



NATIONAL WELDER TRAINING STANDARD

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Code of Practice 1: Training of Welding Operatives

Part 1: Manual and Semi-automatic Arc Welding Processes

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The
Welding
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The Welding Institute, Professional Division under the guidance of the
Association for Welding and Fabrication Training and Education

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Foreword

Historically, much of the welder training conducted in the UK has concentrated on the achievement of practical skills alone and, increasingly, welding personnel are now trained through ad hoc courses or on-the-job programmes, either for a specific application within a particular organisation, or to meet the needs of individuals seeking employment. Such training is a matter of agreement between client and training organisation. The coverage of key matters such as safe working, protecting others, quality, risk and consequences of weld failures and underpinning process knowledge is often not prescribed and the final assessment of skill and knowledge may be unsatisfactory.

An important feature of training and employment is compliance with the requirements of the *Provision and Use of Work Equipment Regulations, 1998 (WER)* which came into force in December of that year with the publication of Statutory Instrument SI 1998-2306. Amongst the obligations they place on employers, and consequentially on Training Providers, are those relating to training given in Section 9 of the Regulations which state:

1. *Every employer shall ensure that all persons that use work equipment have adequate training for purposes of health, and safety, including training in the methods which may be adopted when using the work equipment, any risk which such use may entail and precautions to be taken.*
2. *Every employer shall ensure that any one of his employees who supervises or manages the use of work equipment has received adequate training for purposes of health and safety, including training in the methods which may be adopted when using the work equipment, any risks which such use may entail and precautions to be taken.*

The training of welding personnel in many cases has not met the requirements of 'adequate' as stated in, and implied by, the Regulations. The coverage of key matters of safety and competence which is an absolute requirement of WER Section 9 is often not prescribed and the final competence achieved may not be adequate.

This is a potentially serious situation because of the safety-critical nature of many welded joints and the potential danger to workers from the use of and in proximity to welding and cutting processes.

1 General

1.1 Structure of the Standard

This Code of Practice is one of three which together will form a national standard for the training of welders, covering practical training for skills, essential job knowledge, welder approval and requirements for training organisations. The three codes are:

CP1 Training of Welding Operatives

CP2 Training of Craftsman Welders

CP3 Training of Master Welders

CP1 may also serve as a foundation course for those entering welding and wishing to progress to Craftsman Welder or Master Welder levels, either through National Welder Training Standard (NWTS) programmes or recognised Technical Certificate (Vocationally Related Qualification) courses, or apprenticeships.

The scope of Part 1 of this code is limited to Manual Metal-Arc (MMA), Metal Inert Gas (MIG), Metal Active Gas (MAG) and Tungsten Inert Gas (TIG) welding processes.

For the purpose of this Code, a Welding Operative is defined as a person having limited welding competence involving a single process, a restricted range of welding positions, one group of materials and a small number of applications.

All NWTS documents may be downloaded at www.CSWIP.com

1.2 Objectives of NWTS for Welding Operative Training

The objective of CP1 is to specify the minimum requirements for training a *welding operative* in the use of a single process to produce fit-for-purpose welds for specified applications, to prove competence in working correctly and safely, and to provide an adequate understanding of the process, its application, hazards and safe working practice, and the risks and consequences of weld failure.

The knowledge base prescribed in this Code supports the job knowledge statement included in ISO 9606 Qualification Testing of Welders. For welders already holding certification under this standard, the knowledge content of this code may be taken as a separate course and examination programme.

1.3 Implementation

Training is delivered by training organisations certified under the Certification Scheme for Welder Training Organisations (CSWTO) (see Section 6). Courses offered in accordance with CP1 may only be advertised or referenced as such when delivered by CSWTO certified providers.

Details of CSWTO may be found at www.cswip.com.

CSWTO certified providers may use the NWTS CP1 logo on letterheads and documentation.

Witnessing of qualification testing by an Independent Examiner is required (see Section 3.4).

1.4 Procedure

The outcome of the training programme shall be specified either by the employer for sponsored trainees or by the training provider for individuals without sponsorship. The specification shall include a weld quality requirement and all practical training shall be covered by written welding instructions or a welding procedure specification.

The training provider shall prepare written recommendations for the training and testing programme based on either the employer's requirements or the individual trainee's needs and capabilities.

