collected to identify potential improvement in project performance. How lessons from similar projects can be learned through benchmarking and comparative data.	N/A

1.15 Evaluating production activities in terms of **quality, cost and time.**

Range:

Quality - Specifications, allowances and tolerances, applying suitable inspection methods, product was finished to an acceptable standard, applicable standards, internal quality procedures, function of product.

Cost - Minimal wastage of resources, getting the job right first time, avoiding delays and rework, cost types (fixed, variable, total, marginal, average).

Time - Using and comparing historical data, method statements and time allocated by line management, choosing the most efficient method of completing a task, charts and scheduling techniques (flow charts, Gantt charts, critical path methods, project management packages).

Metrics - Cycle time, time to make changeovers, throughput, capacity utilisation, overall equipment effectiveness, yield, customer rejects/returns, supplier quality incoming, on-time delivery.

What do learners need to learn?	Skills
How to evaluate activities in relation to **quality, cost and time**.	N/A
The definition of quality (in terms of what the customer requires), identifying all costs, **metrics** and how to measure them against the plan.	
How to set out a plan of programmed quality checks.	
How to measure actual spend against planned cost and identify variation to plan.	
How to measure actual progress against planned progress using milestones.	

1.16 **Standard quality inspection and testing methods**

Range:

Testing methods - Destructive testing methods (tensile testing, toughness testing (Charpy v-notch) and fatigue testing), non-destructive testing methods (radiography, dye-penetrant inspection (DPI) and ultrasonic testing).

Techniques - Material inspections, interim inspections, final inspections, functional checks, thorough inspection and test, optical inspection methods, inspection inputs from SMART tooling.

What do learners need to learn?	Skills
The types of **testing methods**.	N/A
The differences between the types of **testing methods.**	
The capabilities and limitations of different **techniques** across different materials manufacture and processing contexts.	
How destructive testing methods are used to help understand how a material or component will perform and behave under stress.	
The non-destructive testing methods commonly used in manufacturing to analyse the properties of a component or material and establish, without damaging the component or material.	
Typical applications for a range of destructive and non-destructive **testing methods.**	
The limitations of each of the destructive and non-destructive **testing methods.**	
The reasons for recording performance data from the tests and how this will influence materials selection for production.	
How to carry out sample testing and why it is important during production.	

1.17 **Communicating technical information and data.**

Range:

Communication skills - Written, verbal, digital skills, presented communications, listening, questioning.
High-quality communications - Promotional collateral, business plans, annual reports.
Communicate - Record, manage, store, amend, upload data, collaborative technologies (shared drives, email, conferencing, software and programs, forums).
Technical information and data - Test data, test results, maintenance results and findings, fault information, inspection sheets, repair methods, maintenance schedules.

What do learners need to learn?	Skills
The **communication skills** needed to **communicate** information effectively and to participate in **high-quality communications.** The differences between formal and non-formal communication. The importance of technical documentation for communication. How to use different types of **technical information and data** communication methods. How collaborative technology is used to communicate technical information and data. Current legislation including General Data Protection Regulations (GDPR), and organisational procedures used to manage data and increase confidentiality of sensitive information.	N/A

1.18 Digital, **information and communication technology** (ICT).

Range:

Information and communication technology - Data systems, recording systems, electronic document and management systems, collaborative technologies, electronic storage.

What do learners need to learn?	Skills
How technology and systems are used to manage production and manufacturing data and documentation. Application of software and **information and communication technology** techniques to record, manage, store and amend production and manufacturing information. Advantages and limitations of using **information and communication technology** to record information. The importance of applying accuracy when utilising ICT to ensure information is correctly input and recorded.	N/A

Practical criteria for performance outcomes

2.1 Interpret and analyse relevant **technical information**, **data**, representations and documentation.

Range:

Technical information - Drawings (1st and 3rd angle orthographic projections, isometric projections, assembly, general arrangement, installation drawings), specifications (materials, welding, bending allowances), charts (limits and fits, tapping drill allowances), SOP, safe working systems, bills of materials, manufacturing planning sheets.

Data - Inspection results, fault information, Statistical Process Control (SPC).

Drawings - 2D, 3D, solid models exploded views, flat patterns.

What do learners need to demonstrate?	Skills
Identify, read, interpret, collate, process and communicate **technical information and data** critical for the successful completion of the job. Confirm the scope of the task/work. Interpret **drawings,** specifications, scales, and technical term related to production processes and activities. Analyse and report **information and data** accurately. Use and communicate the analysed information/data to improve quality of products and reliability of the process. Interpret plan for appropriate disposal of wastage and excess resources.	EC1 EC4 EC5 MC1 MC5 MC7 MC8 DC1 DC4

2.2 Identifying **issues, risks**, and areas for further analysis or investigation.

Issues and risks - Health and safety (risk assessment, control measures, training, reporting), quality (calibration, training), capability (initial machine and equipment checks, checks during processing), availability (resources, maintenance, downtime).

What do learners need to demonstrate?	Skills
Identify **issues and risks** with the immediate task to inform processes and agreed outcomes and timeframes. Consider impact on other activities due to issues being found and delay incurred. Identify areas for further analysis or investigation. Follow reporting procedures for raising any issues. Identify and mitigate **risks**.	EC1 EC2 EC3 EC4 EC6 MC6 MC10 DC1 DC4

3.1 **Prepare** for relevant production tasks or activities.

Range:

Prepare - Resources, materials, components, tools and equipment, computer systems/programmes.
Technical documentation - Risk assessment, inspection sheets, production plans, material requirements, anticipated production issues and preventative measures, standard procedures.
Pre-work checks - Machine, tooling, safe working environment.
Maintenance - Cleaning, lubricating, sharpening, charging.
Disposal of waste - General waste, recycling, re-use, hazardous waste, non-hazardous waste.

What do learners need to demonstrate?	Skills
Outline, review and verify suitable plans and designs for production.	EC1
Select resources to complete job and selected resources meet the required quality specification.	EC2
Prepare materials, components, tooling, machinery and perform necessary checks.	EC4
Identify, anticipate, and address actual and potential issues and problems.	EC5
Monitor and report stock, materials, resources, and usage (e.g. quantities; volumes) in production processes, identifying potential or emerging issues, problems or risks.	MC5
Perform all necessary **pre-work checks** within the work area prior to carrying out practical activities.	MC6
Carry out routine **maintenance** of tools and equipment, in line with organisational guidelines.	DC2
Create and compile appropriate **technical documentation**, including input to any required computer or data collection systems, to ensure work is carried out safely, accurately and that all quality issues have been considered.	DC4
Apply plan for **disposal of waste** in accordance with organisational policies.	

3.2 Use relevant **documentation** to confirm accuracy of plans and instructions.

Range:

Documentation - Drawings, diagrams, specifications, SOP, safe working systems, bills of materials, manufacturing planning sheets, health and safety records, schedules, inspection sheets, quality documentation, Zeus chart (limits and fits, tapping drills), manufacturing documents, paper and computer based documents.
Stakeholders – Customer, manager, engineers, team colleagues.

What do learners need to demonstrate?	Skills
Use all necessary documentation to analyse production methods to determine if product conforms to the specification.	EC1
Complete all inspection and quality control documents to ensure accountability and traceability.	EC2
Communicate with **stakeholders** to discuss and review the production plans.	EC3
Raise concerns about any element that is not accurate or not feasible.	EC4
Suggest resolutions to problems and issues.	EC6
	DC1
	DC2

Produce or amend any **documentation** in line with the outcomes of the discussions ensuring the procedures are appropriate and achievable.	DC3

3.3 Set up and use tools, equipment, machinery and other technologies.

Range:

Measuring aids - Callipers, verniers, micrometers, gauges (height, depth, plug, bore, thread, go/no go), dial test indicator (DTI), rule, protractors, optical inspection aids, laser projection tools.

Checks - Compliance, quality, function.

Equipment and technology - Hand tools, production equipment, production machines, line side computer systems, materials handling equipment, CNC machinery.

Machining operations - Cut, sand, bore, drill, create joints, mould, plane.

Machining parameters - Positional (position of workpiece, position of tool in relationship to workpiece), dynamic (tooling, workpiece or cutter revolutions per minute), pressure, linear feed rate, depth of cut for roughing and finishing, swarf clearance.

Assembly operations - Fastening, joining, aligning.

Assembly parameters – Functional output, torquing limits and fits, clearances.

What do learners need to demonstrate?	**Skills**
Set up, adjust, and accurately use relevant measuring, testing, diagnostic tools, rigs and equipment, confirming correct machining **parameters**. Correct set up **equipment and technology** for **machining operations** to meet production specifications. Perform relevant **checks**. Measure and mark out components according to specifications and requirements, recognising, selecting and using most appropriate tools and equipment. Apply correct locking and securing methods and techniques. Set up and accurately use **measuring aids** and testing equipment. Compliance to relevant instructions and safety requirements.	MC1 MC4 MC6 DC1 DC2 DC4 DC6

3.4 Use correct **methods** for receiving, moving, handling and preparing materials.

Range:

Documentation - Data sheets, lifting procedures, company policies, risk assessments, COSHH assessment, user manuals.

Method - Manual handling, mechanical handling, lifting aids.

Resources - PPE, materials, tools, equipment, consumables.

Load/s - Loose bulk materials, sacks, bags, pallets, sheet materials, bars, ingots, castings, plate, pipes and tubing, wire, rolled sections, powders, liquids (resins, coolants, lubricants).

Equipment - Manually operated handling equipment (sack barrows, pallet trucks), scissor jacks, forklift trucks, telehandler, hoists, pulley, lifts.

Lifting accessories - Fibre or ropes slings, chains (single or multiple leg), hooks, eyebolts, spreader beams, magnetic and vacuum devices.

What do learners need to demonstrate?	Skills
Select appropriate **method** for receiving, moving, and handling of the **load/s**. Check material weight using relevant **documentation.** Use appropriate lifting **equipment, lifting accessories** and **method** of lifting **load/s** when receiving, moving, handling, and preparing **resources**. Arrange workplace and organise layout to receive goods into the work area. Use correct manual and mechanical handling methods to move items around the workplace.	MC6

4.1 Apply suitable **production methods** and techniques.

Range:

Production methods - One off's, short run batches, long run batches, high speed manufacturing, mass production, high/low value items.
Standard Operating Procedures - Step by step sequenced instructions to carry out manufacturing operations with reference to materials, tooling, machinery, equipment, processes to be used, health and safety.

What do learners need to demonstrate?	Skills
Select and apply the appropriate **production methods** in line with available technology, quantities required, value of items, accuracy required and customer requirements. Follow all **standard operating procedures** (SOP) and comply with all health and safety regulations. Demonstrate the correct **production methods and techniques** to ensure the product is created correctly.	MC5 MC6 MC10

4.2 Disassemble and assemble components and sub-assemblies.

Range:

Disassembly - Preparing work area, cleaning parts, selection of tools for disassemble.
Procedures - Storage, identification and organisation of parts prior to reassembly, company operating procedures, risk assessments, torque requirements.
Reassembly - Sequence of assembly operation, repair or replace of parts, orientation checks, use of mechanical fasteners and assembly fixtures.
Fasteners - Solid rivets, hollow rivets, anchor units, pins, nuts, bolts.
Tools - Allen keys, power tools, spanners, wrench, hammer.

What do learners need to demonstrate?	Skills
Plan and prepare the work area to allow for **disassembly** of components and sub-assemblies in accordance with specific working **procedures**. Use working procedures and practices to ensure all items are identified, marked and organised to allow for efficient and accurate re-assembly of items. Perform **reassembly** of all items in the correct sequence using mechanical **fasteners** and **tools**. Check orientation is correct, and any adjustments have been completed to meet specification.	EC5 MC1 MC5 MC6

4.3 Carry out cutting, drilling, sawing and fitting accurately to produce shapes and profiles to meet specifications.

Range:

Method - Cutting, sawing (hand saw, bandsaw), drilling (hand drill, pilar drill), fitting techniques (folding, riveting, self-clinching, fasteners, press tools), drilling (tapping, reaming, countersinking).
Materials - Ferrous metals (stainless steel, cast iron, high speed steel, silver steel, low, medium and high carbon steel), non-ferrous metals (aluminium, copper, brass, lead and zinc).
Assemblies - Bolted, rivetted, screwed, brazed, jointed, dowelled.
Technical documentation - SOPs, inspection sheets, engineering drawings.

What do learners need to demonstrate?	Skills
Set up tools and equipment to carry out cutting, drilling, sawing and fitting activities. Select the most appropriate **method** to produce or alter the component. Use hand and machine cutting tools to manipulate **materials** into shapes and profiles to meet **technical documentation**. Check machined components meet the required quality standard. Fasten components together to produce a range of **assemblies**.	MC1 MC2 MC3 MC4 MC5

4.4 Re-instate work areas and equipment.

Store - Identified, stored correctly, protected and evaluated for future use.
Disposal of waste - General waste, recycling, re-use, hazardous waste (solvents, coolants, sharp materials, oils, fluids), non-hazardous waste (packaging, swarf, material off cuts, replacing of used consumables).
Maintenance - Cleaning, lubricating, sharpening, charging.

What do learners need to demonstrate?	Skills
Clean, tidy and reinstate the work area on completion of the task. Isolate and power down equipment and/or machinery. Perform **maintenance** of tools and equipment before storing in a systematic way in accordance with working procedures. **Store** excess materials correctly to prevent damage or degradation. Replace any items that have perished and ensure stock levels are accounted for. **Dispose of waste** as per legislation and company procedures.	MC6

5.1 Apply **safe systems of work** in the delivery of all activities.

Range:

Safe systems of work - Personal Protective Equipment (PPE), signage, Standard Operating Procedures, risk assessments and control measures, pre-use checks.
Legislation and regulations - Health and Safety at Work Act (HASAWA), Provision and Use of Work Equipment Regulations (PUWER), Control of Substances Hazardous to Health (COSHH) Regulations, Manual Handling Operations Regulations, Personal Protective

Equipment at Work Regulations, Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR).

What do learners need to demonstrate?	Skills
Apply **safe systems of work** at all times. Work in accordance with the organisational and legal health and safety **legislation and regulations** and in carrying out any, and all tasks, minimising the risk of injury to self and others in the process. Comply with all regulations and legislation.	EC1 EC5 MC10

5.2 Monitor **fitting and assembly processes.**

Range:

Processes - Machines, operational processes, tools, equipment, materials, local work area, material, and equipment movement.

Potential risks - Identification of issues, implementing preventive measures, reporting issues.

Fault finding methods and techniques - Visual, fault checking systems, testing.

Issues - Changed parameters, risk, issue, unexpected activity, excessive noise, heat, vibration, sensory.

Improvement - Production modification (process, efficiency, cost, accuracy), quality control (inspection, accountability, traceability).

What do learners need to demonstrate?	Skills
Monitor the performance and efficiency of equipment and the **processes** within production fitting and assembly activities. Identify any **issues** and/or problems with the immediate task to inform processes and agreed outcomes and timeframes. Deal promptly and effectively with issues within the limits of their own authority using approved diagnostic **fault-finding methods and techniques**. Select suitable methods of fault, risk and issue resolution while maintaining operating procedures, output and quality. Make first line basic repairs whilst safeguarding the integrity of components and the surrounding area. Follow reporting procedures for raising any **issues**. Identify and mitigate **potential risks**. Identify areas for **improvement.**	EC1 EC5 EC6 MC5 MC6 MC10

5.3 Carry out or assist with **quality monitoring** and **assurance checks** to review processes.

Range:

Quality monitoring - Inspections, reviewing, amending, supervisory checks, checking of quality.

Assurance checks - Checking and validating reliability and durability, material and product testing.

Conform - Drawings (symbols, abbreviations), specifications (British Standards (BS), British Standards Institution (BSI) issues codes, International Standard (ISO)), identification markings, supplier and manufacturer coding systems, colour coding.

What do learners need to demonstrate?	Skills
Conduct **quality monitoring** and **assurance checks** as part of the production process. Review efficiency of processes, practices and outcomes. Consistently check validity, accuracy and relevance of documentation. Check outcomes **conform** to the requirements in the specification. Communicate technical information, advice and suggestions for improvements. Suggest strategies to increase efficiency of quality monitoring processes, with consideration of performance and potential improvements. Carry out or assist others with testing procedures as required.	EC1 EC6 MC1 MC2 MC5 MC6 MC8 MC10

5.4 Complete effective **handover procedures.**

Range:

Handover procedures - Shift changeovers, breaks, job rotation, end of a process, inter departmental handovers.
Post-production check list information - Job number, drawing number, control reference number, list of operations, operator name, date of work completed, non-conformance details, mapping against standards.

What do learners need to demonstrate?	Skills
Perform **handover procedures** to ensure production process continues as scheduled. Communicate handover to another person to ensure continuity and consistency via verbal, written or computer based methods. Pass on information or documentation pertinent and critical to the smooth running of the process. Notify any production issues arising or observations on process or equipment performance. Complete **post-production check list** confirming quality standards and any specific working requirements have been completed.	EC1 EC2 EC4 DC1 DC2 DC3

6.1 Demonstrate **effective communication**.

Range:

Effective communication - Written, verbal, digital skills, presented communications, listening, questioning, pre-meeting preparation.
High-quality communications - Promotional collateral, business plans, annual reports.

What do learners need to demonstrate?	Skills
Demonstrate effective communication. Prepare adequately for meetings and formal discussions. Support **high-quality communications** in production activities by confirming information, requirements, expectations, plans, performance, and outcomes in ways that are suitable for purpose and context.	EC1 EC2 EC3 EC4 EC6 MC5

	MC6 MC8 MC9 MC10 DC1 DC2 DC3 DC4

6.2 Accurately record relevant technical information, **data**, risks, and issues to support production projects, tasks and activities.

Range:

Information and data - Health and safety records, manufacturing plans, inspection sheets, quality documents, production programmes, authorised alternative methods/materials.

What do learners need to demonstrate?	**Skills**
Keep legible records of tasks undertaken, using a spreadsheet or a logbook.	EC4
Record key technical **information and data** in relation to the process.	EC5
Complete dynamic data sheets in line with production requirements.	MC2
Check sourced or given **information and data** is current.	MC5
Amend or correct **information and data** within own limits of authority.	MC6
Report and escalate where information and data need to be amended which is outside of limit of authority.	DC1 DC2
Contact the person authorised to make the changes and resolve the issue.	DC3 DC4

Guidance for delivery

Opportunities for visits/engagement with local industry, employers and manufacturers should be provided throughout the delivery of the content within this specialism – where appropriate local employers with a production or manufacturing focus could present details of recent projects and the type of problems faced and how they were overcome. For example, manufacturing or production from a range of applications/sectors and from different sized companies e.g. micro to small scale production and large/mass production. Learners work placement experiences could be presented to peers detailing where knowledge and skills within the content was seen in practice.

Formative assessment for the content may include oral Q&A, presentations to peers, observation of measuring activities etc. Reinforcement of learning can be encouraged through revisiting learning, group discussions, and the establishment of a peer support system within the cohort.

Providers must ensure content is delivered in line with current, up-to-date industry practice which will require;

- Provision of appropriate tools, equipment and test instrumentation for demonstration and practical training purposes
- Teaching coverage representing the type of equipment currently available and accepted for use in the UK industry.

Suggested learning resources

Books

- W Bolton, *Production Technology: Processes, Materials and Planning,* Butterworth Heineman, 1988, ISBN 0434901733
- David Blockley, *Engineering: A Very Short Introduction*, OUP Oxford, 2012, ISBN 9780199578696
- Glyn James, Phil Dyke, *Modern Engineering Mathematics,* 6th Edition, Pearson, 2020, ISBN 1292253495
- William D Caster Jnr, David G Rethwisch*, Callister's Materials Science and Engineering,* 10th Edition, John Wiley & Sons, 2020, ISBN 1119453917

Websites

- The Institute of Engineering and Technology **www.theiet.org**
- Institute of Mechanical Engineers **www.imeche.org**
- Manufacturing and Engineering Magazine **www.memuk.org**
- Enginuity **www.enginuity.org**
- Health & Safety Executive **www.hse.gov.uk**

Scheme of Assessment – Fitting and Assembly Technologies

The Fitting and Assembly Technologies Occupational Specialism is assessed by one practical assignment. The duration of the assessment is 25 hours and 15 minutes. Learners will be assessed against the following assessment themes:

- Health and safety
- Planning and preparation
- Production
- Quality review and evaluation.

