Unit 22: Applications of Welding Technology

NQF Level 3: BTEC National

Guided learning hours: 60

Unit abstract

The diverse range of welding processes used within the engineering industry includes manual, mechanised and machine-based techniques. The selection and application of the most suitable joining process is vital not only in terms of quality but also to the economic viability of the finished product.

This unit has been designed to include not only manual and mechanised applications of welding processes but also machine-based processes including laser, friction and resistance welding. The emphasis is on the production of high quality welded joints/components based on the selection of the most appropriate process. To enable learners to make an informed choice they will be required to select joining processes to satisfy a given application.

Learners will perform a range of practical tasks that will include the preparation of the work area and ensuring that health and safety legislation and safe working practices are understood and followed at all times. Before starting to use the process, learners will select and check the condition of appropriate equipment. This stage in the process is particularly important when it is considered that, subject to the process selected, learners may be working with electric currents, combustible gas mixtures or parts rotating at high speed.

Learners will be expected to interpret written, graphical and verbal instructions while carrying out the practical tasks, which will be delivered using tutor-led demonstrations and supervised practise. Learners will inspect their work with reference to relevant quality standards, thus ensuring that they are not only able to produce acceptable welds/components but they are also able to recognise defects.

This unit is designed to accommodate the needs of learners who are either employed or who are being trained to enter an engineering environment in which joining by welding is an integral part of the manufacturing process.

Learning outcomes

On completion of this unit a learner should:

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

2 Be able to use information sources and select and prepare tools and equipment for welding

3 Be able to produce welded joints to a quality standard

4 Understand how quality inspection processes are applied to welded joints/ components.

Unit content

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

Legislation and regulations: 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, The Workplace (Health, Safety and Welfare) Regulations 1992, Health and Safety (First Aid) Regulations 1981, Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations 2004, Simple Pressure Vessels (Safety) Regulations 1991 (SI 1994/3098)

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 **Be able to use information sources and select and prepare tools and equipment for welding**

Information sources: safety instructions; job instructions; engineering drawings; quality control documentation eg weld procedure specification (WPS), assessment sheet

Tools and equipment: check equipment availability, function and condition relevant to the welding process eg cables, hoses, torches/electrode holders, gas pressure regulators, flowmeters; assembling welding equipment eg cables, weld return clamps, electrode holders, gas cylinders, regulators, valves, safety devices

Welding parameters: setting and adjusting eg:

- for manual processes: gas pressure, flow rates, voltage, current (either alternating (AC) or direct (DC))
- for mechanised processes: safety devices, welding speed, other parameters (electrical parameters, flux dispensing and recovery mechanisms, wire feed rate, gas shielding system, mechanical functions (handling, loading, workholding, transfer))

- for resistance welding machines: welding current, welding and squeeze times, electrode pressure cycle, welding speed (seam), weld pitch (spot), mechanical functions
- for laser welding machines: electrical parameters, welding speed, weld alignment and characteristics, beam tracking, beam characteristics (focal spot), gas shielding, mechanical mechanisms for workholding, traversing and transfer
- for friction welding machines: friction and forge cycle time, friction and forge loads (forces), rotational speed or other friction conditions (orbital, frictional burn-off characteristics, forge displacement, braking effort), weld appearance (correct upset)

Welding processes: manual eg manual metal-arc (MMA), metal inert gas (MIG), metal active gas (MAG), metal-arc gas shielded, cored wire, tungsten inert gas (TIG), plasma-arc, gas welding; mechanised eg MIG/MAG, cored wire, TIG, plasma-arc, submerged arc; machine based eg resistance welding machines (spot, seam, projection), laser welding machines, friction welding machines

3 **Be able to produce welded joints to a quality standard**

Safely: fire prevention; accident prevention and reporting; using risk assessment; manual handling; checking conditions eg gas leaks, voltage and amperage, fuses, leads; wearing PPE; using ventilation and extraction; closing down equipment safely after use

Joints/components: eg:

- for manual processes: butt, fillet, autogeneous weld (without filler wire)
- for mechanised processes: two different joint configurations, two different material groups
- for resistance welding machines: two different material thicknesses, two different joint configurations
- for laser and friction welding machines: two different components, two different material groups

Welding positions: to a relevant standard eg British Standard (BS) EN 287 flat (PA), horizontal vertical (PB), horizontal (PC), vertical upwards (PF), vertical downwards (PG), overhead (PE), inclined tube/pipe (H-L045 or J-L045)

