

Unit 22: Fabrication Processes and Technology

Unit code:	L/600/0273
QCF Level 3:	BTEC Nationals
Credit value:	10
Guided learning hours:	60

● Aim and purpose

This unit aims to give learners a knowledge of the processes used to safely measure, mark out, cut, form and assemble fabricated structures using sheet metal.

● Unit introduction

Fabrication processes and technology are used in the production of metal structures in a wide range of manufacturing industries. The fabrication of metal structures involves four essential stages: measuring and marking out, preparation of the material for fabrication, forming processes and the assembly of the materials.

This unit gives learners with no previous fabrication experience an understanding of the processes and technologies used throughout the fabrication industry, whilst learning to work in a safe environment. The unit is appropriate for work-based learners or for those who are being prepared for employment in an industrial environment where fabrication is an integral part of the manufacturing process.

Learners will work with ferrous or non-ferrous metals in the form of sheet, plate and sectional materials to construct a fabricated structure. They will learn how to use a range of industrial hand tools and machinery to complete fabrication tasks. The unit will give learners the ability to identify the correct processes and equipment to use, and the tools and equipment appropriate to each stage of the fabrication process.

● Learning outcomes

On completion of this unit a learner should:

- 1 Know about health and safety legislation, regulations and safe working practices in the fabrication industry
- 2 Know the processes used to mark out and prepare materials to produce fabricated structures
- 3 Know how materials are formed and assembled to produce fabricated structures
- 4 Be able to interpret the specification of a fabricated structure and plan and carry out its manufacture.

Unit content

1 Know about health and safety legislation, regulations and safe working practices in the fabrication industry

Legislation and regulations: applicable to the fabrication industry eg Health and Safety at Work Act 1974, Employment Act 2002, Factories Act 1961, Fire Precautions Act 1971; regulations eg Management of Health and Safety at Work Regulations 1999, Provision and Use of Work Equipment Regulations 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, Workplace (Health, Safety and Welfare) Regulations 1992, Health and Safety (First Aid) Regulations 1981

Safe working practices: safety in the workshop and on site; fire prevention; accident prevention and reporting; risk assessment; manual handling; checking conditions eg gas leaks, voltage and amperage, correct fuses, leads, guarding of machinery and power tools; action to be taken when machinery and equipment are dangerous or in poor condition; personal protective equipment (PPE); ventilation and extraction; closing down eg equipment safety, storing equipment, safe disposal of waste materials

2 Know the processes used to mark out and prepare materials to produce fabricated structures

Marking out: measuring and marking out equipment eg rule, protractor, tee square, set square, tape measure, compass, dividers, trammel, templates, marker pen, scribe, chalk line, laser level; detailed drawing eg dimensions, tolerances; reference points eg datum line, centre line datum; setting out eg radial line, triangulation, projection, true lengths; calculations eg bend allowance, allowance for springback, intersection points, overlap; calibration of equipment

Fabricated structures: examples from local industry; made in a centre's workshop eg equipment storage systems (ie tool rack, tool box), work bench, car maintenance equipment (ie axle stand, ramp, crawler board), ventilation ducting (ie collector hood, reducing section, tee connector)

Preparing materials: obtaining materials eg sheet, bar, plate, section; standard bought out condition eg hot-rolled, cold rolled, standard dimensions, profiles, thickness; metallic materials eg ferrous, non-ferrous; cutting to size and shape eg flame, plasma, powder, water jet, laser, band saw, hacksaw, reciprocating saw; shearing eg hand, bench, rotary, reciprocating; guillotining eg bench, power; nibbling eg hand, power; presswork eg piercing, blanking, punching; material removal eg chiselling, drilling, trepanning, filing, grinding; automated methods eg numerical control (NC), computer numerical control (CNC), direct numerical control (DNC), mechanical copying using templates

3 Know how materials are formed and assembled to produce fabricated structures

Forming: principles eg spring back, bend allowance; forming by hand eg hammer and former, fly press, bench mounted bending machine; forming by machine eg folding machine, press brake; rolling tools (eg rolling rolls, pyramid rolls, slip rolls, cone rolls), angle ring-bending; swaging; deep drawing and pressing; web stiffeners; edge preparation; pipe bending; use of templates and patterns; automated methods eg numerical control (NC), computer numerical control (CNC), direct numerical control (DNC)

