Unit 328HV: Understand how to join pipework by welding

# Delivery guide

Unit information

This unit covers the knowledge, understanding and skills of how to prepare and safely carry out pipe welding procedures using Tungsten Inert Gas (TIG) and Manual Metal Arc (MMA) and Oxy-Acetylene (OA). Learners will understand the quality assurance processes of identifying and rectifying faults in completed pipe welds.

Due to the practical nature of this unit it is expected that learners will spend a suitable period of time within a supervised environment in the centre practicing the relevant skills involved. Both MMA, TIG and OA welding processes are included within this unit and it is expected that the centre will give learners some practical experience of all processes, although it may be desirable to focus on one skill in more depth depending on centre facilities and time constraints. This unit is not designed to generate a competency-based licence to practice but it may be an opportunity to allow learners to reach an industrial standard that could allow them the opportunity to attempt the BESCSA provisional welding test if so desired.

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

* Why is it essential to work safely when carrying out welding?
* What are the different methods and techniques used for welding and how do the industry standards and regulations apply?
* How does welding effect the properties of materials?
* What is the process used to quality control and test welded joints?

Learning outcomes

1. Understand the safe working practices when carrying out welding activities
2. Understand the appropriate industry standards and regulations relevant to welding and how to apply them
3. Understand the applications, advantages, limitations and factors associated with different welding techniques
4. Understand the applications, advantages and limitations of different types of welding equipment and how to assemble, adjust, operate and maintain them
5. Understand the applications, advantages and limitations of different types of welding consumables and fittings
6. Understand the methods and procedures for preparing pipework that is to be welded
7. Understand the techniques used to join pipework in fixed, rotated, and restricted positions by welding
8. Understand how the mechanical properties of materials change through being joined by welding
9. Understand the quality control process and different methods of testing completed welded joints
10. Understand how to interpret diagrams and drawings and welding symbols relevant to the system to locate the pipework that needs to be welded

Suggested resources

Textbooks

* BESA TR/5 Guide to Good Practice – Welding of Carbon Steel Pipework (2003). London: BESA. ISBN 090-3-783-509
* McConnell, C. N. (2003) *Audel Pipefitter’s and Welder’s Pocket Manual: 3 (Audel Technical Trades Series*). London: Audel.

ISBN 978-0-7645-4205-3

Websites

* [BESCA | Homepage](https://www.besca.org.uk/)
* [HSE | Welding](https://www.hse.gov.uk/welding/)
* [Jasic | Welding Safety Guide](https://www.jasic.co.uk/post/welding-safety-guide)
* [Lincoln Electric | Welding Pressure Pipelines and Piping Systems](https://www.lincolnelectric.com/assets/global/Products/Consumable_PipelinerConsumables-Pipeliner-PipelinerLH-D90/c2420.pdf)

British Standards

* BS 2971:1991*. Specification for Class II Arc Welding of Carbon Steel Pipework for Carrying Fluids*
* BS EN ISO 2553:2019. *Welding and Allied Processes. Symbolic Representation on Drawings. Welded Joints.*