By completing the following tasks:

Task	Typical Knowledge and skills
Task 1 - Planning	Displays a breadth of knowledge and practical skills that enables them to plan the manufacturing, fitting and assembly activities. Candidates will need to produce documents that clearly states how they will produce the end product in line with the brief. Candidates will need to produce a risk assessment covering all the activities needed to produce the final product taking into account required safety measures. Candidates will create their own plans and quality check sheets.
Task 2 – Production	Applies a breadth of knowledge and practical skills that enables them to carry out the manufacturing, fitting and assembly of the product in accordance with their planning and interpreting the technical drawings. The task is carried out in a clear and logical sequence. Works in a safe manner, handles materials with care. Tools, materials and equipment are selected and used correctly. Candidates will utilise manual/traditional workshop machinery and hand tools to manufacture, fit and assemble the final product.
Task 3 – Evaluation and implementation (split into 3 sub-tasks)	Displays a breadth of knowledge and understanding in the evaluation of their own manufacturing, fitting and assembly processes, recommending adaptions and improvements to the finished assembly/product or the processes utilised. Inspects assemblies and components for defects and evaluates their cause and prevention. Accurately records and reports data and findings of quality inspections.

The information provided in the following tables demonstrates to approved providers the weightings of each performance outcome and how each performance outcome is assessed.

Performance outcome and weighting (%)	***High level tasks*** *Provide specific instructions for candidates to provide evidence for and are the same for every version of the assessment*	**Assessment Theme**	***Typical evidence***
PO2 Analyse projects and specifications, considering the specific requirements, context, resources, tools and equipment, and the suitability of different production technologies, processes, and methods. (17%)	T1 - Planning	Planning and preparation	Resources list (with measuring equipment calibration check recorded), risk assessment, method statement with justifications, work plan, quality check sheet, commissioning checklist.
	T2 – Production	Health and safety	Risk assessment and method statement with justifications.
		Production – Measuring and marking out	Finished assembly.
		Production – Techniques and methods	Finished assembly.
		Production - Tools and Equipment	Finished assembly.
		Production - Assembly	Finished assembly. Completed commissioning checklist.
	T3 - Quality review and evaluation	Quality review and evaluation – Quality review	Quality inspection report, quality check sheet.

PO3 Plan and prepare relevant materials, resources, tools, and equipment needed to produce the relevant products and outcomes.(20%)	T1- Planning T2 – Production T3 – Quality review and evaluation	Planning and preparation Health and safety Production – Measuring and marking out Production – Techniques and methods Production - Tools and Equipment Production – Assembly Quality review and evaluation – Quality review	Resources list (with measuring equipment calibration check recorded), risk assessment, method statement with justifications, work plan, quality check sheet, commissioning checklist. Risk assessment, method statement (with justifications) Finished assembly, commissioning checklist. Finished assembly, commissioning checklist. Finished assembly, commissioning checklist. Finished assembly, commissioning checklist. Quality inspection report, quality check sheet.
PO4 Produce relevant products and outcomes, considering the specified requirements, context and materials, using the relevant fitting and assembly technologies, methods, and processes. (27%)	T2 – Production	Health and safety Planning and preparation Production – Tools and equipment Production – Measuring and marking out Production – Techniques and methods Production – Assembly	Risk assessment. Work plan. Resource list (with measuring equipment calibration check recorded). Finished assembly, commissioning checklist. Finished assembly. Finished assembly, commissioning checklist.
PO5 Support the delivery (and the management)	T2 – Production	Health and safety	Risk assessment.

by helping to evaluate and review the outcomes to improve the final product, production methods, and work place practices and processes. (20%)	T3 – Quality review and evaluation	Planning and preparation	Work plan.
		Production – Tools and equipment	Finished assembly.
		Production – Measuring and marking out	Finished assembly, commissioning checklist.
		Production – Techniques and methods	Finished assembly.
		Quality review and evaluation – Quality review	Commissioning checklist, quality check list.
		Quality review and evaluation – Reporting, recording and handover	Quality inspection report.
PO6 Communicate production information, proposals and solutions, producing, recording and explaining relevant technical information, representations, processes and outcomes. (16%)	T3 – Quality review and evaluation	Health and safety	Risk assessment, resources list (with measuring equipment calibration check recorded).
		Planning and preparation	Work plan.
		Production – Tools and equipment	Finished assembly.
		Quality review and evaluation – Quality review	Quality check sheet.
		Quality review and evaluation – Reporting, recording and handover	Quality Inspection Report.

332 Machining and toolmaking technologies

Level:	3
GLH:	680
Assessment method	Practical assignment

What is this specialism about?

The purpose of this specialism is for learners to know and undertake a range of industrial processes and manufacturing techniques to manufacture and maintain the engineering tooling used to produce components, products and assemblies. This requires the application of a broad range of activities including the interpretation of engineering drawings and technical instructions and the use of hand, machine and automated computer-controlled machine tools and measuring equipment.

Learners will develop their knowledge and understanding of, and skills in:

- common materials structure, composition and properties.
- special requirements for tools and fixtures for the manufacture of components.
- requirements for tools and fixtures to aid the manufacture of new or changed components.
- how to set up, select and safely operate, the application of a range of hand tools, operating principles of a range of complex and often state of the art workshop machinery.
- analysis of data, documentation, tasks, projects and specifications.
- producing products to specification using suitable methods and techniques.
- undertaking preventative planned maintenance and checking for faults using fault diagnosis.
- utilising project management and process improvement.

Learners may be introduced to this specialism by asking themselves questions such as:

- What are the different techniques that are used to produce complex components?
- How are car parts like alloy wheels, produced and how many people does it take?
- Where do these processes and production methods take place?
- What is the impact on a process if people are replaced by automated processes?

Underpinning knowledge outcomes

On completion of this specialism, learners will understand:

1. Machining and toolmaking technologies knowledge criteria.

Performance outcomes

On completion of this specialism, learners will be able to:

2. Analyse and interpret engineering and manufacturing requirements, systems, processes, technical drawings and specifications.

3. Plan and prepare the relevant processes, tools, equipment, and resources, needed to produce relevant products and produce appropriate outcomes.

4. Produce relevant products and outcomes, considering the specified requirements, context and materials, using the relevant machining and toolmaking technologies, methods and processes.

5. Support the delivery (and management) of relevant projects and activities, helping to evaluate and review processes and outcomes, and to improve practices.

6. Communicate production information, proposals and solutions, producing, recording and explaining relevant technical information, representations, processes and outcomes.

Completion of this specialism will give learners the opportunity to develop their maths, English and digital skills. Details are presented at the end of the specification.

Specialism content

Knowledge criteria for performance outcomes

1.1 Planning, preparing and implementing manufacturing and processing activities.

Range:

Plan - Location, types of facility needed, space requirements, equipment requirements (types, costs, operational processes), people (skilled, unskilled), materials, processes, costs, timescales, quantity, quality control/assessment, finished product (design/finish).

Technical information - Engineering drawings (design, tooling, detail, sub-assembly, assembly), specifications, design concepts, data sheets, test records, maintenance records, work instructions, flow charts, plans, manufacturer's manual/documentation. standard operating procedures (SOP), instructions, inspection documents.

Scale of work - Prototype, batch, mass production, continuous production.

Cost break points and other factors - Revenue, costs, profit and loss, average rate of return, investment (jigs, fixtures, automation).

What do learners need to learn?	Skills
The difference between the scale of work in production, manufacturing and processing activities. How to plan and prepare for the activities. The **technical information** needed to achieve specific outcomes. How to interpret information to create a manufacturing production **plan**. How to produce a plan to the correct **scale of work.** **Cost break points and other factors** for selecting assembly and manufacturing methods.	N/A

1.2 Common **production machines,** tools and their applications.

Range:

Types - Manual, CNC (Computer Numerical Control).

Machines - Lathe, milling machine, router, grinder, borer, laser cutter, plasma cutter, water jet cutter, electrical discharge machine, machines for broaching, honing, lapping, automated and CNC applications, processing (forging, rolling, stamping, extruding, pressing), joining, plating, powder metallurgy machines (mixing, blending, compacting, sintering).

Purpose - Cut, rout, drill, turn, press, bend, slot, grind, join, turn, erode, process.

Parameters - Positional (position of workpiece, position of tool in relationship to workpiece), dynamic (tooling, workpiece or cutter revolutions per minute), pressure, linear feed rate, depth of cut for roughing and finishing, swarf clearance, cooling and lubrication.

Consequences - Poor quality product, product does not meet specification, out of tolerance, material wastage, injuries to operator, damage to machinery/working parts.

What do learners need to learn?	Skills
The **types** of **machines** used in production. The **purpose** of each type of machine and their primary use.	N/A

How the machines operate to remove material to produce semi or fully finished parts. The **parameters** of the machines. The use of cooling and lubrication of the machinery. The use of guarding on exposed parts of the machinery. **Consequences** of a poorly set up machine and the risks the operator could be exposed to.	

1.3 **Measurement techniques.**

Range:

Measurement techniques - Direct measurement; rules, tapes, micrometres, Vernier callipers and CMM machines; indirect measurement; thread gauges, gauge blocks, and comparison plates.
Estimation - Standard time calculation, engineering time standards.

What do learners need to learn?	**Skills**
The purpose of, and uses of a range of **measuring techniques**, devices, accuracy levels and practical applications that they may be used for measurement activities. Factoring used in **estimation**, the application of standard times to production tasks to estimate costs and durations. How to apply correct **measurement techniques** using measurement tools and equipment. Imperial and metric measuring conventions and units of measurement. How to apply measurement to the stages of the manufacturing process from estimating material quantity and costs through to dimensional inspection, with regard to product or process specification.	N/A

1.4 **Component classification, numbering** and **referencing systems.**

Range:

Component classification - Passive, active.
Numbering - Part numbers, identification numbers, material lists, labelling, specifications.
Referencing systems - Identification codes and technical data, manufacturers data sheets, manufacturers safety specifications, colour codes, component numbering, schematic diagrams, BS and ISO Standards.
Marking systems - European (CE mark), UK Conformity Assessed (UKCA - UK marking system).

What do learners need to learn?	**Skills**
The purposes and applications of component **classification, numbering** and **referencing systems.** The differences between the **marking schemes** used in the United Kingdom and Europe. How to interpret current BS and ISO standards related to production activities, including classification, numbering and referencing.	N/A

The purposes and applications of electronic systems that measure performance.	

1.5 **Classification**, **application** and **disposal** requirements of materials.
Range:

Properties - Ductility, malleability, hardness, toughness, tensile strength, elasticity, compressive and shear and modulus of rigidity.

Classification - Ferrous, non-ferrous, ceramics, polymer and composites.

Materials:

Metals - Ferrous (stainless steel, cast iron, high speed steel, silver steel, low, medium and high carbon steel), non-ferrous (aluminium, alloys, copper, lead, brass, bronze and zinc).

Polymers - Thermosets (urea formaldehyde, melamine formaldehyde, phenol formaldehyde, epoxy resin, polyester resin), thermoplastics (ABS, HIPS, PLA, polycarbonate, polypropylene, PMMA/acrylic).

Composites - Glass fibre, carbon fibre, aramid fibre.

Elastomers - Rubber, neoprene.

Considerations - Corrosion, degradation, interaction of dissimilar materials.

Disposal - General waste, recycling, re-use, hazardous and non-hazardous waste.

Wastes - Used materials, used liquids, off cuts, swarf, shavings, hazardous and non-hazardous materials.

Legislation - Environmental Protection (Duty of Care) Act 1990, Hazardous Waste (England and Wales) Regulations 2005, Waste Management (England and Wales) Regulations 2006, Control of Pollution (Applications, Appeals and Registers) Regulations 1996, Trade Effluent (Prescribed Processes and Substances) Regulations 1989.

Forms of supply - Loose bulk materials, sacks, bags, pallets, sheet materials, bars, ingots, castings, plate, pipes and tubing, wire, rolled sections, powders, liquids (resins, coolants, lubricants).

What do learners need to learn?	**Skills**
The **classification** and types of **materials** used in production and manufacturing activities. The **properties** and **considerations** for each material and methods of material selection for an engineered product or application. The **forms of supply** for common materials used in the manufacturing and production process. Common uses and **application** for the materials. The considerations that must be made for **disposal** of various materials and **wastes** in accordance with organisational policies and environmental **legislation.**	N/A

1.6 Standard technical **documentation.**

Range:

Documentation - Engineering drawings (design, tooling, detail, sub-assembly, assembly), circuit diagrams, specifications, design concepts, data sheets, test records, maintenance records, work instructions, flow charts, plans, manufacturer's manual/documentation, standard operating procedures (SOP), instructions, inspection documents.

Standard Operating Procedures - Technical, management, types (checklists, step-by-step lists, hierarchical lists, process flowchart).
Drawings - 2D, 3D, solid models exploded views, flat patterns.

What do learners need to learn?	Skills
The purposes and types of a selection of standard technical **documentation**. How technical **documentation** is produced and who is responsible for its production. How to interpret technical **documentation** and who or what to refer to for guidance. How amendments are made to technical **documentation**, who is responsible and who to refer to for authorisation. Overview of all types of manufacturing documents used in a wide range of manufacturing sectors. How to read and interpret **drawings** and geometric tolerances. Different types of operating procedures. The correct representations, symbols, annotations, and conventions used, as outlined in BS 8888. Different types of **Standard Operating Procedures**. How to identify specific **requirements** and extract information to form material or cutting lists.	N/A

1.7 Application of **work-holding devices.**

Range:

Types of hold - Friction, suction, clamping.
Work-holding devices - Chuck, collets, faceplate, centres and driveplates, lathe dog/carrier, steadies, angle plate, magnetic table, vee block, indexing heads, rotary table, jigs, fixtures, clamp, vice.

What do learners need to learn?	Skills
The **types of hold** and **work-holding devices** and how they work to secure the component in position. How to select the right device for the task. The advantages and disadvantages of each work-holding device.	N/A

1.8 **Hand tools, power tools and measuring equipment.**

Range:

Hand tools - Centre and edge finders, combination, protractor and depth gauges, de-burring tools, dividers, levels, scrapers, scribes, square, straight edges, gauges, vices, punches, reamers, rivet setter, screw extractors, bolt grips, taps and dies, clamps, threading tools, files, hammers.
Task - Measuring, marking-out, cutting, shaping, forming, joining, finishing, inspection/testing.

Measurement equipment - Rule, callipers (vernier, digital), micrometres (outside, depth), gauges (feeler, angle, slip, go/no-go), dial test indicator (DTI), coordinate measuring machines (CMM).

Power tools - Cordless drill, hammer drill, mag base drill, electric screwdriver, band saw, angle grinder, bench grinder, sander, compressed air driven tools.

Maintain - Cleaning, lubricating, sharpening, charging.

Regulations, guidelines and instructions - Work instructions, operating procedures, health and safety legislation and regulations, risk assessments, maintenance records, manufacturer's manuals.

What do learners need to learn?	Skills
How to correctly select **hand tools**, **power tools** and **measuring equipment** that are the most appropriate for various production **task**. How to correctly prepare tools and equipment making adequate and reasonable checks on their condition prior to use. How to adequately **maintain** the tools and equipment after use. How to suitably record and report any faults identified in the condition or performance of the tools. The process/procedure to take damaged or faulty equipment out of service until returned to a suitable condition. Who the authorised and most appropriate person is to ask for advice and guidance. The relevant **regulations, guidelines and instructions** that must be followed when preparing, using, or maintaining tools and equipment.	N/A

1.9 Using **specialist machinery** and technology.

Range:

Specialist machinery - CNC machines (router, plasma cutter, laser cutter, milling machine, lathes, drilling machines, grinding machine).

Parameters - Positional (position of workpiece, position of tool in relationship to workpiece), dynamic (tooling, workpiece or cutter revolutions per minute), pressure, linear feed rate, depth of cut for roughing and finishing, swarf clearance, cooling and lubrication.

Problems - Risk, issue, unexpected activity, excessive noise, heat, vibration, smell.
Faults - Visual, vibration, noise, power failure (electrical, pneumatic, hydraulic) leaks, jams, blockages.
Detection - Sensory (noise, vibration, visual, smell), instrumentation (fume, smoke, heat/fire sensors).
Isolation - Mechanical, electricity, gas, air, fluids.
Resolution - Six-point technique, quantitative, qualitative.

What do learners need to learn?	Skills
How to safely set up a range of **specialist machinery** and technology demonstrating machining **parameters**. Why machines need to be calibrated. How to use a range of **specialist machinery** effectively to meet specification requirements. The importance of following guidelines and instructions. The risks to quality, cost and health and safety of non-compliance.	N/A

Who the appropriate person is to ask for advice and guidance, if and when necessary. The **detection** and identification of **problems** or **faults** with machinery and **isolation** methods. Methods of **resolution** or escalation of issues.	

1.10 **Types** and **purposes** of standard CAD and CAM systems.

Range:

Systems - Computer Aided Design (modelling), Computer Aided Manufacture (CNC, tool path modelling).
CAD - Using software to create, modify, analyse or optimise a design and to create a database for CAM.
CAM - Generating tool paths using software, post processing to convert tool paths into machine language, using CNC machinery.
Types - 2D vector-based drafting, 3D, wireframe and surface modelling, solid modelling.
Purposes - Creation, modification, analysis (of mass, volume, centre of gravity), simulation (of stress, strain, displacement under load), optimisation of design.
Software - Examples - Autodesk, Inventor, Fusion, HSM Cam, CATIA, Dassault Systems, Siemens PLM, PTC.

What do learners need to learn?	**Skills**
How **CAD** and **CAM** are utilised in manufacturing contexts. The **types** of **software** and their applications. The advantages and disadvantages of utilising **CAD** and **CAM systems.** The various **CAD** systems available for design/modelling. The various **CAM** systems available for pre-production. Understand how the systems interface to produce components from digital data. How **CAD** and **CAM** systems can be used across multiple dimensions and collaboratively.	N/A

1.11 Compliance with **standard workplace practices**.

Range:

Standard Operating Procedures - Technical, management, types (checklists, step-by-step lists, hierarchical lists, process flowchart).
Standard workplace practices - Safe systems of work, permits to work, risk assessments, work instructions, standard operating procedures (SOP), user guides, operational instructions.
Compliance - Health and safety, regulations, legislation (PUWER).
Activity - Planning, preparing tools/equipment, using tools/machinery, maintaining tools/machinery.

What do learners need to learn?	**Skills**
The various formats of **Standard Operating Procedures** (SOP) and how to interpret and work to them. The typical **safe workplace practices** contained in an SOP and how the importance of **compliance** with them and any specific instructions. Health and safety documentation including risk assessments, permits. How to comply with standard workplace practices for the relevant **activity**. The consequences of non-compliance on self and others.	N/A

1.12 Engineering **standards.**

Range:

Types - British (BS), European (EN), International (ISO).
Standards - Quality management (BS4500, ISO 9000, 9001), environmental management (ISO 14000, 14001), risk management (ISO 31011). Welding BS EN ISO 15614 - 1 :2017 Level 2
Application - Quality, environmental, risk.
Sector - Aerospace, nuclear, power, utilities, automotive.

What do learners need to learn?	**Skills**
The purpose of a range of **standards**. The **types** of **standards** used in engineering and a variety of manufacturing sector workplaces. The **application** of the **standards** in a manufacturing workplace. The systems and procedures put in place to ensure they are adhered too.	N/A

1.13 **Legal and regulatory frameworks** and documentation.

Range:

Legislation - Health and Safety at Work Act 1974, Employment Act 2002, Factories Act 1961, Fire Precautions Act 1971, Employment Equality, Management of Health and Safety at Work Regulations 1999, Provision and Use of Work Equipment Regulations (PUWER) 1998, Control of Substances Hazardous to Health (COSHH) Regulations 2002, Lifting Operations and Lifting Equipment Regulations 1998, Manual Handling Operations Regulations 1992, Personal Protective Equipment at Work Regulations 1992, Confined Spaces Regulations 1997, Electricity at Work Regulations 1989, Control of Noise at Work Regulations 2005, Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR) 1995, Working Time Regulations 1998.
Health and safety procedures - Health and safety policy, risk assessments, emergency procedures.
Consequences - Improvement and enforcement notices, prosecution (fines, imprisonment, compensation claims), organisation reputation damaged.
Sources - Websites (Gov.UK, HSE, Equalities Commission), e-books, printed texts/matter.