Fabricated structures: examples from local industry; made in a centre's workshop eg equipment storage (ie tool rack, tool box), work bench, car maintenance equipment (ie axle stand, ramp, crawler board), ventilation ducting (ie collector hood, reducing section, tee connector)

Assembly: trial assembly or 'physical mock up' eg offering up, alignment, clamping, dimensional checks, adjustment, modification; workshop clamps eg mitre joint, toggle, G clamp, rivet clamps/skin pins, magnetic clamping devices; joining methods eg spot welding, continuous welding, laser welding, brazing, soldering, structural adhesives, riveting; mechanical fixings eg nuts, bolts, screws, clamps, pipe connectors; web stiffeners; inspect and check against specification

4 Be able to interpret the specification of a fabricated structure and plan and carry out its manufacture

Structure specification: engineering drawing eg assembly, detailed, development; material eg steel, aluminium; material supply forms eg plate of appropriate thickness, hollow section, solid section, pipe, tube; reference points eg edge datum, centre line datum; dimensions eg overall, reference, installation, tolerance; permanent and non-permanent assembly methods eg thermal, adhesive, riveting, mechanical fixings; finish eg paint, polymer coat, electro-plate, polish; quantity eg one off, small batch, large volume

Plan and manufacture: calculations eg bend allowance, allowance for springback, intersection points, quantity of material required, minimisation of waste material; select suitable equipment eg marking out, preparation, templates, patterns, forming and assembly; mark out; produce manufacturing aids eg formers, jigs, templates; prepare and form individual parts of the assembly eg cutting to size, edge preparation, piercing, bending; assemble the fabrication and join parts together eg trial assembly or 'physical mock up', modification, weld, braze, rivet, fixings; meet the required accuracy as specified eg dimensions, tolerances, finish, visual appearance, joint quality; inspect and check against specification

Assessment and grading criteria

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

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:	To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:
P1 identify the health and safety legislation, regulations and safe working practices applicable in a fabrication workshop [IE4]	M1 explain the effect, including aspects of safety and quality, of using incorrect equipment and processes to produce a fabricated structure	D1 justify the methods used to prepare materials when producing a fabricated structure
P2 describe the process of marking out when producing fabricated structures	M2 explain the factors that influence the assembly methods used in the production of a fabricated structure.	D2 evaluate the quality of manufacture against that specified for a fabricated structure.
P3 describe the process of materials preparation when producing fabricated structures		
P4 describe how materials are formed before they are assembled into a fabricated structure		
P5 describe the assembly process for a given fabricated structure		
P6 interpret the specification of a fabricated structure to plan its manufacture		
P7 produce a fabricated structure to specification [SM3].		

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

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

Essential guidance for tutors

Delivery

To establish the context of this unit, delivery should begin with a general overview of what is meant by a 'fabricated structure' and the reasons for producing it by this method. The starting point could be to look at how a common material such as steel plate can be turned into a quality product by using a series of relatively simple processes. It would be useful to provide a brief overview of the production of a fabricated structure, taking account of local industries, so that learners can appreciate how fabrication processes are used to produce a quality product.

Learning outcome 1 covers legislation and safe working practices and links to *Unit 1: Health and Safety in the Engineering Workplace*. However, care should be taken to ensure that the delivery concentrates only on the specific issues relating to fabrication processes. There is a huge amount of health and safety information available and when learners are required to carry out research they should be given structured tasks which lead them to relevant information.

Tutors must ensure that learners understand the hazards and safe working practices associated with fabrication equipment before they are allowed to use the processes. Learners should be introduced to the processes using a series of formative tasks which enable them to improve their skills and demonstrate their competence before attempting the summative practical task associated with learning outcome 4.