Consumables: appropriate to process eg electrode (rutile, basic, nickel alloy, cellulosic, stainless steel, other electrodes), filler wire, gases (oxygen, acetylene, shielding gases), flux/agglomerated flux

Material: forms eg plate (various thickness appropriate to process, up to 6 mm for resistance welding), section, pipe/tube, sheet (<3 mm), other forms; types eg carbon steel, stainless steel, aluminium

Quality standard: minimum weld quality standard equivalent to the level given in the relevant standard eg European/International Standard EN25817/ISO 5187, EN30042/ISO 10042, EN/ISO 13919; meet the required accuracy as specified eg dimensions, tolerances, weld quality, spot and projection welds are correctly located

4 **Understand how quality inspection processes are applied to welded joints/components**

Quality standard: minimum weld quality standard equivalent to the level given in the relevant standard eg European/International Standard EN25817/ISO 5187, EN30042/ISO 10042, EN/ISO 13919; meet the required accuracy as specified eg dimensions, tolerances, weld quality, spot and projection welds are correctly located; non-destructive inspection eg dye penetrant, ultrasonic, radiographic (x-ray, gamma ray), pressure tests (hydraulic, pneumatic), fluorescent particle, magnetic particle

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, regulations and safe working practices applicable to welding P2 using appropriate information sources, select and prepare tools, equipment and welding parameters to safely perform a welding process P3 use one manual or mechanised welding process safely to produce two welded joints/components, using appropriate welding positions, consumables, forms and types of materials P4 use one machine-based welding process safely to produce two welded joints/components, using appropriate welding positions, consumables, forms and types of materials	M1 explain the effect, including aspects of safety and quality, of incorrect use of parameters for a welding process when producing a given welded joint/component M2 compare the advantages and disadvantages of two welding processes for a given application including the impact on quality standards.	D1 justify the selection of a welding process for a given application D2 evaluate the benefits and limitations of non-destructive inspection on a given welded joint/component.

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:**
P5 use one manual or mechanised welding process to produce two welded joints/components to a given quality standard P6 use one machine-based welding process to produce two welded joints/components to a given quality standard P7 select and describe two welding processes for a given application P8 describe the quality inspection process performed on a given combination of welded joints/components and materials.		

Essential guidance for tutors

Delivery

This unit could be 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, classroom-based theory sessions and directed research, using all available learning resources including information technology. Centres may wish to consider industrial visits so that learners can investigate and observe joining processes not generally available within the centre (eg laser and friction welding machines).

Tutors must ensure that learners understand the hazards and safe working practices associated with welding equipment before they are allowed to use the processes. Learners should be introduced to the process using a series of graded formative tasks to enable them to demonstrate their competence before attempting the summative tasks.

Learners should be encouraged to evaluate their performance in the formative tasks using a combination of both tutor and self/peer assessment. The use of inspection within the workshop will encourage self-assessment. Tutors can relate the results of the inspection process to the adjustment of process parameters to enable learners to improve weld quality.

The four learning outcomes follow a natural progression which should enable learners to develop an understanding of the fundamental stages involved in the production of welded joints/components, 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 from safety, selection of tools, equipment and materials, process set-up and operation through to production and inspection of the welded joint/component.

The summative tasks will assess learners' competence in the use of certain welding processes and their ability to control process parameters to produce welds/components that meet a specified quality standard.

Work-based learners should be encouraged to gain a wider knowledge of welding processes used in industry, not just the processes and techniques used at their place of work. Centres can relate tasks to the needs of local industries to prepare learners not currently employed to enter employment with the appropriate skills and knowledge.

Learners will require instruction in the safe application of welding processes and need 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 welding equipment.

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

There are a number of options available to centres when designing tasks for the production of evidence.

In a practical activity to produce two joints/components, the following could be included in the task description of an assignment:

- describe aspects of health and safety legislation and safe working practices applicable to welding (P1)
- using appropriate information sources, select and prepare tools, equipment and welding parameters to safely use a given welding process (P2)
- use a manual or mechanised welding process safely to produce two welded joints/components, using the welding positions, consumables, forms and types of material appropriate to the process (P3) and to a given quality standard (P5)
- describe the quality inspection process performed on a given combination of welded joints/components and materials (P8).