| **Learning outcomes** | **Criteria** | **Delivery guidance** |
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| 1. Understand the safe working practices when carrying out welding activities | * 1. The safe working practices when welding | * Learners to be shown videos and presentations to examine the safe working practices expected when welding: * work area * fire watch * method statements * hot work permits * risk assessments * Personal Protective Equipment (PPE). * Learners to know the correct PPE specific to Oxy-Acetylene (OA), Manual Metal Arc (MMA) and Tungsten Inert Gas (TIG) welding processes and to be able to explain their function and use. * Learners to be able to examine the differing shades of filters, goggles and welding screens. * Learners to be familiar with the welding area and to produce risk assessments in small groups and discuss as a class. |
| * 1. The common hazards associated with welding | * Learners to be shown presentations, risk assessments and method statements within the session to examine the precautions that can be taken to protect against common hazards such as: * temperature * noise * fumes * toxic gases * radiant heat * electricity * chemicals * fire. * Learners to be able to demonstrate the safe use of grinding equipment. * Learners to examine handheld grinders and discuss the various discs used. |
| * 1. Precautions to prevent fires and explosions | * Learners to know about the safe use and storage of gas cylinders. * Learners to be shown the installation of regulators and flash back arrestors and how to check for leakage once secured for use in OA welding. * Learners to be able to examine welding areas and, in small groups, identify potential fire and explosion hazards. * Learners to be set exercises to offer methods of protection against these potential hazards and discuss as a group. * Learners to be able to explain the risk of oils on surfaces when welding and the use of screens etc. when grinding to reduce the risk of fire from sparks. * Learners to be able to examine a range of fire extinguishers and discuss their relative use when welding regarding the various materials and gasses involved. |
| * 1. PPE for different situations when welding | * Learners to know about relevant PPE within the classroom or workshop and its use and function including: * welding shields or helmets * OA welding goggles * flame retardant welding jacket * safety goggles * gloves and gauntlets * Cromer style hats * flame retardant overalls * safety boots * breathing equipment * ear protection. * Learners to be shown how to use reactive welding screens and to know about the filter shades suitable for various processes. * Learners to know about the importance of proper ear and eye protection when grinding and chipping. * Learners to be able to examine overalls and to discuss the information they should have to ensure they are suitable for welding activities. * Learners to be able to examine the types of gauntlets more suitable for OA and MMA welding and TIG. * Learners to be able to examine and demonstrate the use of portable breathing equipment and air filters. |
| * 1. The specific safety requirements relating to the various working environments where pipe welding activities can take place | * Learners to be shown the specific requirements for safety when carrying out welds in varying positions. * Learners to know the hazards of welding overhead and to be able to demonstrate suitable positions to avoid injury. * Learners to know about welds that may be in restricted positions and the practice of prefabrication to avoid this where possible. * Learners to be able to identify explosive atmospheres that may present a danger, such as dusty environments or below ground where gasses may be present. * Learners to be shown presentations and videos to examine how ventilation can be used to reduce risks. |
| * 1. The requirements for setting up the work area for safe welding of pipework | * Learners to be able to create a list of safety measures required for the welding area using previous risk assessments. * Learners to be able to ensure these measures are in place in their area before welding takes place via role-play scenarios including: * screens * warning signs * barriers * noise control * trip hazards * PPE * manual handling * hot work permit * storage of materials * ventilation. * Learners to be able to ensure that safety measures are in place and the areas are suitable before welding takes place. |
| * 1. How to store welding consumables and materials safely and identify defects | * Learners to examine a range of welding consumables such as welding electrodes and filler wires. * Learners to examine the packaging of these consumables and discuss the manufacturers’ instructions regarding storage and protection against damp/moisture. * Learners to tour the workshop/welding area and discuss the specific individual arrangements for storage and disposal of waste metals and consumables. * Learners to be able to examine a range of welding electrodes and filler wires and to use presentations etc. to explain their individual advantages and limitations. * Learners to be able to explain the terminology and codes attached to electrodes regarding their direction and specific use and discuss what would happen if they were to be used incorrectly. |
| 1. Understand the appropriate industry standards and regulations relevant to welding and how to apply them | * 1. The current regulations relating to welding pipework | * Learners to know the current regulations relevant to welding pipework including the following health and safety legislation: * Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR) 1995 * Electricity at Work (EAWR) Regulations 1989 * Provision and Use of Work Equipment (PUWER) Regulations 1998 * Control of Substances Hazardous to Health (COSHH) Regulations 2002. * Learners to be aware of the specific standards and guidance documents relevant to welding and should know where to access this information as they progress through the unit including: * BS 2971:1991. Specification for Class II Arc Welding of Carbon Steel Pipework for Carrying Fluids * BESA TR/5. Welding of carbon steel pipework. |
| * 1. The specific standards relevant to welding pipework | * Learners to know about the specific guidance and standards set out in BS 2971:1991 Specification for Class II Arc Welding of Carbon Steel Pipework for Carrying Fluids and BESA TR/5 Welding of carbon steel pipework or to be able to refer to these documents. * Learners to be comfortable with the information within these documents. * Learners to know the requirements of the BESCA competence assessment and how this is carried out to gain a provisional and 3-year competence ticket. |