It is recommended that practical skills are assessed using, as a minimum, the qualification testing regimes specified by BS 4872. There is a final assessment, alongside the final qualification testing, for knowledge and understanding.

The welding of qualification test pieces, their examination, measurement and testing, and the theoretical examination are witnessed by the Independent Examiner. The results are checked by the Examiner who authorises the Pass/Fail notification. The result is notified to the trainee and employer using the Results Notification Form but the NWTS Certificate is issued centrally, see Section 6.

Accreditation of prior achievement for those having a minimum of two years' satisfactory industrial experience, authenticated evidence of having already completed training equivalent to that specified in this Code and gained recognised approval qualifications, NWTS Certification may be gained by successfully completing the course theory and examination at a CSWTO certified provider. Furthermore, if the candidate holds a recognised vocationally related qualification, exemptions from the CP1 theoretical examination may be granted.

1.5 Certification

Successful candidates are awarded an NWTS Welding Operative Certificate, which identifies the scope of approval gained together with certification for the qualification tests passed.

Certificates are valid for a period of five years. Renewal requires either evidence of satisfactory production records or a retest.

Any specific approval qualifications gained, e.g. BS 4872, will be governed by the time limitations and prolongation rules of the particular standard.

1.6 Entry Appraisal of Potential Candidates

When the aptitude of a candidate for welding, having no previous experience, is not known, it is prudent to apply simple tests to determine whether or not participation in the training programme would be worthwhile. Such tests include understanding verbal and written instructions, attitude, eyesight, concentration, numeracy, literacy and an eye-hand co-ordination test.

Candidates for employment must be at least 16 years old.

1.7 Vocational education of 14-19 Year Old Pupils

This Code may be a useful basis for the instruction of 14-19 year old pupils in general education who are seconded part-time for vocational training to Colleges of Further Education. Colleges should register their interest with TWI Certification Ltd.

2 CP1 - The Welding Operative Training Programme

The Programme consists of two parts:

Part 1: For each process, this Part is common whatever the specific outcome of the Programme. It covers essential job knowledge and the attainment of basic welding skills. It supports the job knowledge requirements of ISO 9606. Much of this part is also common to all arc welding processes and extension of training to other processes does not require this material to be repeated.

It is suggested that the practical work in Part 1 be carried out using carbon steel whereas, in Part 2, the material relevant to the trainee's future work shall be used.

Part 2: This Part is designed by the training provider to meet the specific training needs of the employer or individual trainee. It provides essential product-related job knowledge, and practical training, to achieve the specific outcomes required.

The training hours shown against each component of the programme are recommended minimum times and, in practice, will depend on the capability of the trainees and, in Part 2, also on the nature of the product.

2.1 Part 1: Programme for Manual and Semi-Automatic Arc Welding

2.1.1 Using electricity for arc welding (classroom) (1.5hr)

Objective

- Know the principles of arc welding

Scope

- What is fusion welding
- Basic facts of electricity: voltage (V), current (A), Alternating and Direct Current, resistance, power, mains supply, transformers, rectifiers; inverters
- How electricity is used in arc welding: the electric arc as heat source, simple welding circuits

- How a fusion weld is formed; principal features, role of filler metal; shielding of the weld zone
- Principal welding terms

Outcomes

- Describe the basic principles of arc welding
- Explain how a weld is formed in arc welding

2.1.2 The process and equipment you will use (classroom and workshop) (3hr)

Objectives

- Know the principal features and operating characteristics of the welding process
- Know the equipment and how it is controlled
- Know the principal types of consumables used

Scope

- How the process works: basic principles; circuit and mechanical diagrams
 - MMA: The metal arc; consumable covered electrode; metal transfer
 - MIG/MAG: The metal arc; consumable electrode wire, metal transfer, wire feed; shielding gas (inert and active)
 - TIG: The simple arc; non-consumable electrode; filter wire; shielding gas
- Power source components and their function; output control. Welding and return cables; earthing, clamps.
 - MMA: The electrode holder
 - MIG/MAG: Wire feed mechanism; welding gun. Shielding gas supply
 - TIG: Welding torch; tungsten electrode; sharpening; arc starting. Shielding gas supply
- Consumables for arc welding:
 - MMA: The covered electrode; function of core wire and covering; types of electrodes; care and storage
 - MIG/MAG/TIG: The electrode or filler wire; types of wire; care and storage; function of inert and active shielding gases; types of gas
- Welding parameters: open circuit and arc voltage; welding current; electrode polarity in DC welding; electrode or wire size; VA relationship; duty cycle; typical operating parameters; heat input
- Practical explanation of the equipment and accessories and guided tour of components. Rules for care of equipment
- How welding parameters are controlled