Grading criteria P2, P3, P4 and P5 require evidence to be presented in the form of written reports derived from a range of activities. The unit may therefore be best delivered using tutor-led demonstrations followed by practical tasks, during which learners can gain experience of working with appropriate tools and equipment. Underpinning knowledge can be delivered by integrating practical demonstrations with classroom-based theory sessions and directed research. Learners should be encouraged to evaluate their performance by completing formative tasks which may be self or peer assessed. This should be reinforced with appropriate feedback, to further encourage the development of skills and knowledge.

Centres may wish to consider industrial visits so that learners can investigate and observe fabrication processes not generally available within the centre (eg automated material handling, preparation and bending, laser welding). The internet is also a good resource for obtaining information and short video clips of these processes.

The learning outcomes follow a natural progression which should enable learners to develop an understanding of the fundamental stages involved in the production of fabricated structures, irrespective of the process used. Job instructions should be written in a logical format that will lead learners to consider all aspects of the task. These should include interpretation of technical drawings and specifications, safety, selection of tools, equipment and materials, correct use of process, and inspection.

Work-based learners should be encouraged to relate the learning outcomes to the processes and techniques used at work. They should also gain a wider knowledge of the fabrication processes used throughout the fabrication industry. It may be helpful if centres can relate tasks to the needs of local industries. This will prepare learners not currently employed with appropriate skills and knowledge for when they do enter employment.

Learners will require instruction in the safe application of fabrication processes, and should have access to a wide range of publications, reference data, manufacturers' products, information and computer facilities. The centre should have access to an appropriate range of fabrication equipment.

There is scope within the content of learning outcome 4 to select joining methods appropriate to the materials being fabricated. For learners who are producing a steel fabrication but are not studying *Unit 23: Welding Technology*, the use of spot welding may be appropriate for joining assembled parts, as this is an easy process to learn.

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

Outline learning plan

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

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

Topic and suggested assignments/activities and/assessment

Practical workshop session:

- introduction to unit content, scheme of work and assessment
- induction into fabrication workshops and general safety and emergency procedures
- identify specific processes used in the fabrication industry.

Whole-class teaching:

- health and safety related to fabrication and sheet metal working environments and safe working practices
- health and safety legislation and regulations.

Preparation for and carrying out **Assignment 1: Health and Safety in the Fabrication Industry** (P1, M1).

Whole-class teaching:

- stock material types – sheet, plate, tube, sectional materials
- types of material – ferrous, non-ferrous
- tools and equipment required when measuring and marking out
- marking out fabricated structures – examples.

Workshop practical session:

- measurement techniques and marking out tools
- marking of sheet, plate, tube and sectional materials
- marking out according to material type and surface form.

Whole-class teaching:

- safety when using machinery for the preparation of materials
- types of hand operated, power tools, and machines used in the preparation of materials
- machine and tool maintenance
- automated methods of preparing materials – NC, CNC, DNC.

Workshop practical session:

- safety in the workshop when preparing materials
- selecting processes for the preparation of materials
- correct tool set up and maintenance
- material characteristics when preparing materials.

Preparation for **Assignment 2: Marking Out and Preparing Fabrication Materials** (P2, P3, D1).

Topic and suggested assignments/activities and/assessment

Whole-class teaching:

- safety when using forming tools and machinery
- theory of bending – springback, bend allowance
- forming by hand – hammers, formers, fly press
- forming by machine – bending, folding and rolling theory. Introduction to types of machine and tooling. Pipe bending and use of templates
- examples of forming in fabricated structures
- automated forming machines – NC, CNC, DNC.

Workshop practical session:

- safety in the workshop when using forming equipment
- bending and folding – safety, set up, maintenance, springback, bend allowance
- rolling – safety, set up, maintenance
- hand power tools used for forming operations
- manual forming processes – hammers, formers, fly press.

Whole-class teaching:

- safety in the workshop and in industry during assembly
- thermal joining processes
- mechanical fastenings
- structural adhesives
- types of assembly and best use of materials in fabricated structures.

Workshop practical session:

- preparation of joints for assembly
- safe joining and assembly techniques
- joining materials – thermal, mechanical and bonding with adhesives
- working to specifications and checking assembled components.

Preparation for **Assignment 3: Forming and Assembling Fabrication Materials** (P4, P5, M1, M2).