What do learners need to learn?	**Skills**
The key points of health and safety **legislation** that provide a framework for more specific, task-focused activities at work. The need for organisational health and safety policies for a healthy and safe place of work. Organisational **health and safety procedures**, specifically those related to the learner's role, responsibilities and functions. The typical emergency systems and procedures that would be in place for a manufacturing and processing environments. The importance of complying with legislation and the **consequences** of breaches in legislation on the individual and the organisation. How to access **sources** of authoritative information.	N/A

1.14 Site and process **safety, environment and risk management systems and practices.**

Range:

Safety, environment and risk management systems and practices - Health and safety management system (HSG65) generic risk assessment, COSHH, manual handling, young people, PUWER assessments, Environmental Management System (EMS).

What do learners need to learn?	**Skills**
The role of individuals and the impact they can have when upholding health and safety and organisational policies in a workplace. The purpose and function of **safety, environment and risk management systems**. Reporting procedures and who to inform. How to interpret a health and safety management system (HSG65). How to interpret information from an Environmental Management System (EMS).	N/A

1.15 Standard materials **testing methods** and **techniques.**

Range:

Testing methods - Destructive testing methods (tensile testing, toughness testing (Charpy v-notch) and fatigue testing), non-destructive testing methods (radiography, dye-penetrant inspection (DPI) and ultrasonic testing), hardness of metals (Brinell, Rockwell, Vickers), hardness of non-metals (Moh's).
Techniques - Material inspections, interim inspections, final inspections, functional checks, thorough inspection and test.

	Skills
The types of **testing methods.** The differences between the **types** of **testing methods**. The capabilities and limitations of different **techniques** across different materials manufacture and processing contexts. How destructive **testing methods** are used to help understand how a material or component will perform and behave under stress. The non-destructive **testing methods** commonly used in manufacturing to analyse the properties of a component or material and establish, without damaging the component or material. Typical applications for a range of destructive and non-destructive **testing methods.** The limitations of each of the destructive and non-destructive **testing methods.** The reasons for recording performance data from the tests and how this will influence materials selection for production. How to carry out sample testing and why it is important during production.	N/A

1.16 Recording relevant **quality processes.**

Range:

Quality processes - Policies, procedures, guidance, second line verifications, organisational systems and requirements, sensory checks, checklists, maintenance instructions, data, reports, measurement, analysis of systems.
Documents - Maintenance logs, defect logs, reports, statements, checklists, equipment.
Inspection parameters - functional (mating parts), dimensional (overall sizes, hole tolerances, mass), comparative (surface roughness), completeness, colour.
Inspection parameters - Functional (mating parts), dimensional (overall sizes, hole tolerances, mass), comparative (surface roughness), completeness, colour, geometric tolerances (roundness, flatness, concentricity, run-out).
Inspection documents - Checklists, documents for quantitative and qualitative information.

What do learners need to learn?	Skills
The purpose if quality inspection, testing and recording through **quality processes.** The range of typical **inspection parameters** measured and checked during a production run. A range of typical **documents** used in production to record data and inspections. How **inspection documents** are configured and what data needs to be recorded, how often, and in what format.	N/A

1.17 Business improvement through project management.

Range:

Job performance - Developing own skills, learning existing and new work methods, training, participating in performance review meetings, professional institution membership, professional accreditations, continuing professional development (CPD).
Research - New supply chains, comparing against similar competitors projects, new technologies.
Evaluation - Project review, lessons learned, PDCA cycles.
Improvements - Identification of process improvements, investment in machinery and equipment, increased training of employees, workplace efficiencies, future opportunities.

What do learners need to learn?	Skills
How their individual **job performance** and quality of the end product can be improved. Methods for individuals to improve their own performance. How projects can lead to business **improvement**. The prospects of project success increased by continually seeking to develop own skills, learn existing and new work methods, processes, techniques and developing the capability to offer solutions to problems. The use of Key Performance Indicators (KPI). How **research**, evidence and **evaluation** of projects can identify future **improvements** and improved performance. The types of data that can be collected to identify potential improvement in	N/A

project performance. How lessons from similar projects can be learned through benchmarking and comparative data.	

1.18 Evaluating production activities in terms of **quality, cost** and **time.**

Range:

Quality - Specifications, allowances and tolerances, applying suitable inspection methods, judging whether or not the product was finished to an acceptable standard.
Cost - Determining if resources are being used efficiently with minimal wastage, the importance of getting the job right first time, avoiding the need for rework.
Time - Using and comparing historical data, method statements and time allocated by management, choosing the most efficient method of completing a task.
Metrics - Cycle time, time to make changeovers, throughput, capacity utilisation, overall equipment effectiveness, yield, customer rejects/returns, supplier quality incoming, on-time delivery.

What do learners need to learn?	**Skills**
How to evaluate activities in relation to **quality, cost and time**. The definition of quality (in terms of what the customer requires), identifying all **costs**, **metrics** and how to measure them against the plan. How to set out a plan of programmed **quality** checks. How to measure actual spend against planned **cost** and identify variation to plan. How to measure actual progress against planned progress using milestones.	N/A

1.19 **Communicating technical information and data.**

Range:

Communication skills - Written, verbal, digital skills, presented communications, listening, questioning.
High-quality communications - Promotional collateral, business plans, annual reports.
Communicate - Record, manage, store, amend, upload data, collaborative technologies (shared drives, email, conferencing, software and programs, forums).
Technical information and data - Test data, test results, maintenance results and findings, fault information, inspection sheets, repair methods, maintenance schedules.

What do learners need to learn?	**Skills**
The **communication skills** needed to **communicate** information effectively and to participate in **high-quality communications.** The differences between formal and non-formal communication. The importance of technical documentation for communication. How to use different types of **technical information and data** communication methods. How collaborative technology is used to communicate technical information and data.	N/A

Current legislation including General Data Protection Regulations (GDPR), and organisational procedures used to manage data and increase confidentiality of sensitive information.	

1.20 Digital, **information and communication technology** (ICT).

Range:

Information and communication technology - Data systems, recording systems, electronic document and management systems, collaborative technologies, electronic storage.

What do learners need to learn?	**Skills**
How technology and systems are used to manage production and manufacturing data and documentation. Application of software and **information and communication technology** techniques to record, manage, store and amend production and manufacturing information. Advantages and limitations of using **information and communication technology** to record information.	N/A

Practical criteria for performance outcomes

2.1 Interpret and analyse relevant **technical information**, **data**, representations and documentation.

Range:

Technical information - Drawings, specifications, charts, SOP, safe working systems, bills of materials, manufacturing planning sheets, data sheets.
Data - Inspection results, fault information, Statistical Process Control (SPC).
Drawings - 2D, 3D, solid models exploded views, flat patterns.

What do learners need to demonstrate?	Skills
Identify, read, interpret, collate, process and communicate **technical information and data** critical for the successful completion of the job.	EC1 EC2
Confirm the scope of the task/work.	EC4
Interpret **drawings,** specifications, scales, and technical term related to production processes and activities.	EC5 EC6
Analyse and report **information and data** accurately.	MC6
Use and communicate the analysed information/data to improve quality of products and reliability of the process.	MC8 DC1
Interpret plan for appropriate disposal of wastage and excess resources.	DC4

2.2 Identifying **issues, risks**, and areas for further analysis or investigation.

Range:

Issues and risks - Health and safety (risk assessment, control measures, training, reporting), quality (calibration, training), capability (initial machine and equipment checks, checks during processing), simple machine faults (fast running, blunt tooling, burn marks, incorrect tool compensation), availability (resources, maintenance, downtime).

What do learners need to demonstrate?	Skills
Identify potential **issues** with the immediate task to inform processes and agreed outcomes and timeframes.	EC1 EC2
Consider impact on other activities due to issues being found and delay incurred.	EC3 EC4
Identify areas for improvement.	EC6
Monitor the performance and efficiency of machinery and processes.	MC5
Follow reporting procedures for raising any issues.	MC6
Identify and mitigate **risks**.	MC10 DC1 DC4

3.1 **Prepare** for relevant production tasks or activities.

Prepare - Resources, materials, tools and equipment.
Technical documentation - Risk assessment, inspection sheets, production plans, material requirements, anticipated production issues and preventative measures, standard procedures,
Pre-work checks - Machine, tooling, safe working environment.
Maintenance - Cleaning, lubricating, sharpening, charging.

Disposal of waste - General waste, recycling, re-use, hazardous waste, non-hazardous waste.

What do learners need to demonstrate?	Skills
Outline, review and verify suitable plans, designs and **technical documentation** for production. Select resources to complete job and selected resources meet the required quality specification. **Prepare** materials, tooling, machinery and perform necessary checks. Identify, anticipate, and address actual and potential issues and problems. Monitor and report stock, materials, resources, and usage in production processes, identifying potential or emerging issues, problems or risks. Perform all necessary **pre-work checks** within the work area prior to carrying out practical activities. Carry out routine **maintenance** of tools and equipment, in line with organisational guidelines. Create and compile appropriate technical documentation to ensure work is carried out safely, accurately and that all quality issues have been considered. Apply plan for **disposal of waste** in accordance with organisational policies.	EC1 EC2 EC4 EC5 MC5 MC6 DC2 DC4

3.2 Use relevant **documentation** to confirm accuracy of plans and instructions.

Range:

Documentation - Drawings, diagrams, specifications, SOP, safe working systems, bills of materials, manufacturing planning sheets, health and safety records, schedules, inspection sheets, quality documentation, Zeus chart (limits and fits, tapping drills), manufacturing documents.
Stakeholders - Customer, manager, engineers, team colleagues.

What do learners need to demonstrate?	Skills
Use all necessary **documentation** to analyse production methods to determine if product conforms to the specification. Complete all inspection and quality control documents to ensure accountability and traceability. Communicate with **stakeholders** to discuss and review the production plans. Raise concerns about any element that is not accurate or not feasible. Suggest resolutions to problems and issues. Produce or amend any **documentation** in line with the outcomes of the discussions ensuring the procedures are appropriate and achievable.	EC1 EC4 MC6 DC1 DC3

3.3 Set up and use tools, equipment, machinery and other technologies.

Range:

Checks - Compliance, quality, function.
Equipment and technology - Hand and power tools (standard hand tools, powered (mains, 110v, battery), pneumatic power tools), production equipment, production machines, line side computer systems, materials handling equipment, CNC machinery.
Measuring aids - Engineer's rule, dividers, scribe, templates, set squares, protractors, compasses, combination square, scribes, scribing block/surface gauge, punches (centre and

dot), callipers, Vernier height gauge, slip gauges, Dial Test Indicator (DTI), surface table and plates, angle plates, vee blocks and clamps.
Machining operations - Mill, turn, cut, sand, bore, drill, plane.
Parameters - Positional (position of workpiece, position of tool in relationship to workpiece), dynamic (tooling, workpiece or cutter revolutions per minute), pressure, linear feed rate, depth of cut for roughing and finishing, swarf clearance.

What do learners need to demonstrate?	Skills
Set up, adjust, and accurately use relevant measuring, testing, diagnostic tools, rigs and equipment, confirming correct machining **parameters.** Perform necessary **checks.** Correct set up **equipment and technology** for **machining operations** to meet production specifications. Measure and mark out components according to specifications and requirements, recognising, selecting and using most appropriate tools and equipment. Apply correct locking and securing methods and techniques. Set up and accurately use **measuring aids** and testing equipment. Compliance to relevant instructions and safety requirements.	EC1 EC4 EC5 EC6 MC6 DC1 DC2 DC3 DC4 DC6

3.4 Use correct methods for receiving, moving, handling and preparing **resources**.

Range:

Documentation – Data sheets, lifting procedures, company policies, risk assessments, COSHH assessment, user manuals.
Method – Manual handling, mechanical handling, lifting aids.
Resources – PPE, materials, tools, equipment, consumables.
Load/s – Loose bulk materials, sacks, bags, pallets, sheet materials, bars, ingots, castings, plate, pipes and tubing, wire, rolled sections, powders, liquids (resins, coolants, lubricants).
Equipment - Manually operated handling equipment (sack barrows, pallet trucks), scissor jacks, forklift trucks, telehandler, hoists, pulley, lifts.
Lifting accessories – Fibre or ropes slings, chains (single or multiple leg), hooks, eyebolts, spreader beams, magnetic and vacuum devices.

What do learners need to demonstrate?	Skills
Select appropriate **method** for receiving, moving, and handling of the **load/s**. Check material weight using relevant **documentation.** Use appropriate lifting **equipment**, **lifting accessories** and **method** of lifting **load/s** when receiving, moving, handling, and preparing **resources**. Arrange workplace and organise layout to receive goods into the work area. Use correct manual and mechanical handling methods to move items around the workplace.	EC5 MC6 DC3

4.1 Apply suitable production **methods** and techniques to tasks and activities.

Range:

Production methods – One-off's, short run batches, long run batches, high speed manufacturing, mass production, high/low value items.
Standard Operating Procedures - Step by step sequenced instructions to carry out manufacturing operations with reference to materials, tooling, machinery, equipment, processes to be used, health and safety.

What do learners need to demonstrate?	Skills
Select and apply the appropriate **production methods** in line with available technology, quantities required, value of items, accuracy required and customer requirements. Follow all **standard operating procedures** (SOP) and comply with all health and safety regulations. Demonstrate the correct **production methods** and techniques to ensure the product is created correctly.	MC6

4.2 Accurately shape and manipulate components and products.

Range:

Material - Ferrous metals (stainless steel, cast iron, high speed steel, silver steel, low, medium and high carbon steel), non-ferrous metals (aluminium, copper, brass, lead and zinc).
Machines - Lathe, milling, grinding, sanding.
Tooling:
For milling - Face mills, end mills, slot drills, slotting cutters, slitting saws, profile cutters, twist drills, reamer, boring tools.
For turning - Turning tools, facing tools, form tools, parting off tools, single point threading, boring bar, recessing tool, centre drill, twist drill, reamer, tap, die, knurling tool.
For drilling - Centre drill, drill bit, flat-bottomed drill, counterboring tool, countersinking tool, reamer, tap.
Parameters - Positional (position of workpiece, position of tool in relationship to workpiece), dynamic (tooling, workpiece or cutter revolutions per minute), pressure, linear feed rate, depth of cut for roughing and finishing, swarf clearance.

What do learners need to demonstrate?	Skills
Remove **material** effectively using appropriate **machines**, **tooling**, equipment and machining **parameters**. Shape and manipulate components to specification.	EC5 MC1 MC4 MC5 MC10 MC6

4.3 Accurately **mill**, **turn** and **drill materials** and products.

Range:

Machines - Milling, lathe, drills.

Mill - Flat faces, square faces, parallel faces, angular faces, steps/shoulders, open-ended slots, enclosed slots, recesses, tee slots, drilled holes, bored holes, profile forms, serrations, indexed or rotated forms.

Features:

Turn - Flat faces, parallel diameters, stepped diameters, tapered diameters, drilled holes, bored holes, reamed holes, profile forms, internal threads, external threads, parting off, chamfers, knurls, grooves, undercuts.

Drill - Through holes, blind holes, flat-bottomed holes, counterbored holes, countersinking, reaming, tapping.

Materials - Ferrous metals (stainless steel, cast iron, high speed steel, silver steel, low, medium and high carbon steel), non-ferrous metals (aluminium, copper, brass, lead and zinc).

Quality requirements - Dimensional tolerance equivalent to BS 4500.

Tooling:

For milling - Face mills, end mills, slot drills, slotting cutters, slitting saws, profile cutters, twist drills, reamer, boring tools.

For turning - Turning tools, facing tools, form tools, parting off tools, single point threading, boring bar, recessing tool, centre drill, twist drill, reamer, tap, die, knurling tool.

For drilling - Centre drill, drill bit, flat-bottomed drill, counterboring tool, countersinking tool, reamer, tap.

What do learners need to demonstrate?	**Skills**
Select appropriate **tooling** required to produce the features as determined in the specification to meet **quality requirements**.	MC1 MC2
Check condition of **tooling** prior to use for any problems or issues with cutting surface that could affect performance.	MC3
Set up **materials** on the **machines** as determined in the specification.	MC4
Operate various **machines** to remove material to produce various **features.**	MC5
Change **tooling** in accordance with health and safety requirements including isolation procedures.	
Use appropriate tools and equipment to check components meet the required specifications and **quality requirements.**	
Report any issues, broken or damaged **tooling** in accordance with company procedures.	

4.4 Produce one-off components using a range of **processes and techniques**.

Range:

Processes and techniques - CNC milling, CNC turning, conventional milling and turning, additive manufacturing.

What do learners need to demonstrate?	Skills
Produce components using a range of **processes and techniques**, by the most suitable method for the component to be produced taking into consideration quality, cost and time.	EC5 DC1 DC2 DC3 DC4 DC5 DC6 MC1 MC2 MC4 MC5 MC10

4.5 Operate **CNC machinery** to manufacture components.

Range:

CNC machinery - Lathe, milling machine, router, cutters.

What do learners need to demonstrate?	Skills
Set-up **CNC machinery** to manufacture components to the required specifications using pre-prepared programmes to machine a range of complex features and profiles. Perform safety checks and ensure interlocked guard is correctly positioned. Operate **CNC machinery** to produce components with complex features and profiles to the required specifications. Perform visual checks of the machining process to check for issues or problems and intervene as required. Use the manual overrides and emergency stop as required.	EC5 MC4 MC5 DC1 DC2 DC3 DC4 DC5 DC6

4.6 Re-instate work areas.

Range:

Store - Identified, stored correctly, protected and evaluated for future use.
Disposal of waste - General waste, recycling, re-use, hazardous waste (solvents, coolants, sharp materials, oils, fluids), non-hazardous waste (packaging, swarf, material off cuts, replacing of used consumables).
Maintenance - Cleaning, lubricating, sharpening, charging.

What do learners need to demonstrate?	Skills
Clean, tidy and reinstate the work area on completion of the task. Isolate and power down equipment and/or machinery.	MC6

Perform **maintenance** of tools and equipment before storing in a systematic way in accordance with working procedures. **Store** excess materials correctly to prevent damage or degradation. Replace any items that have perished and ensure stock levels are accounted for. **Dispose of waste** as per legislation and company procedures.	

5.1 Apply **safe systems of work** in the delivery of all activities.

Range:

Safe systems of work - Personal Protective Equipment (PPE), signage, Standard Operating Procedures, risk assessments and control measures, pre-use checks.
Legislation and regulations - Health and Safety at Work Act (HASAWA), Provision and Use of Work Equipment Regulations (PUWER), Control of Substances Hazardous to Health (COSHH) Regulations, Manual Handling Operations Regulations, Personal Protective Equipment at Work Regulations, Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR).

What do learners need to demonstrate?	**Skills**
Apply **safe systems of work**. Work in accordance with the organisational and legal health and safety **legislation and regulations** and in carrying out any and, all tasks, minimising the risk of injury to self and others in the process. Comply with all regulations and legislation.	EC1 EC5 MC10

5.2 Monitor production machining and toolmaking **processes**.

Range:

Processes - Machines, operational processes, tools, equipment, materials, local work area, material and equipment movement.
Potential risks - Identification of issues, implementing preventive measures, reporting issues.
Fault finding methods and techniques - Visual, fault checking systems, testing.
Issues - Changed parameters, risk, issue, unexpected activity, excessive noise, heat, vibration, sensory.
Improvement - Production modification (process, efficiency, cost, accuracy), quality control (inspection, accountability, traceability).

