

# Unit 11: Land-based Engineering Operations – Perform Thermal Joining Processes

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|-------------------------------|----------------------|
| <b>Unit code:</b>             | <b>D/600/3436</b>    |
| <b>QCF Level 3:</b>           | <b>BTEC National</b> |
| <b>Credit value:</b>          | <b>10</b>            |
| <b>Guided learning hours:</b> | <b>60</b>            |

## ● Aim and purpose

The aim of this unit is to provide the learner with the knowledge, understanding and skills required to safely carry out thermal joining processes. This unit aims to introduce learners to skills and understanding of thermal joining processes and how these can be applied in practice. It is designed for learners in centre-based settings looking to progress into the sector or onto further/higher education.

## ● Unit introduction

The use of thermal joining processes is an integral part of the work of the land-based engineer. Knowledge of the materials used in these processes is essential in enabling work to be fit for purpose.

In this unit learners will develop an understanding of the structures and properties of ferrous and non-ferrous materials. They will also develop the ability to choose, prepare and perform suitable joining processes to an appropriate selection of materials found in land-based machinery systems.

On completion of this unit, learners will be able to carry out the cutting and joining of a range of metals using a range of processes including manual metal arc (MMA), metal inert gas (MIG) and tungsten Inert Gas (TIG). Learners will look at the appropriate equipment, materials and methods used for each process.

The properties and structures of materials used in thermal joining processes should be investigated and the learners will study ferrous, non-ferrous and alloy metals. Learners will understand the properties of metals, effects of heat, requirements of a good join, problems of contamination, and common problems with thermal joining processes.

Safe working practices and good housekeeping will be stressed at all times.

## ● Learning outcomes

**On completion of this unit a learner should:**

- 1 Be able to perform thermal joining
- 2 Understand high temperature thermal joining techniques.

# Unit content

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## 1 Be able to perform thermal joining

*Techniques:* oxy-acetylene, manual metal arc (MMA), metal inert gas (MIG), tungsten inert gas (TIG), metal argon gas (MAG), soldering and brazing

*Identification methods for ferrous and non-ferrous metals:* filing; sawing; spark test; nick break; 'scrape'; heat

*Equipment:* joining equipment, personal protective equipment (PPE), avoidance of fire, safety of others and dangers of intense light levels and spatter, electrical control

*Preparation:* cleaning, material removal (abrasives, filing, grinding), fire prevention, spatter control, light control, joint preparation (marking out, preparation, positioning of materials) clamping, tacking, bevelling, positioning

*Health and safety:* health and safety; risk assessment; safe working practices; PPE; environmental risk assessment; fumes; dusts; heat; light and heat radiation; sparks and spatter; relevant, current legislation and codes of practice

## 2 Understand high temperature thermal joining techniques

*Structure and properties of materials:* ferrous; non-ferrous and alloy metal; hardness; softness; strength (tensile, compressive, shear, torsional); brittleness; toughness; elasticity; yield point; plasticity; malleability; ductility; conductivity (electrical, thermal); expansion; chemical stability (corrosion, oxidation)

*Inspection techniques:* visual inspection, non destructive and destructive procedures covering undercutting, slag traps, penetration, cracking leak testing

*Joining:* of ferrous and non-ferrous material, recast iron, alloys, and dissimilar metals

*Safety preparation:* filters, contamination, distortion, material stress relief, fire and fume hazards, electrical/electronic components and/or systems, ancillary equipment

*Precautions:* fumes, explosions, heat/fire, sharp edges, airborne debris, personal injury

*Management:* costs, sources of material, relevant legislation Assessment and grading criteria

## 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: |
| <b>P1</b> prepare the workplace and equipment to carry out a thermal joining process to include safe shut down of equipment<br>[SM, IE]   | <b>M1</b> complete risk assessments for selected thermal joining processes                                      | <b>D1</b> justify the techniques used for joining a range of metals.  |
| <b>P2</b> set up equipment and carry out preparation of material for positional (vertical) welding techniques<br>[SM]                     |   |   |
| <b>P3</b> join and/or repair a range of materials producing joints<br>[SM]  |   |   |
| <b>P4</b> identify faults using appropriate inspection techniques<br>[SM]   |   |   |
| <b>P5</b> explain the different techniques used to carry out positional thermal joining procedures  | <b>M2</b> compare a range of joining techniques.  |   |
| <b>P6</b> explain how to prepare and set up MIG/MAG, TIG, MMA welding equipment for positional welding tasks                              |   |   |
| <b>P7</b> explain how to use thermal joining techniques to join and repair  |   |   |
| <b>P8</b> explain the safety preparations and precautions required to minimise risk prior to and during thermal joining/repair processes. |   |   |

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

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

# Essential guidance for tutors

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## Delivery

Delivery of this unit will involve practical assessments, written assessment, visits to suitable welding and fabrication businesses and will link to industrial experience placements.