| 1. Understand the applications, advantages, limitations and factors associated with different welding techniques | * 1. The different types of pipe welding process | * Learners to be shown presentations, videos, examples of welds and the inspection of welding equipment to explain the different types of welding processes. * Learners to know about Manual Metal Arc (MMA), Tungsten Inert Gas (TIG), Oxy-Acetylene (OA) Gas welding and to be able to identify the advantages and limitations of each including: * physical strength of welds * speed * the requirements specified by the client * physicality of the equipment required * safety * cost. |
| * 1. The different techniques and positions of pipe welding | * Learners to know the different techniques and positions of pipe welding including: * down hand * vertical up * horizontal vertical * overhead * set‐on branch * fillet * multi‐run welds * 1G * 2G * 5G * 6G. * Learners to be aware of: * 1G – (flat welding position) * 2G – (horizontal welding position) * 3G – (vertical welding position) * 4G – (welding position overhead or overhead) * 5G – (uphill/downhill vertical welding position) * 6G/6GR – (overhead vertical welding position). * Learners to be able to show examples of these finished products to examine the weld structure and discuss how fixed position welds are identified. |
| * 1. The advantages and limitations of different pipe welding techniques | * Learners to be able to explain how different welding techniques affect the end product of a pipe weld. * Learners to be able to demonstrate the downward and upward techniques and discuss how these are used. * Learners to know about welding angles and to be shown images and presentations along with practical demonstrations to show the correct angle of the electrodes for various weld positions and techniques. * Learners to know the correct penetration of welds and to be shown good and bad examples of this. * Learners to be set tasks to practice these techniques throughout the unit. |
| 1. Understand the applications, advantages and limitations of different types of welding equipment and how to assemble, adjust, operate and maintain them | * 1. The types of welding sets available for a range of welding processes | * Learners to be able to examine and discuss the different types of welding sets available including: * AC and DC/polarity * arc welding sets * gas welding * generators * rectifiers * transformers * inverter. * Learners to be shown presentations and videos to discuss their working principles, examine the principle of current flow and the difference between AC and DC polarity. * Learners to be able to demonstrate how to set up these machines and know they are operated between their settings. * Learners to be given demonstrations by manufacturers or distributors where possible and to know the advantages and uses of modern welding sets. |
| * 1. The methods used to ensure that welding plant is suitable for the welding process and task | * Learners to be able to distribute and to know specifications for pipework which is to be installed by welding. * Learners to be able to identify the most suitable welding sets, techniques and plant for these specifications. * Learners to be able to use manufacturers’ guidance to ensure that equipment is suitable to produce welds of a desired standard. |
| * 1. The use of different types of welding plant | * Learners to be familiar with the types of welding sets. * Learners to know about the use of generators for electric welding and the provision of suitable electrical supplies. * Learners to be able to demonstrate the use of welding plant and welding sets in the welding area. * Learners to be able to give examples of suitable settings including current and speed. * Learners to be able to explain what indicators to expect when current and speed settings are incorrect. * Learners to be able to demonstrate how to connect welding sets and how to replace electrodes and shrouds. * Learners to be able to show where return leads should be connected and suitable positions to allow consistent welds. |
| * 1. The advantages and limitations of different welding plants | * Learners to be shown presentations, manufacturers’ visits, videos and demonstrations to highlight the advantages and limitations of various welding sets and welding plant. * Learners to be set tasks to produce lists of advantages and limitations of a range of given welding plant relative to various welding scenarios given by the tutor. |
| 1. Understand the applications, advantages and limitations of different types of welding consumables and fittings | * 1. The types of pipework, fittings and materials suitable for pipe welding | * Learners to be able to inspect and compare the different grades of carbon steel pipework and discuss the implications of welding these different grades. * Learners to know about the use of stainless-steel welding rods for use on stainless steel pipe. * Learners to be able to distribute and discuss a range of flange types, including slip on and weld neck types, discuss the terms ‘DN’ and ‘PN’ and examine the bolt hole arrangements. * Learners to be able to distribute a range of weldable fittings and materials to examine including: * stainless steel * flanges * fitting and fixing accessories. |
| * 1. The types and applications of TIG welding and MMA welding consumables and fittings | * Learners to be able to demonstrate and discuss the use and types of welding consumables and fittings including: * welding torch * hoses (water or air) * gas flow meter * gas source * tungsten * nozzle * collet * gas lenses * collet body * back cap * electrode holders * cables * clamps * remote controllers * electrodes * flange square * chipping hammer * grinders * files * level and grinding/cutting discs. * Learners to know their uses and applications within the welding process. |
| 1. Understand the methods and procedures for preparing pipework that is to be welded | * 1. The key welding requirements of joint set up | * Learners to be shown presentations and videos as well as physical demonstrations to explain the requirements of joint set up including: * edge preparation (abrasive and mechanical) * tacking procedure * root face * electrode selection * flame cutting * gaps. * Learners to be able to examine the procedures used to prepare edges of pipe for welding. * Learners to be able to demonstrate how to align pipe and fittings faces correctly and the use of measures, clamps and levels to ensure faces are square. * Learners to know the term ‘root face’ and when it is required. * Learners to be able to demonstrate the procedure of tacking and to discuss how to ensure suitable gaps are maintained whilst these are carried out. * Learners to be aware of the requirements for gaps in accordance with BESCA and how these gaps impact current settings and penetration. * Learners to be able to demonstrate the use of cutting equipment and discuss the design of cutting heads. * Learners to be able to examine a range of electrodes and set tasks to select suitable electrodes for a range of weld and material types. |