What do learners need to demonstrate?	**Skills**
Monitor the performance and efficiency of equipment and the **processes** with machining and toolmaking activities. Identify any **issues** and/or problems with the immediate task to inform processes and agreed outcomes and timeframes. Deal promptly and effectively with issues within the limits of their own authority using approved diagnostic **fault-finding methods and techniques**. Select suitable methods of fault, risk and issue resolution while maintaining operating procedures, output and quality. Make first line basic repairs whilst safeguarding the integrity of components and the surrounding area. Follow reporting procedures for raising any **issues**. Identify and mitigate **potential risks**. Identify areas for **improvement.**	EC1 EC2 EC5 EC4 EC5 EC6 MC5 MC6 MC10 DC6

5.3 Carry out or assist with **quality monitoring** and **assurance checks** to review processes.

Range:

Quality monitoring - Inspections, reviewing, amending, supervisory checks, checking of quality.
Assurance checks - Checking and validating reliability and durability, material and product testing.
Conform - Drawings (symbols, abbreviations), specifications (British Standards (BS), British Standards Institution (BSI) issues codes, International Standard (ISO)), identification markings, supplier and manufacturer coding systems, colour coding.

What do learners need to demonstrate?	Skills
Conduct **quality monitoring** and **assurance checks** as part of the production process. Review efficiency of processes, practices and outcomes. Consistently check validity, accuracy and relevance of documentation. Check outcomes **conform** to the requirements in the specification. Communicate technical information, advice and suggestions for improvements. Suggest strategies to increase efficiency of quality monitoring processes, with consideration of performance and potential improvements. Carry out or assist others with testing procedures as required.	EC1 EC6 MC1 MC2 MC5 MC6 MC8 MC10

5.4 Complete effective handover procedures.

Range:

Handover procedures - Shift changeovers, breaks, job rotation, end of a process, inter departmental handovers.
Post-production check list - Job number, drawing number, control reference number, list of operations, operator name, date of work completed, non-conformance details, mapping against standards.

What do learners need to demonstrate?	Skills
Perform **handover procedures** to ensure production process continues as scheduled. Communicate handover to another person to ensure continuity and consistency. Pass on information or documentation pertinent and critical to the smooth running of the process Notify any issues arising or observations on process or, equipment performance. Complete **post-production check list** confirming quality standards and specific working requirements have been completed.	EC1 EC2 EC4 DC1 DC2 DC3

6.1 Demonstrate **effective communication**.

Range:

Effective communication - Written, verbal, digital skills, presented communications, listening, questioning, pre-meeting preparation.
High-quality communications - Promotional collateral, business plans, annual reports.

What do learners need to demonstrate?	Skills
Demonstrate **effective communication** skills. Prepare adequately for meetings and formal discussions. Support **high-quality communications** in production activities by confirming information, requirements, expectations, plans, performance, and outcomes in ways that are suitable for purpose and context.	EC1 EC2 EC3 EC4 EC6 MC5 MC6 MC8 MC9 MC10 DC1 DC2 DC3 DC4

6.2 Accurately record relevant technical **information**, **data**, risks, and issues to support production projects, tasks and activities.

Range:

Information and data - Health and safety records, manufacturing plans, inspection sheets, quality documents, production programmes, authorised alternative methods/materials, risk assessment, risk management system.

What do learners need to demonstrate?	Skills
Keep legible records of tasks undertaken, using a spreadsheet or a logbook. Record key technical **information and data** in relation to the process. Complete dynamic data sheets in line with production requirements. Check sourced or given **information and data** is current. Amend or correct **information and data** within own limits of authority. Report and escalate where **information and data** need to be amended which is outside of limit of authority. Contact the person authorised to make the changes and resolve the issue.	EC1 EC4 EC5 MC2 MC5 MC6 DC1 DC2 DC3 DC4

Guidance for delivery

Opportunities for visits/engagement with local industry, employers and manufacturers should be provided throughout the delivery of the content within this specialism – where appropriate local employers with a machining or toolmaking focus could present details of recent engineering projects and any problems faced and how they were overcome. Visits could enable learners to see various CNC machines being utilised and integrated software for CAD/CAM. Learners work placement experiences could be presented to peers detailing where knowledge and skills within the content was seen in practice.

Formative assessment for the content may include oral Q&A, presentations to peers, observation of measuring activities etc. Reinforcement of learning can be encouraged through revisiting learning, group discussions, and the establishment of a peer support system within the cohort.

Providers must ensure content is delivered in line with current, up-to-date industry practice which will require;

- Provision of appropriate tools, equipment and test instrumentation for demonstration and practical training purposes
- Teaching coverage representing the type of equipment currently available and accepted for use in the UK industry.

Suggested learning resources

Books

- A L Chitale, E C Gupta, *Production Design and Manufacturing*, 12th Edition, PHI Learning, 2013, USBN 8120342828
- J T Black, Ronald A Kohser, *DeGarmo's Materials and Processes in Manufacturing*, 12th Edition, John Wiley & Sons, 2017, USBN 978119299585
- Rex Miller, Mark R Miller, *Automated Machines and Toolmaking (Audel Technical Trade Series),* 5th Edition, John Wiley & Sons, 2004, ISBN 0764555286
- Michael F Ashby, Hugh Shercliff, David Cebon, *Materials: Engineering, Science, Processing and Design,* 4th Edition, Butterworth-Heinemann, 2018, ISBN 0081023766
- William D Callister, David G Rethwisch, *Callister's Materials Science and Engineering*, 10th Edition, John Wiley & Sons, 2020, ISBN 1119453917

Websites

- Health and Safety Executive (HSE) **www.hse.gov.uk**
- Institute of Mechanical Engineers **www.imeche.org**

Scheme of Assessment – Machining and Toolmaking Technologies

The Machining and Toolmaking Technologies Occupational Specialism is assessed by one practical assignment. The duration of the assessment is 25 hours and 15 minutes. Learners will be assessed against the following assessment themes:

- Health and safety
- Planning and preparation
- Production
- Quality review and evaluation.

By completing the following tasks:

Task	Typical Knowledge and skills
Task 1 - Planning	Displays a breadth of knowledge and practical skills that enables them to plan the manufacturing and assembly of the product. Candidates will need to produce documents that clearly states how they will produce the end product in line with the brief. Candidates will need to produce a risk assessment covering all the activities needed to produce the final product taking into account required safety measures. Candidates will create their own plans, commissioning checklist and quality check sheet.
Task 2 – Production	Applies a breadth of knowledge and practical skills that enables them to carry out the manufacturing, machining and assembly of the product in accordance with their planning and interpreting the technical drawings. The task is carried out in a clear and logical sequence. Works in a safe manner, handles materials with care. Tools, materials and equipment are selected and used correctly. Candidates will utilise both manual/traditional workshop machinery and computer numeric controlled (CNC) machinery to produce the components for the final product.
Task 3 – Evaluation and implementation (split into 3 sub-tasks)	Displays a breadth of knowledge and understanding in the evaluation of their own manufacturing, fitting and assembly processes, recommending adaptions and improvements to the finished assembly/product or the processes utilised. Inspects assemblies and components for defects and evaluates their cause and prevention. Accurately records and reports data and findings of quality inspections.

The information provided in the following tables demonstrates to approved providers the weightings of each performance outcome and how each performance outcome is assessed.

Performance outcome and weighting (%)	***High level tasks*** *Provide specific instructions for candidates to provide evidence for and are the same for every version of the assessment*	**Assessment Theme**	***Typical evidence***
PO2 Analyse projects and specifications, considering the specific requirements, context, resources, tools and equipment, and the suitability of different production technologies, processes, and methods. (17%)	T1 - Planning	Planning and preparation	Resources list (with measuring equipment calibration check recorded), risk assessment, method statement with justifications, work plan, quality check sheet, commissioning checklist.
	T2 – Production	Health and safety	Risk assessment and method statement with justifications.
		Production – Measuring and marking out	Finished machined product, commissioning checklist.
		Production – Techniques and methods	Finished machined product.
		Production - Tools and equipment	Finished machined product.
		Production - Assembly	Finished machined product, commissioning checklist.
	T3 - Quality review and evaluation	Quality review and evaluation – Quality review	Quality inspection report, commissioning checklist, quality check sheet.

PO3 Plan and prepare relevant materials, resources, tools, and equipment needed to produce the relevant products and outcomes. (21%)	T1- Planning T2 – Production T3 – Quality review and evaluation	Planning and preparation Health and safety Production – Measuring and marking out Production – Techniques and methods Production - Tools and equipment Production - Assembly Quality review and evaluation – Quality review Quality review and evaluation - Reporting, recording and handover	Resources list (with measuring equipment calibration check recorded), risk assessment, method statement with justifications, work plan, quality check sheet, commissioning checklist. Risk assessment, method statement (with justifications) Finished machined product, commissioning checklist. Finished machined product. Finished machined product. Finished machined product, commissioning checklist. Quality check sheet, commissioning checklist. Quality inspection report.
PO4 Produce relevant products and outcomes, considering the specified requirements, context and materials, using the relevant fitting and assembly technologies, methods, and	T2 – Production	Health and safety Planning and preparation Production – Tools and equipment Production – Measuring and marking out	Risk assessment. Work plan. Resources list (with measuring equipment calibration check recorded). Finished machined product, commissioning checklist.

processes. (27%)		Production – Techniques and methods	Finished machined product.
		Production – Assembly	Finished machined product, commissioning checklist.
PO5 Support the delivery (and the management) by helping to evaluate and review the outcomes to improve the final product, production methods, and work place practices and processes. (19%)	T2 – Production	Health and safety	Risk assessment.
		Planning and preparation	Work plan.
		Production – Tools and equipment	Finished machined product.
		Production – Measuring and marking out	Finished machined product, commissioning checklist.
		Production – Techniques and methods	Finished machined product.
	T3 – Quality review and evaluation	Quality review and evaluation – Quality review	Commissioning checklist, quality check list.
		Quality review and evaluation – Reporting, recording and handover	Quality inspection report.
PO6 Communicate production information, proposals and solutions, producing, recording and explaining relevant technical information,	T2 Production	Health and safety	Risk assessment, resources list (with measuring equipment calibration check recorded).
		Planning and preparation	Work plan.
		Production – Tools and equipment	Finished machined product.
		Quality review and	

representations, processes and outcomes. (16%)	T3 – Quality review and evaluation	evaluation – Quality review Quality review and evaluation – Reporting, recording and handover	Quality check sheet. Quality inspection report.

333 Composites manufacturing technologies

Level:	3
GLH:	680
Assessment method	Practical assignment

What is this specialism about?

The purpose of this specialism is for learners to know and understand composites manufacturing technologies. Learners will engage with the technical expertise, technology, methods, and skills involved in developing and making products at various scales, using specialist tools, materials, equipment and machinery.

Learners will examine a range of industrial processes, computer-aided manufacture, manual and machining techniques, research, and planning required to develop products using a combination of materials and components to form a lighter, more efficient and stronger rigid structure, and to understand how these complex processes, practices and outcomes are evaluated and optimised.

Learners will develop their knowledge and understanding of, and skills in:

- Scientific and mathematical principles along with technical and materials awareness.
- Suitable tools and equipment, machines and technology widely used in composites manufacturing along with damage assessment and process induced faults and failures.
- General workplace practices and composites manufacturing standards.
- Regulatory and legal requirements, specifically health and safety.
- Project and programme management incorporated into general business and commercial aspects of manufacturing.
- Composites manufacturing quality aspects and communications in the workplace.
- Drawings and tools used in composites manufacturing.
- Planning, preparation, and production of composites manufactured products.
- Communications and supporting composites manufacturing activities.

Learners may be introduced to this specialism by asking themselves questions such as:

- What are the processes involved to manufacture composite components for a high-performance sports car?
- How are composite materials produced and tested for strength?
- How does the use of composite materials affect the design of a product, compared to those traditionally produced in metal?
- What are the cost implications of using composite materials in the manufacturing process?

Underpinning knowledge outcomes

On completion of this specialism, learners will understand:

1. Composites manufacturing technologies knowledge criteria

Performance outcomes

On completion of this specialism, learners will be able to:

2. Analyse and interpret engineering and manufacturing requirements, systems, processes, technical drawings and specifications.
3. Plan and prepare the relevant processes, tools, equipment, and resources, needed to manufacture relevant products and produce appropriate outcomes
4. Produce relevant products and outcomes, considering the specified requirements, context and materials, using the relevant composite manufacturing technologies, methods and processes.
5. Support the delivery (and management) of relevant projects and activities, helping to evaluate and review processes and outcomes, and to improve practices.
6. Communicate production information, proposals, and solutions, producing, recording and explaining relevant technical information, representations, processes and outcomes.

Completion of this specialism will give learners the opportunity to develop their maths, English and digital skills. Details are presented at the end of the specification.

Specialism content

Knowledge criteria for performance outcomes

1.1 Planning, preparing and implementing manufacturing and production activities.

Range:

Plan - Location, types of facility needed, space requirements, equipment requirements (types, costs, operational processes), people (skilled, unskilled), materials, processes, costs, timescales, quantity, quality control/assessment, finished product (design/finish).

Technical information - Engineering drawings (design, tooling, detail, sub-assembly, assembly), specifications, design concepts, data sheets, test records, maintenance records, work instructions, flow charts, plans, manufacturer's manual/documentation, standard operating procedures (SOP), instructions, inspection documents.

Scale of work - Prototype, batch, mass production, continuous production.

Cost break points and other factors - Revenue, costs, profit and loss, average rate of return, investment (jigs, fixtures, automation).

What do learners need to learn?	Skills
The difference between the scale of work in production, manufacturing and processing activities. How to plan and prepare for the activities. The **technical information** needed to achieve specific outcomes. How to interpret information to create a manufacturing production **plan**. How to produce a plan to the correct **scale of work.** **Cost break points and other factors** for selecting assembly and manufacturing methods.	N/A

1.2 Visualising final manufactured products from composite design drawings.

Range:

Drawings - Descriptions, 2D drawings, 3D representatives, sketches, patterns, plugs, moulds, ply stack, virtual reality and fly-through techniques, digital twin simulation of processes.

Technical information - Engineering drawings, specifications, manufacturers' data sheets, material safety data sheets, production process records, material supply, storage and handling records.

What do learners need to learn?	Skills
The range of **drawings** and **technical information** needed to visualise the end to end process and stages of development. How to interpret the 2D drawing view, 1st and 3rd angle projections and how these are interpreted to show the 3D product. How design packages can be used to produce solid models from digital or 2D data. How to produce patterns and moulds from design drawings. How the production process relates to the properties of the finished moulding.	N/A

1.3 **Planning** for composite manufacturing operations.

Range:

Information and documentation - Customer specifications, numbers off, time constraints, cost constraints, part tolerances, critical fit and max deflections, service conditions, material specifications, component drawings, data sheets, risk assessments, SOP, COSHH compliance, ply lay-up requirements, consumables specification.

Consider - Resources, costs, skill set of workers, availability of specialist workers, core material selection, end use, mould preparation, compatibility of materials, environmental considerations, longevity, time, disposal of wastes, inspection.

Planning techniques - Production schedules, job records, production plans, material form and storage removal implications.

Plans - Order of operations, timings, techniques, production activities, materials, quality (inspection), ply orientation and conventions, health and safety, waste disposal.

Disposal - Wastage, recyclability, end of life considerations, sustainability.

What do learners need to learn?	**Skills**
How to obtain the correct **information and documentation** to consider and determine the manufacturing process required and sequence of operations. The **planning techniques** that can be used to plan for producing and preparing a mould to manufacture the product. How to use production **plans** to define what the laminator or machine programmer must do. How to determine the order of ply lay-up operations, the orientation and sequence of consumables required. How to ensure that the required consolidation and de-baulking is achieved during the production phase. How to determine the consolidation and curing requirements. How to make the most efficient use of materials and consumables from the outset, avoiding excessive waste for **disposal**. How to consider the application and **disposal** requirements of materials and consumables used in the process.	N/A

1.4 **Structure, composition and properties** of common and core materials used in composites manufacturing.

Range:

Structure, composition and properties - Mechanical, physical, thermal, chemical, environmental degradation.

Properties of materials - Tensile strength, compressive strength, impact resistance, environmental tolerance, fibre interface.

Considerations - End use environment, effects of temperature (hot/wet versus cold/dry), resistance to fatigue and cyclic loading, ballistic protection, comparison with traditional engineering materials, cost.

Matrix materials - Thermoset, thermoplastic, ceramic matrix, metal matrix, bio resins.

Composites - Fibre material types (glass, carbon, aramid, quartz, bio fibres, thermoplastic), fibre material forms (woven (plain, twill, satin etc), unidirectional, chopped strand mat (CSM), multi-axial, tapes, 3D stitching, preforms, braiding), natural and synthetic fibres, material combinations.

What do learners need to learn?	Skills
The **properties** of **composites**, the atomic bonding of ceramics and polymers, the structure of thermoset and thermoplastic polymers to include crystallinity and cross-linking. How the curing process affects the structure. The **properties of materials** and what effect temperature and environmental condition has on them. The different types of resin systems. The different types of core and **matrix materials**. The orientation and application of reinforcements. Sandwich panels and core materials. Surfacing and finish materials, in-mould and post-mould finishes. Room and elevated temperature resin systems. Weave styles and how to identify them. **Considerations** for the selection of **composites** when determining which materials and combinations are most suitable for a job.	N/A

1.5 Uses and limitations of **materials** in composites manufacturing.

Range:

Forms of supply - Rolls, sheet materials, liquids (resins), pallets, intermediate bulk containers (IBC), powders (fillers), sacks.

Uses - Mould making, production, manufacturing components, processing.

Materials - Natural/sustainable, man-made composite materials, ceramics and polymer matrix combinations, binding agents and sealants.

Properties - Mechanical, physical, thermal, chemical, environmental, electrical.

Degrade and fail – Stress, delamination, in-plane fracture, osmosis, UV degradation, creep, fatigue, oxidation, erosion, mechanical and thermal shock, presence of impurities, foreign object debris (FOD) inclusion, void presence, incomplete cure, chemical attack, barely visible impact damage, dry patches, incorrect fibre volume fraction, kissing bond defects.

Preventative techniques – Gel coats, protective coatings, edge and surface protection, interlayer films, environmental protection, fixing and bonding implications, heat/corrosion protection.

What do learners need to learn?	Skills
The **forms of supply** for common materials used in the manufacturing and production process. The diversity of **uses** for a range of **materials**. The limitations of a range of **materials** in relation to their **properties** e.g. using bronze and copper mesh for lightning conductivity in aerospace. The characteristics relating to material quality and condition. How and why materials **degrade and fail**. How levels of degradation and failure are monitored, e.g. testing. **Preventative techniques** and how to apply them.	N/A

1.6 **Disposal** requirements of **materials** in practice.

Range:

Materials - Glass fibre, carbon fibre, particle, fibre and sheet-based composites, natural and synthetic fibres, resins, bonding agents, additives, chemicals, consumables, titanium, graphene.
Disposal - General waste, segregation of waste, processing of waste, hazardous and non-hazardous waste, cost to dispose/recycle/ship.
Wastes - Used materials, used liquids, off cuts, dust, hazardous and non-hazardous materials, cured and uncured resins, consumables, scrap.
Legislation and regulations - Environmental Protection (Duty of Care) Act 1990, Hazardous Waste (England and Wales) Regulations 2005, Waste Management (England and Wales) Regulations 2006, Control of Pollution (Applications, Appeals and Registers) Regulations 1996, Trade Effluent (Prescribed Processes and Substances) Regulations 1989.

What do learners need to learn?	Skills
The considerations that must be made when disposing of **materials** and **wastes** from composites manufacturing. The categories of waste and the implications if certain products are allowed to interact/mix. The **legislation and regulations** relating to the **disposal** of wastes and protection of the environment. Waste reduction techniques. Reuse, recycle, recover options for composites manufacturing waste.	N/A

1.7 Standard technical **documentation**.

Range:

Documentation - Engineering drawings (design, tooling, detail, sub-assembly, assembly), specifications, design concepts, data sheets, test records, ply lay-up and orientation requirements, manufacturing environment requirements (temperature, humidity), work instructions, flow charts, plans, manufacturer's manual/documentation, material storage, thaw records, shelf life, out-time, cure data (temperature, pressure, environment, timings, dwell periods), standard operating procedures (SOP), instructions, inspection documents, Non-destructive Testing (NDT) results, cutting lists, ply count-back process, orientation conventions, operative log.
Standard Operating Procedures - Technical, management, types (checklists, step-by-step lists, hierarchical lists, process flowchart).
Drawings - 2D, 3D, solid models exploded views, flat patterns, mould feature requirements (clearance, order, history), symbols, terminology, conventions.