Tutors delivering this unit have opportunities to use as wide a range of techniques as possible. Lectures, discussions, seminar presentations, site visits, supervised workshop practicals, research using the internet and/or library resources and the use of personal and/or industrial experience would all be suitable. Delivery should stimulate, motivate, educate and enthuse learners.

Work placements should be monitored regularly in order to ensure the quality of the learning experience. It would be beneficial if learners and supervisors were made aware of the requirements of this unit before any work-related activities, so that naturally occurring evidence can be collected at the time. For example, learners may have the opportunity to carry out repair processes and they should be encouraged to ask for observation records and/or witness statements to be provided as evidence of this. Guidance on the use of observation records and witness statements is provided on the Edexcel website.

Visiting expert speakers could add to the relevance of the subject. For example, land-based machinery technicians or workshop managers could talk about their work, the situations they face and the methods they use.

Whichever delivery methods are used, it is essential that tutors stress the importance of safe working practices in the joining processes. Health and safety issues relating to working in repair and fabrication workshops must be stressed and reinforced regularly, and risk assessments must be undertaken before practical activities and before learners visit any workshop. Adequate PPE must be provided and used following the production of suitable risk assessments.

Tutors should consider integrating the delivery, private study and assessment for this unit with other relevant units and assessment instruments learners are taking as part of their programme of study.

Learners are required to carry out a range of thermal joining techniques on a range of ferrous and non-ferrous metals. Metal recognition, preparation, appropriate technique selection, and safe working methods for both the operator and anyone near by are all essential elements of this. Legislative requirements, for example on fume extraction, should be covered here.

Learners will be aware of the materials, methods and the processes involved in thermal joining. The use of different positions for joining, such as overhead and vertical joining, should be covered. Learners will be required to understand the properties of materials and the effect that heat may have on these. Costs of the processes and materials involved need to be included. Learners need to compare and contrast the processes available and their suitability for a given task.

Throughout delivery the possible dangers should be emphasised including the risk of fire, electrocution, dangers of fumes, direct physical injury through burns and cuts, eye damage, and intense light dangers.

It is expected that practical activities should form the bulk of the delivery of the learning outcomes.

## 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 gives **an indication of the volume of learning it would take the average learner** to achieve the learning outcomes. It is **indicative and is one way of achieving the credit value**.

Learning time should address all learning (including assessment) relevant to the learning outcomes, regardless of where, when and how the learning has taken place.

| Topic and suggested assignments/activities and/assessment   |
|---|
| Introduction and review of unit; testing of previous knowledge.   |
| Theory session: metals and their properties.  |
| Workshop demonstration: welding techniques.   |
| Workshop group activity: health and safety, good working practice, safe systems of work.                        |
| Theory and demonstration session: joining faults, recognition and testing.                                      |
| <b>Assignment 1: Thermal Joining of a Range of Materials (P1, P2, P3, P5, P6, P7).</b>                          |
| Tutor introduces the assignment brief.  |
| <b>Assignment 2: Thermal Joining Faults (P4).</b>   |
| Tutor introduces the assignment brief.  |
| Theory session: arc and oxyacetylene welding, brazing, soldering.   |
| Practical workshop sessions.  |
| Theory session: metal inert gas (MIG) and tungsten inert gas (TIG) welding.                                     |
| <b>Assignment 3: Safety Precautions in Thermal Joining (P8, M1).</b>  |
| Tutor introduces the assignment brief.  |
| Workshop demonstration: welding techniques.   |
| Practical workshop sessions.  |
| Theory session: safety and legislation.   |
| <b>Assignment 4: Thermal Joining Techniques (M2, D1).</b>   |
| Tutor introduces the assignment brief.  |
| Theory session: recap on comparison of techniques, costs and equipment requirements, effects of heat on metals. |
| Assignment and self-study.  |

## Assessment

For P1, learners must prepare the workplace and equipment to carry out a thermal joining process to include safe shutdown of materials. This will include setting up the equipment, turning on and off, closing down and leaving safe. Evidence could take the form of the actual preparation of a worksite in a real working environment and assessed directly by the tutor during practical activities. If this format is used then suitable evidence from guided activities would be observation records completed by learners and the tutor, and accompanied by appropriate work logs or other relevant learner notes. Alternatively, operations could be marked against a checklist.

P2 requires learners to set up equipment for positional (vertical welding). Learners will also be required to suitably prepare the material to be joined. Evidence could take the same form as in P1.

In P3 learners are required to join a range of materials or carry out a repair that requires a joint to be produced. Tutors should identify the joining processes or agree them through discussion with learners. A range of joining techniques should be used to include oxyacetylene, manual metal arc (MMA) and metal inert gas (MIG). The joining processes may be the same as those used to provide evidence for other grading criteria. Where possible, to ensure fairness of assessment the size and complexity of the task should be the same for all learners. If assessed during a work placement, witness statements should be provided by a suitable representative and verified by the tutor. Alternatively, evidence could be in the same form as for P1.