Whole-class teaching:

- specifications – detail drawings, materials, assembly
- working to specifications – planning, visual checks, joint quality, assembly quality, inspection techniques and reports
- quality standards – dimensional accuracy, tolerances and geometrical tolerances
- recording and interpreting accuracy and tolerances
- working to specifications and checking assembled components.

Preparation for **Assignment 4: Manufacturing from a Specification** (P6, P7, D2).

Feedback on assessment and unit review.

Assessment

Assessment of this unit could be achieved through the use of four assignments.

The first assignment could cover P1, with learners being asked to produce a written report. Evidence presented for P1 must be specific to fabrication processes and learners will need to be given clear guidelines about what to present. There is a huge amount of generic material which learners will have access to. Care should be taken to ensure that what they present is referenced properly and not directly copied from the internet or any other source. Grading criteria P1 and M1 complement each other and it may be that centres wish to cover them both in the first assignment. However, learners might do better if M1 is assessed later once they have a better understanding of the problems associated with using the wrong equipment and processes. If this is the case then M1 could be assessed through the assignment which addresses grading criterion P5.

P2 and P3 can be assessed through a second assignment. Evidence could be in the form of a written report supported by drawings, diagrams and photographic images of formative practical work carried out by learners as they investigated the various marking out and materials preparation techniques. Records of responses to oral questioning by the tutor may also be appropriate. D1 requires learners to demonstrate an understanding of the techniques used to prepare materials for fabrication by justifying the use of a selected method.

A third assignment could cover P4, P5, M2 (and M1 if not already covered in the first assignment). This should follow a similar format as assignment 2, with much of the evidence being based on the practical investigations carried out by learners on forming and assembly techniques. Learners' evidence should also demonstrate further understanding of what influences the use of assembly methods for M2. If M1 is covered in this assignment learners' reports/evidence will also need to evidence their understanding of the consequences of using incorrect equipment and processes.

In P6 and P7 learners will use a given specification to plan and produce a fabricated structure. Care should be taken when designing the assignment brief for P6 and P7 to make sure that it does not just become a test of the learners' practical skills. Due to the time constraints of delivering the unit, it is not reasonable to expect learners to carry out joining processes that require a higher level of skill at an expert level.

There is scope to assess learning outcome 4 as a group activity so that learners can appreciate working as a team to produce a larger fabrication. Each learner could be given a part to work on, although care needs to be taken to ensure that the evidence presented by each learner addresses the whole of the unit content and can be substantiated. Digital annotated photographic images together with witness statements and observation records should be used to consolidate learner evidence of practical competence.

To achieve D2 learners should check the quality of the fabricated structure produced in P7 and report on the quality of the structure compared to that set out in the given specification. This offers an opportunity for learners to evaluate the preparation, forming and assembly techniques they have used and identify where they can develop skills and techniques to improve quality.

Programme of suggested assignments

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

Criteria covered	Assignment title	Scenario	Assessment method
P1	Health and Safety in the Fabrication Industry	An activity based assignment that requires learners to research and identify health and safety legislation and safe working practices within the fabrication industry.	A report that outlines legislation and safe working practices applicable to the fabrication industry. The report should identify and clearly reference all research materials.
P2, P3, D1	Marking Out and Preparing Fabrication Materials	A written assignment that evidences and further investigates the formative practical tasks that have been carried out in a fabrication workshop.	A written report will form a summative assessment that contains drawings, diagrams and photographs to evidence the range of marking out and preparation processes. Learners will justify the methods they have used to prepare materials in a fabrication workshop.
P4, P5, M1 and M2	Forming and Assembling Fabrication Materials	A written assignment that evidences the practical investigations that the learner has carried out in a fabrication workshop.	Summative assessment will require a written report that contains evidence of the range of forming and assembly processes used in a fabrication workshop. The report will be supported with diagrams and photographs of their work. The report will examine the possible effects of using incorrect tools and processes. It will also include learners interpretation of why particular assembly processes have been used.
P6, P7, D2	Manufacturing from a Specification	A practical assignment that requires the learner to plan and make a fabricated structure from a given specification.	The learner will interpret information from a given specification and produce a plan of the processes and fabrication techniques to be used. Having planned the work, and agreed the plan with the tutor, the learner will produce the fabricated structure given in the specification. Learners will produce a report which evaluates the quality of their work against the original specification.