What do learners need to learn?	Skills
The purposes and types of standard technical **documentation.** How technical **documentation** is produced and who is responsible for its production. How to interpret technical **documentation** and who or what to refer to for guidance. How amendments are made to technical **documentation**, who is responsible and who to refer to for authorisation.	N/A

Overview of all types of manufacturing documents used in a wide range of composite manufacturing sectors. The importance of traceability. How to read and interpret composite **drawings**. The correct representations, symbols, annotations, and conventions used, as outlined in BS 8888 and on composite drawings. Different types of **standard operating procedures.**	

1.8 Specific applications of different types of **machinery and equipment** used to manufacture composite products.

Range:

Machinery and equipment - Freezers, de-gassers, vacuum bags, film, heated press, heat lamps/hairdryers, autoclave, oven, heated blankets, infrared lights, resin injection equipment, spray lay-up, automated fibre placement machines, sanding and finishing equipment, routers and computer numerical control (CNC) machining processes, vacuum application equipment, tooling, moulding tools (male, female, matching, multi-part, closed, mandrels), resin mixers, pultrusion/extrusion, filament winding, compression moulding, bulk and sheet moulding, overbraider, overmoulder, laser ply alignment, ply cutters, additive layer manufacturing, extraction and dust handling system/equipment.

Maintain - Cleaning, lubricating, sharpening, charging, filter changing, inspection, sequencing, calibration, portable appliance testing (PAT), storing.

What do learners need to learn?	**Skills**
How to safely set up a range of **machinery and equipment** to manufacture composite products. How to use a range of machinery and equipment effectively to meet specification requirements. The coefficient of thermal expansion with tooling material choice. The importance of following guidelines and instructions. The risks to quality, cost and health and safety of non-compliance. Who the appropriate person is to ask for advice and guidance, if and when necessary. How to detect and identify problems or faults with equipment or machinery and how isolation methods. Methods of resolution or escalation of issues. How to adequately **maintain** the machinery and equipment after use.	N/A

1.9 **Hand tools, power tools and equipment.**

Range:

Types - Protractor & depth gauges, micrometer, de-burring tools, safe edger, viscosity measuring cups, square, straight edges, gauges, punches, heat gun, forming tools, resin mixers, clamps, files, scales and balances.

Purpose - Measuring, marking-out, cutting, laminating, shaping, forming, joining, finishing, inspection/testing.

Hand and power tools and equipment - Standard hand tools, powered hand tools electrical power (full mains, 110v, battery), pneumatic power tools, high-speed cut-off tools, die grinders, power drills, sanders, polishers (hand and power).

Maintain - Cleaning, lubricating, sharpening, charging, storing.

Legislation, guidelines and instructions - Work instructions, operating procedures, health and safety legislation and regulations, risk assessments, maintenance records, manufacturer's manuals.

What do learners need to learn?	**Skills**
The **types** of **hand tools, power tools and equipment** commonly used to manufacture composites products. The **purpose** of standard hand and power tools and equipment. How to correctly select tools and equipment for the task. How to correctly prepare tools and equipment making adequate and reasonable checks on their condition prior to use. How to adequately **maintain** the tools and equipment after use. How to suitably record and report any faults identified in the condition or performance of the tools. The process/procedure to take damaged or faulty equipment out of service until returned to a suitable condition. The relevant **legislation, guidelines and instructions** that must be followed when preparing, using, or maintaining tools and equipment.	N/A

1.10 **Calibration** and testing of equipment used in composites manufacturing.

Range:

Calibration - Accuracy, drift, duration, consistency.

Documentation - Calibration record, national or international standard, user manuals, maintenance logs/record.

What do learners need to learn?	**Skills**
The importance of **calibration** and why **calibration** is needed. How calibration is achieved. The frequency of calibration/re-calibration. The use of national/international standards. How to establish if a piece of equipment has been calibrated. **Documentation** needed for the calibration process. Cost of calibration compared to the cost of replacement.	N/A

1.11 How to use **equipment and technology** in composite manufacturing.

Range:

Legislation - HASAWA, COSHH, Manual Handling, PUWER.
Equipment - Rollers, brushes, spray guns, mould, vacuum bags, heated press, autoclave, oven, heat guns, injection equipment, freezers, sanding and finishing equipment.
PPE - Overalls, safety glasses, respirators, gloves, head protection, safety footwear, skin protection (barrier creams, clothing), vacuum cupboard.
Faults and isolation methods - Monitoring of machinery, fault detection, performance measurement, isolation, and recovery (FDIR), e.g. sensor readings, condition-based maintenance, planned preventive maintenance, corrective maintenance.
Resolution - Maintenance, adjusting parameters, replacement.
Guidelines and instructions - SOP, specifications, method statements, risk assessments, manufacturers manual, data sheets.

What do learners need to learn?	Skills
The use of safety equipment/guarding on **equipment** to prevent risk to operator. The use of **PPE** to protect the user. Importance of following **guidelines and instructions**. How to safely use **equipment** following SOP's and health and safety regulations and relevant **legislation.** Types of **faults and isolation methods.** Detection and **resolution** methods. When to seek guidance and assistance.	N/A

1.12 **Methods** of laying-up composite **materials**.

Range:

Materials – Resins (catalysts, accelerators, hardeners), glass fibre, carbon fibre, particle, fibre and sheet-based composites (natural and synthetic).
Methods - Hand lay-up, spray lay-up, pre-preg lay-up, resin infusion/transfer, automated lay-up.

What do learners need to learn?	Skills
The different **methods** of laying-up composite **materials.** The advantages and disadvantages of each laying-up method.	N/A

1.13 Compliance with **standard workplace practices**.

Range:

Standard Operating Procedures - Technical, management, maintenance and material records, types (checklists, step-by-step lists, hierarchical lists, process flowchart).

Workplace practices - Safe systems of work, permits to work, risk assessments, work instructions, standard operating procedures (SOP), user guides, operational instructions, health monitoring.

Practices - Health and safety, regulations, legislation (PUWER).

Activity - Planning, preparing tools/equipment, using tools/machinery, maintaining tools/machinery.

What do learners need to learn?	Skills
The various formats of **Standard Operating Procedures** (SOP) and how to interpret and work to them. The typical **safe working practices** contained in an SOP and how to comply with them and any specific instructions e.g., tools and equipment. Health and safety documentation including risk assessments, permits. How to comply with **standard workplace practices** and regulations for the relevant **activity**. The consequences of non-compliance on self and others.	N/A

1.14 Creating complex **jigs and templates** to meet manufacturing specifications and requirements.

Range:

Jigs and templates - Handheld templates, holding fixtures, machine guiding templates, assembly jigs, installation/laminating tooling.

What do learners need to learn?	Skills
The circumstances when **jigs and templates** are required. What to do when items are an unusual shape. How to recognise when a jig or template will save time and enhance quality through repeatability and interchangeability. The process for generating jigs and templates, including the principals of location and positioning of items relative to other parts.	N/A

1.15 Properties, uses and limitations of a range of **joining techniques** used in composite manufacturing.

Range:

Joining techniques - Mechanical, adhesives.

Bonding process - Use of epoxy resins, curing, monolithic and sandwich panels/test pieces.

What do learners need to learn?	Skills
How to prepare a composite for bonding. Bonding methods and techniques. How to secure a composite during the **bonding process**. Different bonding materials.	N/A

1.16 **Fault diagnosis and resolution methods** in composites manufacture and production processes.

Range:

Faults - Visual, barely visible impact damage, noise attenuation/transmission, poor dimensional control, surface defects, disbonds, debonds, incorrect cure, heat damage, FOD inclusion, voids.
Detection - Sensory (noise, vibration, visual, smell), ultra-sound, Xray, thermography, deflection, physical attributes measurement processes, CMM.
Isolate - Mechanical, electricity, gas, air (pressure and vacuum), fluids.
Resolution - Six-point technique, quantitative, qualitative, continuous improvement, conformance to specification.

What do learners need to learn?	Skills
How typical **faults** can be diagnosed and resolved quickly. How to recognise faults using sensory **detection**. How to recognise faults using non-destructive evaluation processes. How to **isolate** power and pressure equipment prior to checks. The basic, or first line, **resolution** methods that can be applied.	N/A

1.17 Engineering **standards**.

Range:

Types - British (BS), European (EN), International (ISO) ISO 9001, ISO 8062, FAA, CAA.
Impact - Quality, compliance, performance, function.
Standards - Quality management (BS4500, ISO 9000, 9001), environmental management (ISO 14000, 14001), risk management (ISO 31011).
Sector - Aerospace, nuclear, power, utilities, automotive.

What do learners need to learn?	Skills
The purpose of a range of **standards**. The types of **standards** used in engineering and manufacturing **sector** workplaces. The application and **impact** of the **standards** in a manufacturing workplace. The systems and procedures put in place to ensure they are adhered too.	N/A

1.18 **Legal and regulatory frameworks and documentation.**

Range:

Legislation - Health and Safety at Work Act 1974, Employment Act 2002, Factories Act 1961, Fire Precautions Act 1971, Employment Equality, Management of Health and Safety at Work Regulations 1999, Provision and Use of Work Equipment Regulations (PUWER) 1998, Control of Substances Hazardous to Health (COSHH) Regulations 2002, Lifting Operations and Lifting Equipment Regulations 1998, Manual Handling Operations Regulations 1992, Personal Protective

Equipment at Work Regulations 1992, Confined Spaces Regulations 1997, Control of Noise at Work Regulations 2005, Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR) 1995, Working Time Regulations 1998.

Health and safety procedures - Health and safety policy, risk assessments, emergency procedures.

Consequences - Improvement and enforcement notices, prosecution (fines, imprisonment, compensation claims), organisation reputation damaged.

What do learners need to learn?	Skills
The key points of health and safety **legislation** that provide a framework for more specific, task-focused activities at work. The company's health and safety policy and how it sets the scene for ensuring a healthy and safe place of work. The company's **health and safety procedures**, specifically those related to the learner's role, responsibilities and functions. The typical emergency systems and procedures that would be in place for a composites manufacturing and processing environment. The importance of complying with legislation and the **consequences** of breaches in legislation on the individual and the organisation. How to access sources of authoritative information.	N/A

1.19 Site and process **safety, environment and risk management systems and practices**.

Range:

Safety, environment and risk management systems and practices - Health and safety management system (HSG65) generic risk assessment, COSHH, manual handling, young people, PUWER assessments, Environmental Management System (EMS).

What do learners need to learn?	Skills
The role of individuals and the impact they can have when upholding health and safety and organisational policies in a workplace. The purpose and function of **safety, environment and risk management systems**. Reporting procedures and who to inform. How to interpret a health and safety management system (HSG65). How to interpret information from an Environmental Management System (EMS).	N/A

1.20 Business improvement through project management.

Range:

Job performance - Developing own skills, learning existing and new work methods, training, participating in performance review meetings, professional institution membership, professional accreditations, continuing professional development (CPD).

Research - New supply chains, comparing against similar competitors projects, new technologies.

Evaluation - Project review, lessons learned, plan-do-check-act (PDCA) cycles.

Improvements - Identification of process improvements, investment in machinery and equipment, increased training of employees, workplace efficiencies, future opportunities.

What do learners need to learn?	Skills
How their individual **job performance** and quality of the end product can be improved. Methods for individuals to improve their own performance. How projects can lead to business **improvement**. The prospects of project success increased by continually seeking to develop own skills, learn existing and new work methods, processes, techniques and developing the capability to offer solutions to problems. The use of Key Performance Indicators (KPI). How **research**, evidence and **evaluation** of projects can identify future **improvements** and improved performance. The types of data that can be collected to identify potential improvement in project performance. How lessons from similar projects can be learned through benchmarking and comparative data.	N/A

1.21 Evaluate composites manufacturing activities in terms of **quality, cost** and **time.**

Range:

Quality - Specifications, allowances and tolerances, applying suitable inspection methods, product was finished to an acceptable standard, applicable standards, internal quality procedures, function of product, longevity of product, environmental protection.

Cost - Minimal wastage of resources and consumables, minimal inventory and storage, minimising machining and fastening, getting the job right first time, avoiding delays and rework, cost types (fixed, variable, total, marginal, average).

Time - Using and comparing historical data, method statements and time allocated by line management, choosing the most efficient method of completing a task, charts and scheduling techniques (flow charts, Gantt charts, critical path methods, project management packages).

Metrics - Cycle time, time to make changeovers, throughput, capacity utilisation, overall equipment effectiveness, yield, customer rejects/returns, supplier quality incoming, on-time delivery.

What do learners need to learn?	Skills
How to evaluate activities in relation to **quality**, **cost and time.** The definition of quality (in terms of what the customer requires), identifying all costs and how to measure them against the plan. How to set out a plan of programmed quality checks. How to measure actual spend against planned cost and identify variation to plan and **metrics** used in manufacturing. How to measure actual progress against planned progress using milestones.	N/A

1.22 Standard quality inspection and **testing methods**

Range:

Types - Representative sample and whole product quality controls, destructive testing methods (tensile testing, hardness testing (Barcol)), peel test, three-point bend test, fatigue testing, fibre volume testing by acid digestion or combustion), state of cure tests (DSC, Tg and HDT), mechanical performance, deflection under load tests, toughness testing (Charpy v-notch), impact and strength tests (dropping ball and ballistic testing), non-destructive testing methods (visual inspection, weighing, radiography, tap test, ultrasonic testing, thermography). cosmetic appearance, colour, gloss and surface smoothness tests, class 'a' specification.

Techniques - Material inspections, interim inspections, final inspections, functional checks, thorough inspection and test, in-service checks.

What do learners need to learn?	**Skills**
The **types** of testing methods. The differences between the **types** of testing methods. The capabilities and limitations of different **techniques** across different composite materials manufacture and processing contexts. How destructive testing methods are used to help understand how a material or component will perform and behave under stress. The non-destructive testing methods commonly used in composites manufacturing to analyse the properties of a component or material and establish, without damaging the component or material. Typical applications for a range of destructive and non-destructive testing methods. The limitations of each of the destructive and non-destructive testing methods The reasons for recording performance data from the tests and how this will influence materials selection for production. How to carry out sample testing and why it is important during production.	N/A

1.23 **Recording quality processes** in composites manufacturing.

Range:

Inspection parameters - Functional (mating parts), dimensional (overall sizes, hole tolerances, mass), comparative (surface roughness), completeness, colour, processing logs, laminating records, ply count-back records, de-bulk, operating parameters records.

Documents - Recording (maintenance logs, defect logs, reports, statements, checklists, equipment), inspection (checklists, documents for quantitative and qualitative information).

Quality processes - Policies, procedures, guidance, second line verifications, organisational systems and requirements, sensory checks, checklists, maintenance instructions, data, reports, measurement, analysis of systems, equipment and material suppliers and dates.

What do learners need to learn?	**Skills**
The range of typical **inspection parameters** measured and checked during a manufacturing run. A range of typical recording **documents** used in manufacturing to record data and inspections.	N/A

How **quality processes** are configured and what data needs to be recorded, how often, and in what format.	

1.24 **Communicating technical information and data.**

Range:

Communication skills - Written, verbal, digital skills, presented communications, listening, questioning.
High-quality communications - Promotional collateral, business plans, annual reports.
Communicate - Record, manage, store, amend, upload data, collaborative technologies (shared drives, email, conferencing, software and programs, forums).
Technical information and data - Test data, test results, maintenance results and findings, fault information, inspection sheets, repair methods, maintenance schedules.

What do learners need to learn?	**Skills**
The **communication skills** needed to **communicate** information effectively and to participate in **high-quality communications.**	N/A
The differences between formal and non-formal communication.	
The importance of technical documentation for communication.	
How to use different types of **technical information and data** communication methods.	
How collaborative technology is used to communicate technical information and data.	
Current legislation including General Data Protection Regulations (GDPR), and organisational procedures used to manage data and increase confidentiality of sensitive information.	

1.25 Digital, **information and communication technology** (ICT).

Range:

Information and communication technology - Data systems, recording systems, electronic document and management systems, collaborative technologies, electronic storage.

What do learners need to learn?	**Skills**
How technology and systems are used to manage production and manufacturing data and documentation.	N/A
Application of software and **information and communication technology** techniques to record, manage, store and amend production and manufacturing information.	
Advantages and limitations of using **information and communication technology** to record information.	

Practical criteria for performance outcomes

2.1 Interpret and analyse relevant **technical information, data**, representations and documentation.

Range:

Technical information - Drawings (1st and 3rd angle orthographic projections, isometric projections, assembly, general arrangement, installation drawings), specifications (matrix, core and fibre materials), charts (limits and fits, ply clock), SOP, safe working systems, material safety data sheet (MSDS), material supplier and history, curing requirements, bills of materials, manufacturing planning sheets, ply-up and orientation sheets.

Data - Inspection results, fault information, Statistical Process Control (SPC).

Drawings - 2D, 3D, solid models exploded views, flat patterns, mould feature requirements (clearance, order, history), symbols, terminology, conventions.

What do learners need to demonstrate?	Skills
Identify, read, interpret, collate, process and communicate **technical information** and **data** critical for the successful completion of the job.	MC2 DC1 DC4
Confirm the scope of the task/work.	
Interpret composite **drawings**, specifications, scales, and technical term related to composite production processes and activities.	
Analyse and report information and data accurately.	
Use and communicate the analysed information/data to improve quality of products and reliability of the process.	
Interpret plan for appropriate disposal of wastage and excess resources.	

2.2 Identify **issues**, **risks**, and areas for further analysis or investigation.

Range:

Issues and potential risks - Health and safety (risk assessment, control measures, training, reporting), quality (calibration, training), capability (initial mould and equipment checks, checks and recordings during processing), availability (resources, maintenance, downtime).

What do learners need to demonstrate?	Skills
Identify **issues and potential risks** with the immediate task to inform processes and agreed outcomes and timeframes.	EC1 EC2 EC4 EC5 EC6 MC6 DC1 DC4
Consider impact on other activities due to issues being found and delay incurred.	
Identify areas for improvement.	
Mitigate risks.	
Follow reporting procedures for raising any issues or unmitigated risks.	

3.1 Prepare for composites manufacturing tasks or activities.

Technical documentation - Risk assessment, inspection sheets, production plans, material requirements, anticipated production issues and preventative measures, standard procedures, PAT testing certificates.
Pre-work checks - Moulds, tooling, suitable environment, material mixing or thawing requirements, safe working environment.
Maintenance - Cleaning, repairing, mould releasing, charging.
Disposal of wastes - General waste, recycling, re-use, hazardous waste, non-hazardous waste.
Materials - Woven pre-preg carbon/epoxy, moulds, laminating tools, consumables, liquid resins, glass fibres (CSM and woven) Uni-directional carbon/epoxy pre-preg.
Equipment and moulds - Oven, heat blanket, auto-clave, resin infusion rig, vacuum pump, mixing station, fume extraction and recovery equipment, electronic scales, sheers or ply cutters, consumables station, platens, mandrels.

What do learners need to demonstrate?	Skills
Outline, review and verify suitable plans and designs for manufacture.	EC1
Check and evaluate requirements to help plan and agree methods and sequence of work through the stages of production.	EC2
Select resources to complete job and selected resources meet the required quality specification.	EC3
Prepare and check **materials** conform to grades and dimensions.	EC4
Prepare **equipment and moulds** to manufacture composite products.	MC6
Identify, anticipate, and address actual and potential issues and problems.	MC9
Monitor and report stock, materials and state, resources, and usage (e.g. quantities; volumes) in production processes, identifying potential or emerging issues, problems or risks.	DC1
Perform all necessary **pre-work checks** within the work area prior to carrying out practical activities.	DC4
Carry out routine **maintenance** of tools and equipment, in line with organisational guidelines.	
Create and compile appropriate **technical documentation** to ensure work is carried out safely, accurately and that all quality issues have been considered.	
Apply plan for **disposal of wastes** in accordance with organisational policies.	

3.2 Produce relevant **documentation**, records and schedules to confirm appropriateness and feasibility with **stakeholders.**

Range:

Stakeholders - Customer, manager, engineers, suppliers, team colleagues, client.
Documentation - Records, schedules, job instructions, risk assessments, method statements, laminating records, process parameters.