P4 requires learners to identify faults using the appropriate techniques including direct visual inspection. The joints inspected could be those produced in P3. Where necessary, the tutor should provide examples of joints with suitable faults for learners to identify. To ensure fairness of assessment exemplar joints should be the same for all learners. Evidence could be generated through verbal questioning during practical activities.

For P5, learners are required to explain the different techniques used to carry out positional thermal joining procedures. This could be the same process as in P3 and evidence could be taken from the workplace. If this format is used then suitable evidence from guided activities would be observation records completed by learners and relevant learner notes. Alternatively, evidence could take the form of a written report or presentation to the group.

In P6 learners are required to explain how to prepare and set up welding equipment for positional welding techniques covering MIG/MAG, TIG and MMA equipment. This could be assessed directly by the tutor in the workplace and evidence provided by verbal questioning during practical activities. Alternatively, evidence could take the form of a written report or presentation to the group.

P7 requires the learner to explain how to use thermal joining techniques to join or repair. Evidence could take the form of a written report or presentation to the group.

For P8, learners must explain the safety preparations and precautions to be carried out to minimise risk prior to and during thermal joining/repair processes. This could be assessed directly by the tutor in the workplace and evidence for this could be the same as for P6.

For M1, learners must carry out risk assessments for selected thermal joining processes. Tutors should identify the joining processes or agree them through discussion with learners. The joining processes may be the same as those used to provide evidence for other grading criteria. Where possible, to ensure fairness of assessment the size and complexity of the task should be the same for all learners. Evidence should be in a format that is recognised within the industry and by the Health and Safety Executive.

M2 requires learners to compare a range of joining techniques. To ensure fairness, the range must be the same for all learners. Evidence could take the form of a written report or presentation to the group.

D1 requires learners to justify the techniques used for joining a range of metals. Tutors should identify the range and, to ensure fairness of assessment, the range should be the same for all learners and include both ferrous and non-ferrous metals of varying thickness. The techniques may be the same as those used to provide evidence for other grading criteria. Evidence could be taken from the workplace. If this format is used then suitable evidence from guided activities would be observation records completed by learners and relevant learner notes. Alternatively, evidence could take the form of a written report or presentation to the group.

### Programme of suggested assignments

The following table shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the 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, P2, P3, P5, P6, P7 | Thermal Joining of a Range of Materials | You are in a practical workshop situation and required to set up safely and correctly, prepare material, thermally join, and close down the equipment, explaining throughout what actions you are taking. | Practical observation and assessment. |

| Criteria covered | Assignment title                      | Scenario  | Assessment method                            |
|------------------|---------------------------------------|---|--|
| P4               | Thermal Joining Faults                | Identify joining faults and explain the cause using appropriate techniques.                       | Practical observation and assessment.        |
| P8, M1           | Safety Precautions in Thermal Joining | Identify and explain safety issues related to thermal joining processes and how to minimise them. | Practical assessment.<br>Written assessment. |
| M2, D1           | Thermal Joining Techniques            | Produce a report comparing and contrasting thermal joining techniques.                            | Written report.                              |

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

This unit forms part of the BTEC land-based sector suite. This unit links with many units in this specification and has particular links with:

| Level 2   | Level 3   |
|---|---|
| Land-based Engineering Operations – Perform Thermal Joining and cutting processes | LEO9 Core land-based engineering principles – Thermal joining processes |

## Essential resources

Learners will need supervised access to workshop facilities containing a sufficiently diverse range of materials and equipment to meet unit requirements. Health and safety considerations and effective learning require one welding station per learner.

Learners should also have access to sufficient library and internet facilities to enable research into techniques, materials, equipment and work examples.

This unit requires vocationally-specific craft knowledge and appropriately qualified tutors to deliver it.

Manufacturers' training videos, operator manuals and periodicals will make a significant contribution to learner achievement.

## Employer engagement and vocational contexts

It is essential that this unit is delivered in an applied and vocational context. Work-based experience will also be important. The unit will be enhanced by contact with employers. Centres are encouraged to develop links with local businesses, manufacturers, machinery dealers and workshops, who can support the breadth and application of this unit. Employers can provide real-work practical exercises and guest speakers and experts to support the learning experience. Employer engagement will ensure the use of technically up-to-date information and processes.