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

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

Level 1	Level 2	Level 3
	Fabrication Techniques and Sheet Metal Work	Welding Technology
		Welding Principles

The unit also covers some of the knowledge and understanding associated with the SEMTA Level 3 National Occupational Standards in Fabrication and Welding Engineering, particularly:

- Unit 22: Marking Out Components for Metalwork
- Unit 23: Cutting Sheetmetal to Shape Using Hand and Machine Tools
- Unit 24: Forming Sheetmetal Using Hand and Machine Tools
- Unit 25: Producing Sheetmetal Assemblies
- Unit 27: Developing and Marking Out Templates for Metalwork
- Unit 28: Joining Fabricated Components using Mechanical Fasteners
- Unit 29: Bonding Engineering Materials Using Adhesives
- Unit 30: Joining Materials by Resistance Spot Welding
- Unit 32: Cutting Plate and Sections using Shearing Machines
- Unit 33: Cutting and Shaping Materials using Portable Thermal Cutting Equipment
- Unit 34: Cutting Materials using Saws and Abrasive Discs
- Unit 35: Bending and Forming Plate using Press Brakes or Bending Machines
- Unit 36: Forming Platework using Power Rolling Machines
- Unit 37: Producing and Finishing Holes using Drilling Machines
- Unit 38: Producing Platework Assemblies.

Essential resources

Learners will need access to workshop facilities equipped with a range of marking out, forming and assembly tools and equipment, along with a variety of fabrication materials. Access to current health and safety legislation and regulations would also be useful for learning outcome 1.

Employer engagement and vocational contexts

The use of vocational contexts is essential in the delivery and assessment of this unit. The materials and processes used should reflect those used in the learners' workplace, or be based on case studies of local employers for those preparing for employment. Learners may benefit from industrial visits to provide an understanding of fabrication processes and techniques in an industrial context, and to also appreciate the range of processes and materials used in industry.

Work-based learners would also benefit if the structure in learning outcome 4 was related to their industry or directly to their workplace. Engaging with employers could also provide suitable examples for those who are not employed to aid the learners' appreciation of local industry.

There are a range of organisations that may be able help centres engage and involve local employers in the delivery of this unit, for example:

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

Indicative reading for learners

Textbooks

Kenyon W – *Basic Welding and Fabrication* (Longman, 1987) ISBN 9780582005365

Robinson A – *The Repair of Vehicle Bodies* (Butterworth-Heinemann, 2005) ISBN 9780750667531

Smith B D – *Welding Practice* (Butterworth-Heinemann, 1995) ISBN 9780340614068

Timings R L – *Fabrication and Welding Engineering* (Newnes, 2008) ISBN 0750666919

Wakeford R E – *Sheet Metal Work* (Special Interest Model, 1987) ISBN 9780852428498

Delivery of personal, learning and thinking skills

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

Skill	When learners are ...
Independent enquirers	identifying and using health and safety information to discuss safe working practices
Self-managers	planning and manufacturing a fabricated structure.

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

Skill	When learners are ...
Independent enquirers	evaluating the quality of their manufactured product
Creative thinkers	planning the manufacture of a fabricated structure
Reflective learners	evaluating the quality of their manufactured product.

● Functional Skills – Level 2

Skill	When learners are ...
ICT – Find and select information	
Access, search for, select and use ICT-based information and evaluate its fitness for purpose	searching for health and safety information
Mathematics	
Understand routine and non-routine problems in a wide range of familiar and unfamiliar contexts and situations	calculating springback and bend allowances
Identify the situation or problem and the mathematical methods needed to tackle it	measuring and marking out patterns
Interpret and communicate solutions to practical problems in familiar and unfamiliar routine contexts and situations	working with dimensions and tolerances and assessing the extent of inaccuracies
English	
Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts	
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	reading and interpreting specifications, quality standards and safety information relating to fabrication processes
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	describing marking out, preparing, forming and assembling processes.