What do learners need to demonstrate?	Skills
Communicate with **stakeholders** to discuss and review the manufacturing plans.	EC1
Raise concerns about any element that is not accurate or not feasible.	EC2
Suggest resolutions to problems and issues.	EC3
	EC4

Produce or amend any **documentation** in line with the outcomes of the discussions ensuring the procedures are appropriate and achievable.	EC6 DC1 DC2 DC3

3.3 Set up measurement **equipment**.

Range:

Equipment - Rules, tapes, micrometers, Vernier callipers, scales and CMM machines, thickness measurement.

What do learners need to demonstrate?	**Skills**
Prepare measuring **equipment** for use.	EC1
Check equipment has been calibrated.	EC4 MC6 DC1 DC3

3.4 Use correct **methods** for receiving, moving, handling and preparing materials.

Range:

Resources - PPE, materials, tools, equipment, consumables.
Method - Manual handling, mechanical handling, lifting aids.
Load/s - Loose bulk materials, sacks, bags, pallets, sheet materials, bars, moulds and mouldings, plate, pipes and tubing, powders, liquids (resins, release agents, cleaning products).
Equipment - Manually operated handling equipment (sack barrows, pallet trucks, barrel trucks), scissor jacks, forklift trucks, telehandler, hoists, pulley, lifts.
Lifting accessories - Fibre or ropes slings, chains (single or multiple leg), hooks, eyebolts, spreader beams, vacuum devices.

What do learners need to demonstrate?	**Skills**
Select appropriate **method** for receiving, moving, and handling of the **load/s**.	MC6
Use appropriate **lifting equipment, lifting accessories** and **method** of lifting **load/s** when receiving, moving, handling, and preparing **resources**.	
Arrange workplace and organise layout to receive goods into the work area.	
Use correct manual and mechanical handling methods to move items around the workplace.	

3.5 Setting up and using **tools, equipment and technologies.**

Range:

Checks - Compliance, quality, function.
Tools, equipment and technologies - Hand tools, moulding equipment, production machines, line side computer systems, materials handling equipment.
Machining operations - Cut, sand, bore, drill, create joints, mould, rout.

What do learners need to demonstrate?	Skills
Carry out risk assessments on all foreseeable hazards and reduce the risk so far as is reasonably practicable. Set up, adjust, and accurately use relevant measuring, testing, diagnostic tools, rigs and equipment, confirming correct operating parameters. Carry out all mandatory and statutory pre-use inspections and **checks** on materials, tools and equipment. Correct set up **tools, equipment and technologies** for **machining operations** to meet production specifications. Apply correct locking and securing methods and techniques. Run and monitor production equipment in line with procedures and parameters.	MC1 DC1 DC2 DC4 DC6

3.6 Measure and mark out components using measurement and marking out **tools and equipment.**

Range:

Tools and equipment - Engineer's rule, dividers, scribe, templates, set squares, protractors, compasses, combination square, callipers, Vernier height gauge, Dial Test Indicators (DTI), paint pencil (white).

What do learners need to demonstrate?	Skills
Select the **tools and equipment** needed for the job. Measure and accurately mark out components to specification, minimising wastage of material. Use a range of measuring and marking tools to mark lengths, profiles, angles, points, lines, arcs on materials of different shapes (regular and irregular), dimensions and to varying degrees of dimensional accuracy.	MC1 MC3 MC4 MC6 MC7

4.1 Apply suitable composite **manufacturing methods** and techniques.

Range:

Manufacturing methods - Short run batches, long run batches, high speed manufacturing, mass production, high/low value items.

Standard Operating Procedures - Step by step sequenced instructions to carry out manufacturing operations with reference to materials, tooling, machinery, equipment, processes to be used, health and safety.

What do learners need to demonstrate?	Skills
Select and apply defined technologies, **methods** and processes to produce items, components or products. Comply with **Standard Operating Procedures** (SOP) and work towards best practice.	N/A

4.2 **Assemble** components, sub-assemblies and composite mouldings.

Range:

Assemble - Components, sub-assemblies, mouldings.
Joining techniques - Through thickness bolts, bonding, co-curing, embedded fasteners.

What do learners need to demonstrate?	Skills
Plan and prepare the work area to allow for assembly activities in accordance with specific working procedures.	MC6
Use working procedures and practices to ensure all items are identified, marked and organised to allow for efficient and accurate assembly of items.	
Assemble all items in the correct sequence using the correct **joining techniques.**	
Check orientation is correct, and any adjustments have been completed to meet specification prior to drilling and/or bonding.	

4.3 Accurately **shape** components and products by material removal to achieve best fit.

Range:

Tooling - Safe edging, roughing, finishing, facing, polishing, grooving.
Milling machine and **router** - Milling and/or routing using 3 and 5 axis machines to achieve net-shape and surface finish.
Operations - Milling, polishing.
Materials - Carbon/epoxy, aramid/vinyl ester, polyester/chopped strand mat glass, ceramic reinforced ceramic.
Shape - Steps, surface finish, net shape.

What do learners need to demonstrate?	Skills
Select appropriate **tooling** required for the **operations** to produce the	MC1
shape as determined in the specification.	MC2
Check condition of **tooling** prior to use for any problems or issues with cutting surface that could affect performance.	MC3
	MC4
Set up **materials** on a **milling machine** or **router** as determined in the specification.	MC5
Remove material to produce various features and to achieve best fit.	
Change **tooling** in accordance with health and safety requirements,	
including isolation procedures.	
Use appropriate tools and equipment to check components meet the required specifications and quality requirements.	
Report any issues, broken or damaged **tooling** in accordance with company procedures.	

4.4 Carry out **drilling** accurately to given tolerances.

Range:

Drilling machines - Hand, powered hand, bench, pedestal, CNC.

What do learners need to demonstrate?	Skills
Set up drilling machines safely, selecting the required drills and sizes to produce finished and pre-work holes to tolerance and positional location.	MC1 MC2
Produce drilled components to the required drawing and specification using a range of **drilling machines.**	MC3
Use various reamers and countersinks to finalise the hole accurately to the required tolerances and sizes.	MC4
Use Go/No Go gauges to check hole accuracy and positional locations.	MC5
Check drilled components meet the specification and quality requirements.	
Identify defects and mitigate.	

4.5 Carry out relevant moulding and laying up activities to support production.

Range:

Methods - Spray lay-up, wet lay-up, hand lay-up of pre-preg materials, automated lay-up, resin infusion.
Materials - Glass fibre/polyester, carbon fibre/epoxy, particle, aramid fibre and sheet-based composites, natural and synthetic fibres and matrix.

What do learners need to demonstrate?	Skills
Set up equipment and **materials** needed to produce moulded components.	MC1 MC2
Produce moulded components to the required drawing and specification using a range of moulding **methods**.	MC3 MC4 MC5

4.6 Fix and install components.

Range:

Methods - Spray lay-up, wet lay-up, hand lay-up of pre-preg materials, automated lay-up, resin infusion.
Fixings - Riveting, self-clinching, embedded fasteners, threaded fasteners, through thickness bolting, tabbing and over-lamination, potting and surface bonding of inserts and fixings.

What do learners need to demonstrate?	Skills
Select suitable **fixings** as determined in the specification.	MC6
Use appropriate installation **methods** to fix and install components to specification.	
Check finished or semi-finished items meet specification and quality standards.	

4.7 Re-instate work areas and equipment effectively, storing and maintaining tools and equipment appropriately.

Range:

Maintenance - Replace any perished items, re-grind/replace tooling, complete basic tool maintenance.

Dispose of wastes:

Non-hazardous materials - Packaging, material off cuts, trim waste, extraction dusts, replacing of used consumables.

Hazardous materials - Chemicals, solvents, coolants, sharp materials, dusts, oils, fluids.

What do learners need to demonstrate?	Skills
Clean, tidy and reinstate the work area on completion of the task. Isolate and power down machinery. Return tools to storage. Perform **maintenance** of tools and equipment. **Dispose of wastes** as per legislation and company procedures. Store excess materials correctly to prevent damage or degradation. Sort and maintain any resources and store in a systematic way in accordance with working procedures. Replace any items that have perished and ensure stock levels are accounted for. Correctly dispose of any hazardous materials and non-hazardous materials and refer to any appropriate health and safety regulations and documentation.	MC6

5.1 Apply **safe systems of work** in the delivery of all activities.

Range:

Safe systems of work - Personal Protective Equipment (PPE), signage, Standard Operating Procedures, risk assessments and control measures, pre-use checks.

Legislation and regulations - Health and Safety at Work Act (HASAWA), Provision and Use of Work Equipment Regulations (PUWER), Control of Substances Hazardous to Health (COSHH) Regulations, Manual Handling Operations Regulations, Personal Protective Equipment at Work Regulations, Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR).

What do learners need to demonstrate?	Skills
Apply **safe systems of work** at all times. Work in accordance with the organisational and **legislation and regulations** and in carrying out any, and all tasks, minimising the risk of injury to self and others in the process. Comply with all **legislation and regulations.**	EC1 EC5 MC10

5.2 Monitor composites **manufacturing processes**.

Range:

Manufacturing processes - Machines, operational processes, tools, equipment, materials, local work area, material, storage and recording of materials usage and out life, equipment movement.
Problems - Changed parameters, risk, issue, unexpected activity, excessive noise, heat/overheating, vibration, smell, machining defects.

What do learners need to demonstrate?	Skills
Identify issues with the immediate task to inform **manufacturing processes** and agreed outcomes and timeframes. Consider impact on other activities due to issues being found and delay incurred. Monitor quality and dimensions throughout production and on completion of the job. Deal promptly and effectively with **problems** within the limits of their responsibility using approved diagnostic methods and techniques. Monitor the performance and efficiency of equipment and processes including machining defects. Follow reporting procedures for raising any issues. Identify and mitigate risks. Identify areas for improvement.	EC1 EC6 MC5 MC6 MC10 DC6

5.3 Carry out or assist with appropriate quality monitoring, assurance **checks and tests.**

Range:

Checks and tests - Process checks, fill and flow, temperature and cure monitoring, visual checks, dimensional checks (including overall sizes, hole tolerances, weight) completeness, colour, functional checks, markings/labelling, non-destructive testing, dust particle count, room conditions (humidity, positive pressure air locks).

What do learners need to demonstrate?	Skills
Perform different types of quality **checks and tests** to ensure compliance of the product. Perform visual and dimensional checks on the individual components prior to, and after production.	EC1 EC6 MC1 MC2 MC5 MC6 MC8 MC10

6.1 Demonstrate **effective communication**.

Range:

Effective communication - Written, verbal, digital skills, presented communications, listening, questioning, pre-meeting preparation.
High-quality communications - Promotional collateral, business plans, annual reports.

What do learners need to demonstrate?	Skills
Demonstrate **effective communication** skills. Prepare adequately for meetings and formal discussions. Support **high-quality communications** in production activities by confirming information, requirements, expectations, plans, performance, and outcomes in ways that are suitable for purpose and context.	EC1 EC2 EC3 EC4 EC6 MC5 MC6 MC8 MC9 MC10 DC1 DC2 DC3 DC4

6.2 Accurately record relevant technical **information**, **data**, risks, and issues to support production projects, tasks and activities.

Range:

Information and data - Health and safety records, manufacturing plans, inspection sheets, quality documents, production programmes, authorised alternative methods/materials, risk assessment, risk management system.

What do learners need to demonstrate?	Skills
Keep legible records of tasks undertaken, using a spreadsheet or a logbook. Record key technical **information and data** in relation to the process. Complete dynamic data sheets in line with production requirements. Check sourced or given **information and data** is current. Amend or correct **information and data** within own limits of authority.	EC1 EC4 EC5 MC2 MC5 MC6

Report and escalate where **information and data** need to be amended which is outside of limit of authority. Contact the person authorised to make the changes and resolve the issue.	DC1 DC2 DC3 DC4

Guidance for delivery

Opportunities for visits/engagement with local industry, employers and manufacturers should be provided throughout the delivery of the content within this specialism – where appropriate local employers with a composites manufacturing focus could present details of recent manufacturing projects and any problems faced and how they were overcome. For example, manufacturing from a range of applications/sectors and from different sized companies e.g. micro to small scale production and large/mass production. Learners work placement experiences could be presented to peers detailing where knowledge and skills within the content was seen in practice.

Formative assessment for the content may include oral Q&A, presentations to peers, observation of measuring activities etc. Reinforcement of learning can be encouraged through revisiting learning, group discussions, and the establishment of a peer support system within the cohort.

Providers must ensure content is delivered in line with current, up-to-date industry practice which will require;

- Provision of appropriate tools, equipment and test instrumentation for demonstration and practical training purposes
- Teaching coverage representing the type of equipment currently available and accepted for use in the UK industry.

Suggested learning resources

Books

- A Brent Strong, *Fundamentals of Composites Manufacturing: Materials, Methods, and Applications*, 2nd Edition, Society Manufacturing Engineers, 2007, ISBN 0872638545
- S Kalpakjian, S Schmid, *Manufacturing Engineering & Technology: SI Version*, 7th Edition, Pearson, 2013, ISBN 9810694067
- Timothy G Gutowski, *Advanced Composites Manufacturing*, 1st Edition, Wiley-Interscience, 1997, ISBN 047115301X
- K Chawla, *Composite Materials: Science and Engineering, Materials Research and Engineering,* Springer, 2013, ISBN 9780387743646
- D Gay, *Composite Materials: Design and Applications*, 3rd edition, CRC Press, 2014, ISBN 9781466584877
- K Lin, *Composite Materials: Materials, Manufacturing, Analysis, Design and Repair*, CreateSpace Independent Publishing Platform, 2015, ISBN 9781511585347
- F C Campbell, *Manufacturing Processes for Advanced Composites*, Elsevier Science, 2003, ISBN 9781856174152
- L C Dorworth, G L Gardiner and G M Mellema, *Essentials of Advanced Composite Fabrication & Repair*, Aviation Supplies and Academics, Inc., 2009, ISBN 9781560277521
- R.P.L. Nijssen, *Composite Materials An Introduction*, InHolland University of Applied Sciences, 2015, ISBN 9789090324456

Websites

- MAKE UK The Manufacturers' Organisation **www.makeuk.org**
- Composites UK **www.compositesuk.co.uk**
- The Manufacturer **www.themanufacturer.com**
- Make It British **www.makeitbritish.co.uk**
- Office for National Statistics (Manufacturing & Production Industry) **www.ons.gov.uk**
- Guide to Composites **www.gurit.com**
- Composites World **www.compositesworld.com**
- National Composites Centre **www.nccuk.com**

Scheme of Assessment – Composites Manufacturing Technologies

The Composites Manufacturing Technologies Occupational Specialism is assessed by one practical assignment. The duration of the assessment is 24 hours and 15 minutes. Learners will be assessed against the following assessment themes:

- Health and safety
- Planning and preparation
- Production
- Quality review and evaluation.

By completing the following tasks:

Task	Typical Knowledge and skills
Task 1 - Planning	Displays a breadth of knowledge and practical skills that enables them to plan production of the composite assembly. Candidates will need to produce documents that clearly states how they will develop the composite assembly in line with the brief. Candidates will need to produce a risk assessment covering all the activities needed to produce the assembly taking into account required safety measures. Candidates will create their own plans and quality check sheets.
Task 2 – Production (split into 3 sub-tasks)	Applies a breadth of knowledge and practical skills that enables them to carry out the manufacture of the composite assembly in accordance with their planning and interpreting the technical drawings. The task is carried out in a clear and logical sequence. Works in a safe manner, handles materials with care. Tools, materials and equipment are selected and used correctly.
Task 3 – Evaluation and implementation (split into 3 sub-tasks)	Displays a breadth of knowledge and understanding in the evaluation of their own assembly and production process, recommending adaptions and improvements to the design of the assembly or the processes utilised. Inspects assemblies and components for defects and evaluates their cause and prevention. Accurately records and reports data and findings of quality inspections.

The information provided in the following tables demonstrates to approved providers the weightings of each performance outcome and how each performance outcome is assessed.

Performance outcome and weighting (%)	***High level tasks*** *Provide specific instructions for candidates to provide evidence for and are the same for every version of the assessment*	**Assessment Theme**	***Typical evidence***
PO2 Analyse and interpret engineering and manufacturing requirements, systems, processes, technical drawings and specifications. (10%)	T1- Planning	Planning and preparation	Resources lists with measuring equipment calibration check recorded, risk assessment, method statement with justifications, work plan.
	T2 – Production	Health and safety	Risk assessment and method statement with justifications.
		Production - Moulding	Completed composite assembly.
		Production - Laminating	Completed composite assembly.
		Production - Consolidation, curing and demoulding	Completed composite assembly.
		Production – Assembly	Completed composite assembly.
PO3 Plan and prepare the relevant processes, tools, equipment, and resources, needed to manufacture relevant products and produce appropriate outcomes. (28%)	T1- Planning	Planning and preparation	Resources lists with measuring equipment calibration check recorded, risk assessment, method statement with justifications, work plan.
	T2 – Production	Health and safety	Risk assessment.
		Production – Tools and equipment	Resource lists with measuring equipment calibration check recorded.
	T3 – Quality review and evaluation	Quality review and evaluation – Quality review	Quality inspection report. Quality check sheet.
		Quality review and evaluation – Reporting, recording and handover	Quality inspection report.

PO4 Produce relevant products and outcomes, considering the specified requirements, context and materials, using the relevant composite manufacturing technologies, methods and processes. (43%)	T2 – Production	Health and safety Production - Moulding Production – Laminating Production - Consolidation, curing and demoulding Production – Tools and equipment Production – Assembly	Risk assessment. Moulded assembly. Completed composite assembly. Completed composite assembly. Completed composite assembly. Completed composite assembly.
PO5 Support the delivery (and management) of relevant projects and activities, helping to evaluate and review processes and outcomes, and to improve practices. (10%)	T2 – Production T3 – Quality review and evaluation	Health and safety Production – laminating Quality review and evaluation – Quality review Quality review and evaluation – Reporting, recording and handover	Risk assessment, observations. Finished assembly. Quality inspection report. Quality check sheet. Quality inspection report.
PO6 Communicate production information, proposals and solutions, producing, recording and explaining relevant technical information, representations, processes and outcomes. (9%)	T3 – Quality review and evaluation	Health and safety Quality review and evaluation – Quality review Quality review and evaluation – Reporting, recording and handover	Risk assessment, resources list with measuring equipment calibration check recorded. Quality inspection report. Quality check sheet. Quality inspection report.

334 Fabrication and welding technologies

Level:	3
GLH:	680
Assessment method	Practical assignment

What is this specialism about?

The purpose of this specialism is for learners to know and undertake a range of industrial processes and manufacturing techniques to carry out metal fabrication work and in welding technologies which can be used across a range of sectors including civil engineering, marine, automotive, petro-chemical and aviation. The size and weight of the fabrications can range from components that can easily be picked up by hand, to massive structures that require several cranes to manipulate.

Learners will develop their knowledge and understanding of, and skills in:

- knowledge of structure, properties and characteristics of common materials.
- knowledge of general engineering mathematical and scientific principles including metallurgy.
- knowledge of machinery and technology used in fabrication and welding.
- knowledge of importance to continually review fabrication and general engineering processes and procedure.
- knowledge of principles, procedures and testing of different joining techniques.
- skills in the analysis of technical documentation, tasks, projects and specifications.
- skills in producing products to specification using suitable methods and techniques.
- skills in cutting and forming metal for the production of fabricated products.
- skills in quality, compliance or testing using the correct procedures, processes and/or equipment.

Learners may be introduced to this specialism by asking themselves questions such as:

- What are the different welding techniques that are used to produce complex components?
- Do I like working as part of a team to achieve a common goal?
- Do I like working to given instructions, working accurately and being responsible for the quality of a finished product?
- How are welds tested for quality and strength?

Underpinning knowledge outcomes

On completion of this specialism, learners will understand:

1. Fabrication and welding technologies knowledge criteria

Performance outcomes

On completion of this specialism, learners will be able to:

2. Analyse the tasks, projects and specifications, considering the specific processing requirements, context, resources, materials, tools and equipment, and the suitability of different fabrication and welding technologies, methods and processes.

3. Plan and prepare the relevant processes, tools, equipment, and resources, needed to produce relevant materials and products.