## Indicative reading for learners

### Textbooks

- Davies D – *The Science and Practice of Welding: Volume 2: The Practice of Welding, 10th Edition* (Cambridge University Press, 1993) ISBN 0521435668
- Davies D – *The Science and Practice of Welding: Volume 1: Welding Science and Technology, 10th Edition* (Cambridge University Press, 1993) ISBN 052143565X
- Farnsworth S – *Welding for Dummies* (John Wiley and Sons, 2010) ISBN 0470455969
- Finch R – *Welder's Handbook: A Guide to Plasma Cutting, Oxyacetylene, ARC, MIG and TIG Welding, Revised Edition* (HP Books, 2007) ISBN 1557885133
- Flood C R – *Fabrication Welding and Metal Joining Processes* (Butterworth-Heinemann, 1981) ISBN 0408004487
- Gibson S and Smith A – *Basic Welding* (Thomson Learning, 1993) ISBN 0333578538
- Gourd L – *Principles of Welding Technology, 3rd Edition* (Butterworth-Heinemann, 1995) ISBN 0340613998
- Griffin I, Roden E and Briggs C – *Basic Oxyacetylene Welding, 4th Edition* (Delmar, 1984) ISBN 0827321376
- Griffin I, Roden E and Briggs C – *Basic Arc Welding, 4th Edition* (Delmar, 1984) ISBN 0827321317
- Health and Safety Executive – *Health and Safety in Arc Welding* (HSE Books, 2000) ISBN 0717618137
- HSE – *Essential of Health and Safety at Work* (HSE Books, 2006) ISBN 0717661794
- Kenyon W – *Basic Welding and Fabrication, 2nd Edition* (Longman, 1987) ISBN 0582005361
- Pearce A – *Farm and Workshop Welding, 2nd revised Edition* (Old Pond Publishing Ltd, 2007) ISBN 1905523300
- Pritchard D – *Soldering, Brazing & Welding: A Manual of Techniques* (The Crowood Press, 2001) ISBN 1861263910

### Websites

- |  |   |
|--|---|
| <a href="http://www.baba.org.uk">www.baba.org.uk</a>             | British Artist Blacksmiths Association                |
| <a href="http://www.bagma.com">www.bagma.com</a>                 | British Agricultural and Garden Machinery Association |
| <a href="http://www.defra.gov.uk">www.defra.gov.uk</a>           | Department for Environment, Food and Rural Affairs    |
| <a href="http://www.gowelding.com">www.gowelding.com</a>         | Go Welding  |
| <a href="http://www.howstuffworks.com">www.howstuffworks.com</a> | HowStuffWorks   |
| <a href="http://www.hse.gov.uk">www.hse.gov.uk</a>               | Health and Safety Executive                           |
| <a href="http://www.iagre.org">www.iagre.org</a>                 | Institution of Agricultural Engineers                 |
| <a href="http://www.lantra.co.uk">www.lantra.co.uk</a>           | Lantra Sector Skills Council                          |
| <a href="http://www.roytech.co.uk">www.roytech.co.uk</a>         | Welding Processes                                     |
| <a href="http://www.twi.co.uk/p">www.twi.co.uk/p</a>             | The Welding Institute                                 |

## Delivery of personal, learning and thinking skills (PLTS)

The following table identifies the PLTS opportunities that have been included within the assessment criteria of this unit:

| Skill                        | When learners are ...  |
|------------------------------|--|
| <b>Independent enquirers</b> | identifying faults   |
| <b>Self-managers</b>         | joining and/or repairing a range of materials producing joints<br>preparing the workplace and equipment to carry out a thermal joining process<br>setting up equipment and carrying out preparation of material for positional welding techniques<br>identifying faults. |

Although PLTS opportunities 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 ...   |
|----------------------------|---|
| <b>Reflective learners</b> | explaining the different techniques used to carry out positional thermal joining procedures<br>explaining how to prepare and set up MIG/MAG, TIG and MMA welding equipment<br>explaining how to use thermal joining techniques to join or repair. |

## ● Functional Skills – Level 2

| Skill  | When learners are ...  |
|--|--|
| <b>ICT – Develop, present and communicate information</b>  |  |
| Enter, develop and format information independently to suit its meaning and purpose including: <ul style="list-style-type: none"> <li>• text and tables</li> <li>• images</li> <li>• numbers</li> <li>• records</li> </ul> |  |
| Bring together information to suit content and purpose   | producing a risk assessment<br>producing a report comparing a range of joining techniques  |
| Present information in ways that are fit for purpose and audience  | giving presentations to peers  |
| Evaluate the selection and use of ICT tools and facilities used to present information   |  |
| <b>English</b>   |  |
| Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts   | explaining the different techniques used to carry out positional thermal joining procedures<br>explaining how to prepare and set up MIG/MAG, TIG and MMA welding equipment<br>explaining how to use thermal joining techniques as to join or repair<br>explaining the safety preparations and precautions required to minimise risk prior to and during thermal joining/repair processes |
| Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions   | using manufacturers' handbooks to understand how a range of thermal joining techniques operate and can be used   |
| Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively  | producing a risk assessment<br>producing a report comparing a range of joining techniques.   |