| * 1. The techniques to cut, profile and bevel pipework | * Learners to be shown demonstrations of flame cutting of carbon steel pipework and allowed to practice these techniques. * Learners to know the equipment and techniques that can be used to cut bevels onto pipework including: * mechanical * abrasive * oxy‐acetylene * plasma cutting. * Learners to be shown videos of modern equipment and demonstrations of how to bevel pipework using grinding equipment before being given similar tasks. * Learners to be shown how to use plasma cutters and profile cutting equipment or to be shown videos of this equipment in use. * Learners to be set tasks to cut profiles and branches into LCS pipework. * Learners to undertake an exercise on how to develop a branch connection in the classroom prior to marking then cutting out. |
| 1. Understand the techniques used to join pipework in fixed, rotated and restricted positions by welding | * 1. The correct welding techniques for a range of weld types | * Learners to be set tasks to produce a range of welds to practice the welding techniques. * Learners to be shown one-to-one and group demonstrations to ensure they are comfortable with angles, set up, equipment use, speed, rotation, current, gaps and travel. * Learners be able to give feedback on welds and techniques of their peers and to inspect end products to generate discussions regarding how these techniques can be improved or refined. * Learners to be shown videos, presentations and examples to explain methods to produce suitable welds. |
| * 1. The use of manipulators and clamps | * Learners to be able to explain how clamps and manipulators are used to make the welding process easier and more efficient. * Learners to be shown examples of clamps and manipulators used for both set up, tacking, route, fill and reinforcement runs. * Learners to be shown how these manipulators are used to rotate pipework and fittings and to discuss body positions when welding relative to the position of the manipulator. |
| * 1. The process of producing route, filler and reinforcing runs in a number of weld types | * Learners to be shown videos, presentations and examples of finished welds to explain the methods used to produce route, filler and reinforcing welds including: * fillet * branch * horizontal vertical * vertical up. * Learners to be given set tasks to produce a range of welds to practice the welding techniques. * Learners to be comfortable with angles, set up, equipment use, speed, rotation, current, gaps and travel. * Learners to be able to feedback on welds and techniques of their peers and to inspect end products to generate discussions regarding how these techniques can be improved or refined. |
| 1. Understand how the mechanical properties of materials change through being joined by welding | * 1. The processes involved in controlling distortion and stresses in pipework during welding | * Learners to be shown practical demonstrations and videos to show the effect of distortion when heat is applied to pipework through welding. * Learners to know about the use of clamps and preheating and to identify suitable pipe sizes for use on branches. * Learners to know about current and electrode size and to be able to demonstrate the use of wedges when tacking pipework. |
| * 1. The terms relating to structural change in metals during welding | * Learners to be shown videos, presentations, examples of welds and demonstrations to explain the terms relating to structural change in metals through welding including: * full fusion * base metal * filler metal * porosity * heat-affected zone. |
| 1. Understand the quality control process and different methods of testing completed welded joints | * 1. The different methods of quality control and testing completed welded joints | * Learners to be able to demonstrate how quality control and testing is carried out on completed welds including: * visual inspection * soundness testing (hydraulic and pneumatic) * destructive testing * non‐destructive testing. * Learners to be able to examine the standards marking sheets used to determine the quality of a weld during the BESCA provisional welding assessment. * Learners to be set tasks to carry out visual inspections and of a weld they have produced. * Learners to be able to cut coupons from welds and to demonstrate how to carry out a reverse bend test. * Learners to be set tasks to carry out this test on their own pieces before marking their own work in line with the BESCA score sheet and then discuss the outcomes as a group. * Learners to be shown videos of non-destructive tests and where possible invite Non-Destructive Testing (NDT) specialists in to demonstrate the process or to give presentations. |
| * 1. The common weld faults | * Learners to know examples of welds that have common faults within them. * Learners to be shown images and presentations to explain the reasons for these faults. * Learners to inspect a range of welds they have produced and to identify any faults that may be present before discussing this as a group including: * slag inclusion * undercut * overlap * lack of fusion * cracks * lack of penetration * concave/convex profile * porosity. |
| * 1. The methods to repair common weld faults | * Learners to know the reasons why common weld faults occur and to offer examples of how these can be avoided by adjusting gaps, current, rotation and travel speed, position, angle etc. * Learners to be able to demonstrate how welds can be rectified using grinding equipment and adjusting the welding techniques to carry out repairs. |
| 1. Understand how to interpret diagrams and drawings and welding symbols relevant to the system to locate the pipework that needs to be welded | * 1. Interpreting engineering drawings and welding specifications to locate pipework that needs to be welded | * Learners to be familiar with welding drawings for examination. * Learners to be able to explain the common information found on these drawings and to identify how information can be determined from these to allow correct welding procedures to be carried out. |
| * 1. The common symbols used on assembly drawings | * Learners to be shown common welding symbols on drawings and through presentations within the classroom. * Learners to be set tasks to study drawings and specifications to identify information and determine correct weld requirements from drawing symbols. |