4. Produce the relevant product considering the specified requirements and raw materials using the relevant fabrication and welding process and method.

5. Support the delivery (and the management) of relevant fabrication and welding projects and activities, helping to evaluate and review processes and outcomes, and to improve practices.

6. Communicate production information, proposals and solutions, producing, recording and explaining relevant technical information, representations, processes and outcomes.

Completion of this specialism will give learners the opportunity to develop their maths, English and digital skills. Details are presented at the end of the specification.

Specialism content

Knowledge criteria for performance outcomes

1.1 Planning, preparing and implementing manufacturing and processing activities.

Range:

Plan - Location, types of facility needed, space requirements, equipment requirements (types, costs, operational processes), people (skilled, unskilled), materials, processes, costs, timescales, quantity, quality control/assessment, finished product (design/finish).

Technical information - Engineering drawings (design, tooling, detail, sub-assembly, assembly), circuit diagrams, specifications, design concepts, data sheets, test records, maintenance records, work instructions, flow charts, plans, manufacturer's manual/documentation. standard operating procedures (SOP), instructions, inspection documents.

Scale of work - Prototype, batch, mass production, continuous production.

Cost break points and other factors - Revenue, costs, profit and loss, average rate of return, investment (jigs, fixtures, automation).

What do learners need to learn?	Skills
The difference between the scale of work in production, manufacturing and processing activities. How to plan and prepare for the activities. The **technical information** needed to achieve specific outcomes. How to interpret information to create a manufacturing production **plan**. How to produce a plan to the correct **scale of work.** **Cost break points and other factors** for selecting assembly and manufacturing methods.	N/A

1.2 **Measurement techniques.**

Range:

Measurement techniques - Direct measurement (rules, tapes, micrometers, welding gauges) indirect measurement (thread gauges, gauge blocks, and comparison plates).

Estimation - Standard time calculation, engineering time standards.

Apply – dimensions, current, voltage, temperature, gas flow

What do learners need to learn?	Skills
The purpose of & uses of a range of **measuring techniques**, devices, accuracy levels and practical applications that they may be used for measurement activities. Factoring used in **estimation,** the application of standard times to production tasks to estimate costs & durations. How to apply correct **measurement techniques**. Imperial and metric measuring conventions and units of measurement. How to **apply** measurement to the stages of the manufacturing process from estimating material quantity and costs through to dimensional inspection, all with regard to product or process specification.	N/A

1.3 Uses, application and **disposal requirements** of materials.

Range:

Properties - Ductility, malleability, hardness, toughness, tensile strength, elasticity, compressive and shear.
Classification and types - Ferrous (stainless steel, cast iron, high speed steel, silver steel, low, medium and high carbon steel), non-ferrous (aluminium, copper, lead and zinc).
Marking systems - European (CE mark), UK Conformity Assessed (UKCA - UK marking system).
Disposal - General waste, recycling, re-use, hazardous and non-hazardous waste.
Wastes - Used materials, used liquids, off cuts, swarf, shavings, hazardous and non-hazardous materials.
Regulations and legislation - Environmental Protection (Duty of Care) Act 1990, Hazardous Waste (England and Wales) Regulations 2005, Waste Management (England and Wales) Regulations 2006, Control of Pollution (Applications, Appeals and Registers) Regulations 1996, Trade Effluent (Prescribed Processes and Substances) Regulations 1989.

What do learners need to learn?	**Skills**
The **classification and types** of common metals and welding filler materials. The **properties** of each material and methods of material selection. The **forms of supply** for common materials used in the fabrication and production process. The differences between the marking schemes that apply to materials and manufactured goods and products. The application of materials in fabrication and welding activities. The effects that welding has on the properties of the material being used. The correct preparation of material prior to welding. The **disposal** considerations that must be made when disposing of various materials and **wastes** in accordance with organisational policies, **regulations and legislation.**	N/A

1.4 Standard technical **documentation.**

Range:

Documentation - Engineering drawings (design, tooling, detail, sub-assembly, assembly), specifications (BSEN ISO), design concepts, data sheets, test records, work instructions, flow charts, plans, manufacturer's manual/documentation. standard operating procedures (SOP), instructions, inspection documents, cutting lists, fabrication lists.
Standard Operating Procedures - Technical, management, types (checklists, step-by-step lists, hierarchical lists, process flowchart).
Drawings - 2D, 3D, solid models exploded views, flat patterns, assembly drawings, isometric drawings symbols, terminology, conventions.

What do learners need to learn?	**Skills**
The purposes and types of standard technical **documentation**. How technical documentation is produced and who is responsible for its production. How to interpret technical **documentation** and who or what to refer to for guidance. How amendments are made to technical documentation, who is responsible and who to refer to for authorisation.	N/A

Overview of all types of manufacturing documents used in a wide range of manufacturing sectors. How to read and interpret fabrication and welding **drawings**. The correct representations, symbols, annotations, and conventions used, as outlined in BS 8888 and BS EN ISO 2553 Different types of **standard operating procedures.**	

1.5 **Hand tools, power tools and equipment.**

Range:

Types - Centre & edge finders, combination, protractor & depth gauges, de-burring tools, dividers, levels, scribes, square, straight edges, gauges, vices, punches, rivet setter, bolt grips, taps & dies, clamps, files, hammers, tin snips.
Purpose - Measuring, marking-out, cutting, shaping, forming, joining, finishing, inspection/testing.
Tools and equipment - Standard hand tools, powered hand tools electrical power (full mains, 110v, battery), pneumatic power tools, powered cutters/nibblers, mag base drills.
Maintain - Cleaning, lubricating, sharpening, charging, storing.
Guidelines and instructions - Work instructions, operating procedures, health and safety legislation and regulations, risk assessments, maintenance records, manufacturer's manuals.

What do learners need to learn?	**Skills**
The **types** of hand tools, power tools and equipment commonly used in fabrication and welding. The **purpose** of standard hand and power tools and equipment in fabrication and welding. How to correctly select **tools and equipment** for the task. How to correctly prepare tools and equipment. How to carry out pre-use inspection of tools and equipment prior to use. How to adequately **maintain** the tools and equipment after use. How to suitably record and report any faults identified in the condition or performance of the tools. The process/procedure to take damaged or faulty equipment out of service until returned to a suitable condition. The relevant **guidelines and instructions** that must be followed when preparing, using, or maintaining tools and equipment.	N/A

1.6 **Specialist machinery** and technology.

Range:

Welding equipment - Flux, clamps, magnets, sheet metal gauge, conduit, electrode, wire and electrode feed system (pinch rolls, push-pull, spool on gun), gun, angle grinder, wire brush, cables.
Specialist machinery - Fume extractors, local exhaust ventilation systems (LEV), metal inert gas (MIG) rig, gas shielded metal arc (MAG) welding rig, manual metal arc (MMA), resistance/spot welder, tungsten inert gas (TIG) welding, plasma cutting, drills, presses, cutting machines, portable welding plant (inverter welders), generator welding plant.
PPE - Auto-darkening welding helmet, air-fed welding helmet, welding jacket or apron, welding shoes/boots, gloves, safety glasses, ear plugs or ear defenders, mask or respirator.
Isolation methods - Monitoring of machinery, fault detection, isolation, and recovery (FDIR).

Resolution - Maintenance, adjusting parameters.
Guidelines and instructions - SOP, specifications, method statements, risk assessments, manufacturers manual, data sheets.

What do learners need to learn?	Skills
How to safely set up a range of **specialist machinery** and technology for fabrication and welding activities. How to use a range of **specialist machinery** and **welding equipment** effectively to meet specification requirements. The importance of following **guidelines and instructions.** The **PPE** required when operating specialist machinery and welding equipment. The risks to quality, cost and health and safety of non-compliance. Who the appropriate person is to ask for advice and guidance, if and when necessary. The detection and identification of problems or **faults** with machinery. How to apply **isolation methods**. Methods of **resolution** or escalation of issues. How to adequately **maintain** the tools and equipment after use.	N/A

1.7 Compliance with **standard workplace practices**.

Range:

Standard Operating Procedures - Technical, management, types (checklists, step-by-step lists, hierarchical lists, process flowchart, method statements).
Standard workplace practices - Safe systems of work, permits to work (hot works permit), risk assessments, work instructions, standard operating procedures (SOP), user guides, operational instructions.
Compliance - Health and safety, regulations, legislation (PUWER), Electromagnetic Field Directive (EMF)
Activity - Planning, preparing tools/equipment, using tools/machinery, maintaining tools/machinery.

What do learners need to learn?	Skills
The various formats of **Standard Operating Procedures** (SOP) and how to interpret and work to them. The typical **safe workplace practices** contained in an SOP and how the importance of **compliance** with them and any specific instructions. Health and safety documentation including risk assessments, permits. How to comply with standard workplace practices for the relevant **activity**. The consequences of non-compliance on self and others.	N/A

1.8 Engineering **standards.**

Range:

Types - British (BS), European (EN), International (ISO).
Standards - Quality management (BS4500, ISO 9000, ISO 9001, BS EN ISO 3834), environmental management (ISO 14000, 14001), risk management (ISO 31011).
Application - Quality, environmental, risk, Construction Products Regulation (CPR).
Sectors - Aerospace, nuclear, power, utilities, automotive.
Fabrication and welding – BS EN ISO 5817: 2014 Welding specification, BS EN 287 weld positions (superseded by ISO 9606/1 ASME IX specification).

What do learners need to learn?	**Skills**
The purpose of a range of **standards** for different engineering **sectors.** The **types** of **standards** used in engineering and manufacturing workplaces. The types of standards specific to **fabrication and welding**. The **application** of the **standards** in a manufacturing workplace. The systems and procedures put in place to ensure they are adhered too.	N/A

1.9 **Legal and regulatory frameworks**, documentation and authoritative information.

Range:

Health and safety procedures - Health and safety policy, risk assessments, emergency procedures.
Consequences - Improvement and enforcement notices, prosecution (fines, imprisonment, compensation claims), organisation reputation damaged.
Sources - Websites (Gov.UK, HSE, Equalities Commission), e-books, printed texts/matter.

What do learners need to learn?	**Skills**
The key points of health and safety legislation that provide a framework for more specific, task-focused activities at work. Welding specific HSE Health and safety guidance e.g. fume protection and control. The company's health and safety policy and how it sets the scene for ensuring a healthy and safe place of work. The company's health and safety procedures, specifically those related to the learner's role, responsibilities and functions. The typical emergency systems and procedures that would be in place for a manufacturing and processing environments. The importance of complying with legislation and the consequences of breaches in legislation on the individual and the organisation. How to access sources of authoritative information.	N/A

1.10 Site and process **safety, environment and risk management systems and practices.**

Range:

Safety, environment and risk management systems and practices - Health and safety management system (HSG65) generic risk assessment, COSHH, manual handling, young people, PUWER assessments, Environmental Management System (EMS).

What do learners need to learn?	**Skills**
The role of individuals and the impact they can have when upholding health and safety and organisational policies in a workplace. The purpose and function of **safety, environment and risk management systems**. Reporting procedures and who to inform. How to interpret a health and safety management system (HSG65). How to interpret information from an Environmental Management System (EMS).	N/A

1.11 Business **improvement** through project management.

Range:

Job performance - Developing own skills, learning existing and new work methods, training, participating in performance review meetings, professional institution membership, professional accreditations, continuing professional development (CPD).

Research - New supply chains, comparing against similar competitors projects, new technologies.

Evaluation - Project review, lessons learned, PDCA cycles.

Improvements - Identification of process improvements, investment in machinery and equipment, increased training of employees, workplace efficiencies, future opportunities.

What do learners need to learn?	**Skills**
How their individual **job performance** and quality of the end product can be improved. Methods for individuals to improve their own performance. How projects can lead to business **improvement**. The prospects of project success increased by continually seeking to develop own skills, learn existing and new work methods, processes, techniques and developing the capability to offer solutions to problems. The use of Key Performance Indicators (KPI). How **research**, evidence and **evaluation** of projects can identify future **improvements** and improved performance. The types of data that can be collected to identify potential improvement in project performance. How lessons from similar projects can be learned through benchmarking and comparative data.	N/A

1.12 Evaluating materials manufacture and processing activities in terms of **quality, cost** and **time.**

Range:

Quality - Specifications, allowances and tolerances, applying suitable inspection methods, product was finished to an acceptable standard, applicable standards, internal quality procedures, function of product.

Cost - Minimal wastage of resources, getting the job right first time, avoiding delays and rework, cost types (fixed, variable, total, marginal, average).

Time - Using and comparing historical data, method statements and time allocated by line management, choosing the most efficient method of completing a task, charts and scheduling techniques (flow charts, Gantt charts, critical path methods, project management packages).

Metrics - Cycle time, time to make changeovers, throughput, capacity utilisation, overall equipment effectiveness, yield, customer rejects/returns, supplier quality incoming, on-time delivery.

What do learners need to learn?	Skills
How to evaluate activities in relation to **quality**, **cost and time.**	N/A
The definition of quality (in terms of what the customer requires), identifying all costs and how to measure them against the plan.	
How to set out a plan of programmed quality checks.	
How to measure actual spend against planned cost and identify variation to plan and **metrics** used in manufacturing.	
How to measure actual progress against planned progress using milestones.	

1.13 Application of **testing methods** and quality control **techniques.**

Range:

Testing methods - Destructive testing (tensile testing, toughness testing (Charpy v-notch) and fatigue testing), non-destructive testing methods (radiography, dye-penetrant inspection, magnetic particle inspection, visual inspection, ultrasonic testing).

Techniques - Material inspections, interim inspections, final inspections, functional checks, thorough inspection and test.

What do learners need to learn?	Skills
The types of **testing methods.**	N/A
The differences between the **types** of **testing methods**.	
The capabilities and limitations of different **techniques** across different materials manufacture and processing contexts.	
How destructive **testing methods** are used to help understand how a material or component will perform and behave under stress.	
The non-destructive **testing methods** commonly used in manufacturing to analyse the properties of a component or material and establish, without damaging the component or material.	
Typical applications for a range of destructive and non-destructive **testing methods.**	
The limitations of each of the destructive and non-destructive **testing**	

methods. The reasons for recording performance data from the tests and how this will influence materials selection for production. How to carry out sample testing and why it is important during production.	

1.14 **Communicating technical information and data.**

Range:

Communication skills - Written, verbal, digital skills, presented communications, listening, questioning.
High-quality communications - Promotional collateral, business plans, annual reports.
Communicate - Record, manage, store, amend, upload data, collaborative technologies (shared drives, email, conferencing, software and programs, forums).
Technical information and data - Test data, test results, maintenance results and findings, fault information, inspection sheets, repair methods, maintenance schedules.

What do learners need to learn?	**Skills**
The **communication skills** needed to **communicate** information effectively and to participate in **high-quality communications.** The differences between formal and non-formal communication. The importance of technical documentation for communication. How to use different types of **technical information and data** communication methods. How collaborative technology is used to communicate technical information and data. Current legislation including General Data Protection Regulations (GDPR) and organisational procedures that are used to manage data and increase confidentiality of sensitive information.	N/A

1.15 Digital, **information and communication technology** (ICT).

Range:

Information and communication technology - Data systems, recording systems, electronic document and management systems, collaborative technologies, electronic storage.

What do learners need to learn?	**Skills**
How technology and systems are used to manage production and manufacturing data and documentation. Application of software and **information and communication technology** techniques to record, manage, store and amend production and manufacturing information. Advantages and limitations of using **information and communication technology** to record information.	N/A

Practical criteria for performance outcomes

2.1 Interpret and analyse relevant **technical information, data**, representations and documentation.

Range:

Technical information - Drawings (1st and 3rd angle orthographic projections, isometric projections, assembly, general arrangement, installation drawings), specifications (materials, welding, bending allowances), charts (limits and fits, tapping drill allowances), SOP, safe working systems, bills of materials, manufacturing planning sheets.
Data - Inspection results, fault information, Statistical Process Control (SPC).

What do learners need to demonstrate?	Skills
Identify, read, interpret, collate, process and communicate **technical information** and **data** critical for the successful completion of the job. Confirm the scope of the task/work. Interpret drawings, specifications, scales, and technical term related to production processes and activities. Analyse and report information and data accurately. Use and communicate the analysed information/data to improve quality of products and reliability of the process. Interpret plan for appropriate disposal of wastage and excess resources.	MC2 DC1 DC4

2.2 Identify **issues, risks,** and areas for further analysis or investigation.

Range:

Issues and risks - Health and safety (risk assessment, control measures, training, reporting), quality (calibration, training), capability (initial machine and equipment checks, checks during processing), availability (resources, maintenance, downtime).

What do learners need to demonstrate?	Skills
Identify **issues and risks** with the immediate task to inform processes and agreed outcomes and timeframes. Consider impact on other activities due to issues being found and delay incurred. Identify areas for improvement. Follow reporting procedures for raising any issues. Identify and mitigate risks.	EC1 EC2 EC4 EC5 EC6 MC6 DC1 DC4

3.1 **Prepare** for relevant production tasks or activities.

Range:

Prepare - Resources, materials, tools and equipment.
Technical documentation - Risk assessment, inspection sheets, production plans, material requirements, anticipated production issues and preventative measures, standard procedures, PAT testing certificates, permits.
Pre-work checks - Machine, tooling, safe working environment.
Maintenance - Cleaning, lubricating, sharpening, charging.
Disposal of wastes - General waste, recycling, re-use, hazardous waste, non-hazardous waste.

What do learners need to demonstrate?	Skills
Outline, review and verify suitable plans and designs for fabrication. Select resources to complete job and selected resources meet the required quality specification. Check materials conform to grades and dimensions. **Prepare** materials, equipment and machinery. Identify, anticipate, and address actual and potential issues and problems. Monitor and report stock, materials, resources, and usage (e.g. quantities; volumes) in production processes, identifying potential or emerging issues, problems or risks. Perform all necessary **pre-work checks** within the work area prior to carrying out practical activities. Carry out routine **maintenance** of tools and equipment, in line with organisational guidelines. Create and compile appropriate **technical documentation** to ensure work is carried out safely, accurately and that all quality issues have been considered. Apply plan for **disposal of wastes** in accordance with organisational policies.	EC1 EC2 EC4 EC5 MC6

3.2 Use relevant **documentation** to confirm accuracy.

Range:

Documentation - Inspection sheets, quality documentation, engineering/fabrication/welding drawings, Zeus chart (limits and fits, tapping drills, etc), manufacturing documents, schedules, issues logs, data sheets.
Requirements - Time, cost, resources, management, processes, and outcomes.

What do learners need to demonstrate?	Skills
Utilise a range of **documentation** to analyse project **requirements** ensuring that there is a realistic prospect of achieving a successful project completion. Communicate any concerns to colleagues and authorised persons, anything that could interrupt the project schedule. Agree suitable constituent parts, consumables, methods to be used.	EC1 EC4 MC6 DC1 DC3

3.3 Prepare materials and measuring **tools and equipment**.

Range:

Tools and equipment - Welding (flux, clamps, magnets, sheet metal gauge, conduit, electrode, wire and electrode feed system (pinch rolls, push-pull, spool on gun), gun, angle grinder, wire brush, cables), cutting (grinder, oxy fuel cutting equipment).

What do learners need to demonstrate?	Skills
Prepare materials in preparation for marking out, cutting and fabrication. Prepare weld face to ensure weld root is correct. Set up the **tools and equipment** following organisational guidelines. Carry out pre-use inspection before use. Set up cutting and welding equipment to the correct parameters.	EC1 EC4 EC5 EC6 MC6 DC1 DC3

3.4 Use correct **method** for receiving, moving, handling and preparing **resources**.

Range:

Documentation - Data sheets, lifting procedures, company policies, risk assessments, COSHH assessment, user manuals.
Method - Manual handling, mechanical handling, lifting aids.
Resources – PPE, materials, tools, equipment, consumables.
Load/s - Loose bulk materials, sacks, bags, pallets, sheet materials, bars, ingots, castings, plate, pipes and tubing, wire, rolled sections, powders, liquids (resins, coolants, lubricants).
Lifting equipment - Manually operated handling equipment (sack barrows, pallet trucks), jacks, forklift trucks, telehandler, hoists, pulley, lifts.
Lifting accessories - Fibre or ropes slings, chains (single or multiple leg), hooks, eyebolts, spreader beams, magnetic and vacuum devices.

