Unit 22: Fabrication Processes and Technology

NQF Level 3: BTEC National

Guided learning hours: 60

Unit abstract

Fabricated structures have been around from the earliest times, with one of the first being a simple frame made from tree branches covered with leaves. The fabrication process consisted of a number of steps: preparing the branches by measuring and cutting to length, joining them together using fixings such as rope and wooden pegs and then covering with leaves.

Exactly the same principles are used today when assembling or welding together an engineering structure made up from a number of different parts. For example, a car exhaust system consists of a number of metal pipes and boxes which have been bent to shape and then joined together by welding so that they form a complete assembly. Another example of a fabricated structure is the body of an aeroplane which is constructed by first producing a frame and then joining curved aluminium panels onto it using rivets and adhesives.

Producing products using fabrication methods is very cost effective because there is much less material wastage compared to cutting from solids and lower energy costs when compared to casting or forging.

This unit will allow learners to develop their knowledge and understanding of the main processes and methods used to fabricate engineering structures. It investigates the health and safety legislation and safe working practices applicable to fabrication processes. This knowledge will be put to good use when learners carry out practical activities later in the unit.

Learners will be expected to manufacture a fabricated product to a specification which will be given to them in the form of an engineering drawing.

Learning outcomes

On completion of this unit a learner should:

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

2 Understand the process of marking out and preparing the materials used to produce fabricated structures

3 Understand the forming and assembly methods used 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 fabrication**

Legislation: legislation 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: fire prevention; accident prevention and reporting; risk assessment; manual handling; checking conditions eg gas leaks, voltage and amperage, correct fuses, leads; personal protective equipment (PPE); ventilation and extraction; closing down eg equipment safety, storing equipment, safe disposal of waste materials

2 **Understand the process of marking out and preparing the materials used to produce fabricated structures**

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

Fabricated structures: eg equipment storage (such as tool rack, tool box), work bench, car maintenance equipment (such as axle stand, ramp, crawler board), ventilation ducting (such as collector hood, reducing section, tee connector)

Preparing materials: obtain materials eg sheet, bar, plate, section, standard bought out condition; prepare to size eg cutting (such as flame, plasma, powder, water jet, laser, band saw, hacksaw, reciprocating saw), shearing (such as hand, bench, rotary, reciprocating), guillotining (such as bench, power), nibbling (such as hand, power), presswork (such as piercing, blanking, punching), material removal (such as chiselling, drilling, trepanning, filing, grinding), automated methods (such as numerical control (NC), computer numerical control (CNC), direct numerical control (DNC), mechanical copying using templates)

3 **Understand the forming and assembly methods used to produce fabricated structures**

Forming: principles eg spring back, bend allowance; forming eg by hand (such as hammer and former, fly press, bench mounted bending machine), by machine (such as folding machine, press brake), tooling (such as 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 (such as numerical control (NC), computer numerical control (CNC), direct numerical control (DNC))

Fabricated structures: eg equipment storage (such as tool rack, tool box), work bench, car maintenance equipment (such as axle stand, ramp, crawler board), ventilation ducting (such as collector hood, reducing section, tee connector), workshop clamps (such as mitre joint, toggle), support stand for a bicycle

Assembly: trial assembly eg offering up, alignment, clamping, dimensional checks, adjustment, modification; joining methods eg welding (such as spot, continuous, laser), brazing, soldering, adhesives, riveting, fixings (such as 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, polymer; 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; assembly method eg thermal, adhesive, riveting, 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 former, jig, template; prepare and form individual parts of the assembly eg cut to size, edge prepare, pierce, bend; assemble the fabrication and join parts together eg trial assembly, modification, weld, braze, rivet, fixings; meet the required accuracy as specified eg dimensions, tolerances, finish, visual appearance, joint quality; inspect and check against specification

Grading grid

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

Grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P1 describe aspects of health and safety legislation and regulations and safe working practices applicable to fabrication P2 describe the process of marking out when producing fabricated structures P3 describe the process of materials preparation when producing fabricated structures P4 describe how material is formed before it is assembled into a fabricated structure P5 describe the assembly process for a given fabricated structure P6 interpret the specification for a given fabricated structure to plan its manufacture	M1 explain the effect, including aspects of safety and quality, of using incorrect equipment and processes to produce a fabricated structure M2 explain the factors that influence the choice of assembly method to be used when producing a fabricated structure.	D1 justify the selection of fabrication processes and methods to be used when manufacturing a given fabricated structure.