The evidence for P1 is likely to be achieved by a response to a written task. The satisfactory achievement of P2 will precede tasks targeting criteria P3 and P5. To achieve criteria P8, it is recommended that learners describe the inspection of the welds produced to achieve P3 and include reference to the standards, accuracy and non-destructive inspection methods used. Witness statements/observation records used to show the evidence for criteria P2, P3 and P5 are best supported by annotated photographs and a table of quality outcomes for the two welded joints/components.

Care must be taken to consult the content section of the unit to ensure that the range of welding positions, joints/components, materials and consumables are appropriate to the joining process being assessed. The choice of whether a manual or mechanised process should be used is left to the centre and may be decided by the pathway that learners are following in their workplace. Obviously, more freedom of choice exists with centre based learners but attention should be given to likely local employment opportunities.

A similar assignment can be used to give opportunities to meet criteria P4 and P6. This could involve machine-based processes and would also give a further opportunity to assess P1 and P2 if the first assignment was not achieved successfully in these respects. Again, witness statements/observation records used to show the evidence for criteria P2, P4 and P6 are best supported by annotated photographs and a table of quality outcomes for the two welded joints/components.

Once learners have experienced a range of processes, consideration can be given to achieving the outstanding pass criteria (P7) and the higher grading criteria. A task needs to be given asking learners to select and describe two welding processes for given applications. The expectation within this task is that all areas of the two processes will be described. Obviously the practical experience will influence learners' ability to answer this task.

To achieve a merit grade, learners will need to explain the effect of incorrect use of parameters on a welding process for a given welded joint/component (M1). This evidence would be best demonstrated by a written task, which could be related to the activities carried out to meet either P3 and P5 or to meet criteria P4 and P6. Similarly, M2 could be a written task that asks learners to compare the advantages and disadvantages of two welding processes for a given application. Care needs to be taken when selecting the given application to ensure learners have opportunities to carry out this comparison. Although it is not compulsory to have a manual and mechanised process, this is where opportunities may be maximised during a comparison.

To achieve a distinction grade, learners will need to demonstrate their knowledge of both joining processes and the properties of engineering materials when justifying the selection of a process for a given application. The task used to provide evidence to satisfy D1 is likely to be a written answer that extends the task designed to meet P3/P5 or P4/P6, M1 and M2. Again, care should be taken when selecting the given application to ensure opportunities exist to justify and say why the process is appropriate and others are not. D2 will require learners to use the results of the practical work carried out to achieve P5 and P6 and the written outcome from M2, enabling them to evaluate non-destructive inspection.

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

This unit has links with the following units from the Level 3 SEMTA National Occupational Standards in Fabrication and Welding Engineering:

- Unit 4: Welding Materials by the Manual Metal Arc Process
- Unit 5: Welding Materials by the Manual MIG/MAG and other Continuous Wire Processes
- Unit 6: Welding Materials by the Manual TIG and Plasma Arc Welding Process
- Unit 7: Welding Materials by the Manual Gas Welding Process
- Unit 16: Welding Materials with Mechanised Arc Welding Equipment
- Unit 17: Welding Materials using Resistance Spot, Seam and Projection Welding Machines
- Unit 18: Welding Materials using Laser Welding Machines
- Unit 20: Welding Materials using Friction Welding Machines.

Essential resources

Centres will need access to appropriate welding equipment and related materials and consumables as specified in the unit content. Applications of welded componentry should be appropriate to the learners' particular pathway within welding materials.

Indicative reading for learners

Textbooks

Davies A — *Science and Practice of Welding, Volume 1* (Cambridge, 1993) ISBN 052143565X

Davies A — *Science and Practice of Welding, Volume 2* (Cambridge, 1993) ISBN 0521435668

Raj B, Shankar V and Bhaduri A — *Welding Technology for Engineers* (Alpha Science International Ltd, 2005) ISBN 1842651943

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

Weman K — *Welding Processes Handbook* (CRC Press, 2003) ISBN 0849317738

Zhang H — *Resistance Welding* (CRC Press, 2005) ISBN 0849323460

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.

Problem solving Level 3	
When learners are:	**They should be able to develop the following key skills evidence:**
• using appropriate information sources to select and prepare tools, equipment and welding parameters to safely use in a welding process.	PS3.1 Explore a problem and identify different ways of tackling it.