What do learners need to demonstrate?	Skills
Select appropriate **method** for receiving, moving, and handling of the **load/s**. Check material weight using relevant **documentation**. Use appropriate **lifting equipment**, **lifting accessories** and **method** of lifting load/s when receiving, moving, handling, and preparing **resources.** Arrange workplace and organise layout to receive goods into the work area. Use correct manual and mechanical handling methods to move items around the workplace.	MC6

3.5 Accurately set and adjust machine, **equipment**, and tool operating parameters.

Range:

Welding equipment - Flux, clamps, magnets, sheet metal gauge, conduit, electrode, wire and electrode feed system (pinch rolls, push-pull, spool on gun), gun, angle grinder, wire brush.
Cutting equipment - Plasma, laser, flame, hand tools.
Specialist machinery - Fume extractors, local exhaust ventilation systems (LEV), metal inert gas (MIG) rig, gas shielded metal arc (MAG) welding rig, manual metal arc (MMA), resistance/spot welders, tungsten inert gas (TIG) welding, plasma cutting.
Other machinery - Pedestal drill, press, cutter.

What do learners need to demonstrate?	Skills
Set up and adjust **specialist machinery**, **cutting equipment** and **welding equipment** for use in accordance with manufacturer's instructions. Set up all equipment within given parameters on engineering drawing. Set up **other machinery** needed for fabrication.	EC5 MC10 DC1 DC2 DC4 DC5 DC6

3.6 Measure and **mark out** components.

Range:

Tools and equipment - Engineer's rule, dividers, scribe, templates, set squares, protractors, compasses, combination square, scribes, scribing block/surface gauge, punches (centre and dot), slip gauges, surface table and plates, angle plates, vee blocks and clamps.
Mark out - Lengths, profiles, angles, points, lines, arcs (regular and irregular), true lengths (square to round).

What do learners need to demonstrate?	Skills
Measure and accurately **mark out** components to specification and agreed tolerances. Use a range of measuring and marking **tools and equipment** to **mark out**. Use methods to minimise wastage of material.	EC5 MC1 MC3 MC4 MC6 MC7

4.1 Apply suitable fabrication and welding **methods and techniques**.

Range:

Methods and techniques - Welding, fabricating, forming.
Production methods - Prototyping, short run batches, long run batches, high speed manufacturing, mass production, high/low value items.
Quality checks - Weld thickness, component parts and completed assemblies, defects.

What do learners need to demonstrate?	Skills
Select and apply the most suitable fabrication and welding **methods and techniques** for the component to be produced. Follow all standard operating procedures (SOP) and comply with all health and safety regulations. Demonstrate the correct **production methods** and techniques to ensure the product is created correctly. Perform **quality checks** throughout the fabrication process.	EC5 MC6

4.2 Produce quality welds.

Range:

Welding processes - Gas welding, manual metal arc (MMA), tungsten inert gas (TIG), metal inert gas (MIG), metal active gas (MAG).
Welding positions – 2 from: flat (PA), horizontal (PC), vertical Up (PF), and overhead butt (PE)
Welded joints - Butt, corner, t-fillet, lap, edge.

What do learners need to demonstrate?	Skills
Select appropriate **welding processes** to suit the material. Produce quality welds to meet specific requirements using **two** welding processes to produce single run welds (to a minimum of 150mm). Produce quality welds for **two** different **welding positions**. Produce **three** different **welded joints**. Check welded components are good and free from defects.	MC6

4.3 **Fix components**.

Range:

Fix components - Permanent, non-permanent, temporary.
Method - Nuts and bolts, screws, riveting, torquing of flanged joints, welding, soldering and adhesives.

What do learners need to demonstrate?	Skills
Select the correct fixing **method** for each component and material. **Fix components** using the most appropriate **method** taking into consideration factors that may include amount of load, heat and vibration.	EC4 MC1

4.4 Produce one-off components.

Range:

Processes and techniques - Marking out, fabrication, welding.

What do learners need to demonstrate?	Skills
Produce components using a range of **processes and techniques**, by the most suitable method for the component to be produced taking into consideration quality, cost and time.	EC5 MC1 MC2 MC4 MC5 MC10 DC1 DC2 DC3 DC4 DC5 DC6

4.5 Re-instate work areas and equipment.

Range:

Sort, maintain and store resources - Identified, stored correctly, protected and evaluated for future use, maintaining tools and resources (replace any perished items, re-grind tooling, complete basic tool maintenance).
Dispose of waste - Non-hazardous materials (packaging, swarf, material off cuts, replacing of used consumables), hazardous materials (solvents, coolants, sharp materials, oils, fluids).

What do learners need to demonstrate?	Skills
Reinstate the work area on completion of the task. Isolate and power down equipment and/or machinery. **Sort, maintain and store resources** in accordance with working procedures. Replace any items that have perished and ensure stock levels are accounted for. **Dispose of waste** as per legislation and company procedures.	MC6

5.1 Apply **safe systems of work** in the delivery of all activities.

Range:

Safe systems of work - Personal Protective Equipment (PPE), signage, Standard Operating Procedures, risk assessments and control measures, pre-use checks, permits.
Legislation and regulations - Health and Safety at Work Act (HASAWA), Provision and Use of Work Equipment Regulations (PUWER), Control of Substances Hazardous to Health (COSHH) Regulations, Manual Handling Operations Regulations, Personal Protective Equipment at Work Regulations, Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR).

What do learners need to demonstrate?	Skills
Apply **safe systems of work.** Work in accordance with the organisational and legal health and safety **legislation and regulations** and in carrying out any and, all tasks, minimising the risk of injury to self and others in the process. Comply with all regulations and legislation.	EC1 EC5 MC10

5.2 Monitor fabrication and welding processes.

Range:

Potential risks, issues and problems - Potential risks (identification of issues, implementing preventive measures, reporting issues), issues and problems (changed parameters, risk, issue, unexpected activity, excessive noise, heat, vibration, sensory).
Diagnostic methods - Visual, fault checking systems, testing.
Improvement - Production modification (process, efficiency, cost, accuracy), quality control (inspection, accountability, traceability).

What do learners need to demonstrate?	Skills
Identify **potential risks, issues and problems** with the immediate task to inform processes and agreed outcomes and timeframes. Monitor welding activity, during and on completion of welding for performance and efficiency of equipment and processes. Deal promptly with problems within limits of their responsibility using approved **diagnostic methods** and techniques. Follow reporting procedures for raising any issues. Identify areas for **improvement.**	EC1 EC2 EC4 EC5 EC6 MC5 MC6 MC10 DC6

5.3 Complete effective **handover** procedures.

Range:

Handover - Shift changeovers, breaks, job rotation, end of a process, inter departmental handovers.
Production check list - Job number, drawing number, control reference number, list of operations, operator name, date of work completed, non-conformance details, mapping against standards.

What do learners need to demonstrate?	Skills
Perform **handover procedures** to ensure production process continues as scheduled. Communicate handover to another person to ensure continuity and consistency. Pass on information or documentation pertinent and critical to the smooth running of the process. Notify any production issues arising or observations on process or equipment performance. Complete post **production check list** confirming quality standards and any specific working requirements have been completed.	EC1 EC2 EC4 DC1 DC2 DC3

5.4 Carry out **quality monitoring** and **assurance checks** to review processes.

Range:

Quality monitoring - Inspections, reviewing, amending, supervisory checks, checking of quality.
Assurance checks - Checking and validating reliability and durability, material and product testing, non-destructive testing (radiography, dye-penetrant inspection, magnetic particle inspection, visual inspection, ultrasonic testing).
Conform - Drawings (symbols, abbreviations), specifications (British Standards (BS), British Standards Institution (BSI) issues codes, International Standard (ISO)), identification markings, supplier and manufacturer coding systems, colour coding.

What do learners need to demonstrate?	Skills
Conduct **quality monitoring** and **assurance checks** as part of the production process. Carry out non-destructive testing (NDT) on the finished product. Review efficiency of processes, practices and outcomes. Consistently check validity, accuracy and relevance of documentation. Check outcomes **conform** to the requirements in the specification. Communicate technical information, advice and suggestions for improvements. Suggest strategies to increase efficiency of quality monitoring processes, with consideration of performance and potential improvements.	EC1 EC2 EC4 MC1 DC1 DC2 DC3

6.1 Demonstrate **effective communication**.

Range:

Effective communication - Written, verbal, digital skills, presented communications, listening, questioning, pre-meeting preparation.
High-quality communications - Promotional collateral, business plans, annual reports.

What do learners need to demonstrate?	Skills
Demonstrate **effective communication** skills. Prepare adequately for meetings and formal discussions. Support **high-quality communications** in production activities by confirming information, requirements, expectations, plans, performance, and outcomes in ways that are suitable for purpose and context.	EC1 EC2 EC3 EC4 EC6 MC5 MC6 MC8 MC9 MC10 DC1 DC2 DC3 DC4

6.2 Accurately record relevant technical **information**, **data**, risks, and issues to support production projects, tasks and activities.

Range:

Information, data and communications - Health and safety records, manufacturing plans, inspection sheets, quality documents, production programmes, authorised alternative methods/materials.

What do learners need to demonstrate?	Skills
Keep legible records of tasks undertaken, using a spreadsheet or a logbook. Record key technical **information, data and communication** in relation to the process. Complete dynamic data sheets in line with production requirements. Check sourced or given **information, data and communication** is current. Amend or correct **information, data and communication** within own limits of authority. Report and escalate where **information, data and communication** need to be amended which is outside of limit of authority. Contact the person authorised to make the changes and resolve the issue.	EC1 EC4 EC5 MC2 MC5 MC6 DC1 DC2 DC3 DC4

Guidance for delivery

Opportunities for visits/engagement with local industry, employers and manufacturers should be provided throughout the delivery of the content within this specialism – where appropriate local employers with a fabrication and welding focus could present details of recent engineering projects and any problems faced and how they were overcome. Learners work placement experiences could be presented to peers detailing where knowledge and skills within the content was seen in practice. It would be advantageous to arrange visits to a range of local businesses to demonstrate the variety of tools and equipment and welding processes undertaken comparing a small scale operation with a larger more commercial operation.

Formative assessment for the content may include oral Q&A, presentations to peers, observation of measuring activities etc. Reinforcement of learning can be encouraged through revisiting learning, group discussions, and the establishment of a peer support system within the cohort.

Providers must ensure content is delivered in line with current, up-to-date industry practice which will require;

- Provision of appropriate tools, equipment and test instrumentation for demonstration and practical training purposes
- Teaching coverage representing the type of equipment currently available and accepted for use in the UK industry.

Suggested learning resources

Books

- Michael F Ashby, Hugh Shercliff, David Cebon, *Materials: Engineering, Science, Processing and Design,* 4th Edition, Butterworth-Heinemann, 2018, ISBN 0081023766
- J Lee, S Wagstaff, G Lambotte, A Allanore, F Tesfaye, *Material Processing Fundamentals (The Minerals, Metals & Materials Science Series),*1st Edition, Springer, 2020, ISBN 978-3030365554
- William D Callister, David G Rethwisch, *Callister's Materials Science and Engineering*, 10th Edition, John Wiley & Sons, 2020, ISBN 1119453917
- Kip Hanson, *Fabricating for Dummies*, 1st Edition, For Dummies, 2018, ISBN 1119474043
- Steven Robert Farnsworth, *Welding for Dummies*, 1st Edition, For Dummies, 2020, ISBN 0470455969
- Roger Timings, *Fabrication and Welding Engineering*, 1st Edition, Routledge, 2008, ISBN 0750666919

Websites

- Health and Safety Executive (HSE) **www.hse.gov.uk**
- Institute of Mechanical Engineers **www.imeche.org**
- The Welding Institute **www.theweldinginstitute.com**
- The British Institute of Non-destructive Testing **www.bindt.org**

Scheme of Assessment – Fabrication and Welding Technologies

The Fabrication and Welding Technologies Occupational Specialism is assessed by one practical assignment. The duration of the assessment is 26 hours and 15 minutes. Learners will be assessed against the following assessment themes:

- Health and safety
- Planning and preparation
- Production and assembly
- Quality testing, review and evaluation.

By completing the following tasks:

Task	Typical Knowledge and skills
Task 1 - Planning	Displays a breadth of knowledge and practical skills that enables them to plan production of the product to be fabricated. Candidates will need to produce documents that clearly states how they will develop the product in line with the brief. Candidates will need to produce a risk assessment covering all the activities needed to produce the final product taking into account required safety measures. Candidates will create their own plans and quality check sheets.
Task 2 – Production	Applies a breadth of knowledge and practical skills that enables them to carry out the fabrication of the product in accordance with their planning and interpreting the technical drawings. The task is carried out in a clear and logical sequence. Works in a safe manner, handles materials with care. Tools, materials and equipment are selected and used correctly. Applies a breadth of knowledge and practical skills of welding processes to fabricate and assemble the product in line with the brief to a recognised industry standard.
Task 3 – Evaluation and implementation (split into 3 sub-tasks)	Displays a breadth of knowledge and understanding in the evaluation of their own fabrication and welding processes, recommending adaptions and improvements to the design of the finished assembly or the processes utilised. Inspects assemblies and components for defects and evaluates their cause and prevention. Utilises non-destructive testing (NDT) to test the quality of the welds. Accurately records and reports data and findings of quality inspections and NDT results.

The information provided in the following tables demonstrates to approved providers the weightings of each performance outcome and how each performance outcome is assessed.

Performance outcome and weighting (%)	***High level tasks*** *Provide specific instructions for candidates to provide evidence for and are the same for every version of the assessment*	**Assessment Theme**	***Typical evidence***
PO2 Analyse the tasks, projects and specifications, considering the specific processing requirements, context, resources, materials, tools and equipment, and the suitability of different fabrication and welding technologies, methods and processes. (13%)	T1 - Planning	Planning and preparation	Resources list (with measuring equipment calibration check recorded), risk assessment, method statement with justifications, work plan, cutting list, quality check sheet, completed hot works permit.
		Health and safety	Risk assessment and method statement with justifications, completed hot works permit (countersigned)
	T2 – Production	Production – Measuring and marking out	Fully fabricated and welded product.
		Production – Cutting components	Fully fabricated and welded product.
		Production – Techniques and methods	Fully fabricated and welded product.
	T3 - Quality review and evaluation	Quality testing, review and evaluation – Quality testing	Quality check sheet.
		Quality testing, review and evaluation – Quality review	Quality inspection report, quality check sheet.

PO3 Plan and prepare the relevant processes, tools, equipment, and resources, needed to produce relevant materials and products. (19%)	T1- Planning T2 – Production T3 – Quality review and evaluation	Planning and preparation Health and safety Production – Tools and equipment Production – Measuring and marking out Production – Cutting components Quality testing, review and evaluation – Quality testing	Resources lists with measuring equipment calibration check recorded, risk assessment, method statement with justifications, work plan. Risk assessment, hot works permit (countersigned). Resource lists with measuring equipment calibration check recorded. Fully fabricated and welded product. Fully fabricated and welded product. Quality check sheet.
PO4 Produce the relevant product considering the specified requirements and raw materials using the relevant fabrication and welding process and method. (35%)	T2 – Production	Health and safety Production – Tools and equipment Production – Measuring and marking out Production – Cutting components Production – Techniques and methods	Risk assessment, hot works permit (countersigned). Resource lists with measuring equipment calibration check recorded. Fully fabricated and welded product. Fully fabricated and welded product. Fully fabricated and welded product.
PO5 Support the delivery (and management)	T2 – Production	Health and safety Production – measuring	Risk assessment (countersigned)

of relevant fabrication and welding projects and activities, helping to evaluate and review processes and outcomes, and to improve practices. (21%)	T3 – Quality review and evaluation	and marking out Production – Techniques and methods Quality testing, review and evaluation – quality testing Quality testing, review and evaluation – Quality review Quality testing, review and evaluation – Reporting, recording and handover	Fully fabricated and welded product. Fully fabricated and welded product. Quality check sheet. Quality check sheet. Quality inspection report. Quality inspection report.
PO6 Communicate production information, proposals and solutions, producing, recording and explaining relevant technical information, representations, processes and outcomes. (12%)	T3 – Quality review and evaluation	Health and safety Planning and preparation Quality testing, review and evaluation – Quality testing Quality testing, review and evaluation – Quality review Quality testing, review and	Risk assessment, resources list with measuring equipment calibration check recorded. Work plan. Quality check sheet. Quality check sheet. Quality inspection report. Quality inspection report.

		evaluation – Reporting, recording and handover	

Appendix 1 Maths, English and digital skills

General English Competencies

The following outlines a framework of six General English Competences, with no prioritisation or interpretation of order intended:

- EC1. Convey technical information to different audiences
- EC2. Present information and ideas
- EC3. Create texts for different purposes and audiences
- EC4. Summarise information/ideas
- EC5. Synthesise information
- EC6. Take part in/lead discussions

General Mathematical Competencies

The following outlines a framework of ten General Mathematical Competences, with no prioritisation or interpretation of order intended:

- MC1. Measuring with precision
- MC2. Estimating, calculating and error spotting
- MC3. Working with proportion
- MC4. Using rules and formulae
- MC5. Processing data
- MC6. Understanding data and risk
- MC7. Interpreting and representing with mathematical diagrams
- MC8. Communicating using mathematics
- MC9. Costing a project
- MC10. Optimising work processes

General Digital Competencies

The following outlines a framework of six General Digital Competences, with no prioritisation or interpretation of order intended:

- DC1. Use digital technology and media effectively
- DC2. Design, create and edit documents and digital media
- DC3. Communicate and collaborate
- DC4. Process and analyse numerical data
- DC5. Be safe and responsible online
- DC6. Controlling digital functions

Appendix 2 Sources of general information

The following documents contain essential information for Providers delivering City & Guilds T Level Technical Qualifications. They should be referred to in conjunction with this specification and the Provider approval and quality assurance information.

You can download these from **www.cityandguilds.com**.

Centre Contract General Terms
Quality Assurance Standards: Centre Handbook
Quality Assurance Standards: Centre Assessment

Within these documents you will find information in relation to;

- centre assessment,
- internal quality assurance (IQA),
- IQA strategy,
- alternative locations and subcontractors,
- non-compliance,
- malpractice, and
- centre support roles and resources

All T Level providers must ensure they familiarise themselves with the above documents and adhere to the general terms as part of their conditions of approval.

Useful contacts

UK learners General qualification information	**E: learnersupport@cityandguilds.com**
International learners General qualification information	**E: intcg@cityandguilds.com**
Centres Exam entries, Certificates, Registrations/enrolment, Invoices, Missing or late exam materials, Nominal roll reports, Results	**E: centresupport@cityandguilds.com**
Single subject qualifications Exam entries, Results, Certification, Missing or late exam materials, Incorrect exam papers, Forms request (BB, results entry), Exam date and time change	**E: singlesubjects@cityandguilds.com**
International awards Results, Entries, Enrolments, Invoices, Missing or late exam materials, Nominal roll reports	**E: intops@cityandguilds.com**
Walled Garden Re-issue of password or username, Technical problems, Entries, Results, e-assessment, Navigation, User/menu option, Problems	**E: walledgarden@cityandguilds.com**
Employer Employer solutions, Mapping, Accreditation, Development Skills, Consultancy	**T: +44 (0)121 503 8993** **E: business@cityandguilds.com**

If you have a complaint, or any suggestions for improvement about any of the services that City & Guilds provide, email: **feedbackandcomplaints@cityandguilds.com**

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The City & Guilds Group operates from three major hubs: London (servicing Europe, the Caribbean and Americas), Johannesburg (servicing Africa), and Singapore (servicing Asia, Australia and New Zealand). The Group also includes the Institute of Leadership & Management (management and leadership qualifications), City & Guilds Licence to Practice (land-based qualifications) and Learning Assistant (an online e-portfolio).

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Get in touch

The City & Guilds Quality team are here to answer any queries you may have regarding your T Level Technical Qualification delivery.

Should you require assistance, please contact us using the details below:

Monday - Friday | 08:30 - 17:00 GMT

T: 0300 303 53 52

E: **technicals.quality@cityandguilds.com**

W: **www.cityandguilds.com/tlevels**

Web chat available **here**.