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:**
P7 manufacture a fabricated structure to a given specification.		

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 low-value material such as steel plate can be turned into a higher value product by using a series of relatively simple processes. It might be useful at this point to provide a brief overview of the production of motor car bodies, so that learners appreciate how the use of highly automated fabrication processes has resulted in a significant reduction in manufacturing costs.

Learning outcome 1 covers legislation and safe working practices and links to *Unit 7: Health, Safety, Risk Assessment and Welfare 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 data available and when learners are required to carry out research they should be given structured tasks which lead them to the relevant information. Learning outcome 1 may be best assessed using a single assignment which covers just P1.

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 graded formative tasks which enable them to 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.

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.

Learning outcomes 2, 3 and 4 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 gain a wider knowledge of the fabrication processes used across industry, not just the processes and techniques used at their place of work. It may be helpful if centres can relate tasks to the needs of local industries so that learners who are not currently employed gain appropriate skills and knowledge.

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 a joining method appropriate to the materials being fabricated. For learners who are producing a steel fabrication but are not studying *Unit 23: Applications of 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.

Assessment

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

The first assignment could cover P1, with learners being asked to produce a written report. Evidence presented for P1 should 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 and care should be taken to ensure that what they present is not just directly copied from the internet.

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.

Criteria P2 and P3 complement each other and could be assessed through a second assignment. Evidence could be in the form of a written report supported by diagrams and images of formative practical work carried out by learners as they investigated the various marking out and materials preparation techniques. Transcripts of responses to oral questioning by the tutor may also be appropriate.

A third assignment to cover P4 could follow the same format as assignment 2, with much of the evidence being based on practical investigations carried out by learners.

Grading criteria P5 and M2 are linked and could be assessed by a fourth assignment. Alternatively it could be assessed in the third assignment in order to reduce the number of assignments given. To achieve P5 learners will present evidence derived from working with a given fabricated structure. For learners who are employed it may be appropriate to let them choose the fabricated structure in agreement with the tutor. As stated earlier, M1 could be incorporated into this assignment as it draws together knowledge gained across the whole unit.

A fifth assignment could cover P6, P7 and D1. Care should be taken when designing the assignment brief 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 at an expert level.

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

To achieve D1 learners will need to produce a piece of detailed evaluative writing with consideration being given to the effectiveness of the processes selected. They should be drawing on their own experiences and care must be taken to ensure that what they present as evidence is authentic. All aspects of the process need to be taken into account, such as heath and safety, preparation, forming and assembly methods.

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

This unit links to *Unit 23: Applications of Welding Technology* and *Unit 27: Welding Principles*.

The unit 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 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

To meet the needs of this unit it is essential that the centre has, or has access to, the fabrication equipment and related materials and consumables as specified in the unit content. Applications of fabrication componentry should be appropriate to the learners' particular pathway within welding materials. Learners will also need access to relevant British and International Standards and health and safety publications.

Indicative reading for learners

Textbooks

Kenyon W — *Basic Welding and Fabrication* (Longman, 1987) ISBN 0582005361

Smith B — *Welding Practice* (Butterworth-Heinemann, 1995) ISBN 0340614064

Key skills

Achievement of key skills is not a requirement of this qualification but it is encouraged. Suggestions of opportunities for the generation of Level 3 key skill evidence are given here. Staff should check that learners have produced all the evidence required by part B of the key skills specifications when assessing this evidence. Learners may need to develop additional evidence elsewhere to fully meet the requirements of the key skills specifications.

Communication Level 3	
When learners are:	**They should be able to develop the following key skills evidence:**
• describing the process of materials preparation when producing fabricated structures.	C3.3 Write **two** different types of documents, each one giving different information about complex subjects. One document must be at least 1000 words long.
Problem solving Level 3	
When learners are:	**They should be able to develop the following key skills evidence:**
• interpreting the specification for a given fabricated structure to plan its manufacture.	PS3.1 Explore a problem and identify different ways of tackling it.