Outcomes

- Explain how the welding process works and the principal items of equipment needed
- Describe the types and functions of the consumables
- Name the parameters involved
- Identify the components, accessories and controls of a typical welding set-up

2.1.3 What are the health and safety hazards and safe working practices in arc welding (classroom) (2.5hr)

Objective

- Know the principles of risk assessment
- Know the hazards of arc welding
- Know how to work safely in the welding/fabrication shop (and on site if applicable)

Scope

- Radiation from the electric arc; arc eye
- Electrical hazards
- Fumes and gases from the parent metal, surface coatings and from consumables; respiratory hazards; work in 'confined' spaces
- Hot metal and emitted particles; burns, eye injuries
- Fire and explosions
- Risks arising from chipping, wire brushing, cutting, gouging and grinding
- Risks from welding and cutting gases and from compressed gas cylinders
- Planing work and ways of working to reduce risk
- Personal protection for eyes, face, body, hands and respiratory protection. Correct selection, fitting and maintenance.
- Control of fumes and gases; general and local ventilation
- Safe working and control of atmosphere in confined spaces
- Safe working in the fabrication shop: general workshop conditions; dust, handling heavy and hot material; care in presence of moving vehicles and machinery; avoiding falls due to trailing cables and obstructions; protecting others from welding hazards; welding screens
- Emergency procedures
- Safe working with hand held power tools for example grinding, wire brushing and chipping
- Safe working with welding hand tools
- Safe use of compressed gas equipment
- Protecting the environment, safe disposal of waste materials
- Key legislation in relation to welding: The European '6 Pack' inclusive of Health and Safety at Work Act: Control of Substances Hazardous to Health Regulations; Personnel Protective Equipment at Work Regulations, Provision and Use of Work Equipment Regulations
- Procedure for assessing the risks involved in a given welding activity

Outcomes

- Identify dangers from use of electricity and welding arcs
- Explain the origins of fumes and gases; the risks to health
- Identify the risk of burns, fire, explosion and eye injuries
- Describe and demonstrate the essential personal protective equipment for arc welding
- Explain the need for and correct use of ventilation and local fume extraction
- Identify the special precautions needed in 'confined' spaces
- Identify major hazards present in fabrication shops
- Identify methods for safe disposal of waste materials from welding
- Demonstrate safe working with power tools used in welding
- Explain the risks from welding gases and from the use of compressed gas cylinders
- Identify the key legislation governing welding activities
- Explain how the risks of given situations are assessed

2.1.4 Preparing to weld (workshop)

(2hr)

Objective

- Know how to set up and take care of the equipment and identify potential safety hazards; understand the purpose of the welding procedure specification.

Scope

- Setting up the equipment ready for welding; shut down procedures
- Checking the equipment for safety; potential faults
- Interpreting simple fabrication drawings and weld symbols

- Instructions for welding: the welding procedure specification and the importance of following it
- Selection and care of personal protection equipment
- Check that ventilation and local fume extraction equipment is in place and working correctly.

Outcomes

- Demonstrate how to set up and check the equipment, including safety checks
- Demonstrate correct selection of personal protection equipment
- Describe how to take care of equipment
- Interpret a simple fabrication drawing to determine weld types and locations
- Explain the purpose and content of the welding procedure specification
- Demonstrate how to shut down the equipment

2.1.5 Striking and maintaining an arc (workshop)

(4hr)

Objective

- Learn how to strike, maintain and restrike an arc; technique for continuing and ending the weld bead – as appropriate to the process in use

Scope

- Use a simple WPS to set parameters and select consumables
- Deposit weld beads on plate in flat position; striking, maintaining and re-striking an arc; correct manipulation of electrode, welding torch or gun; technique for continuing and ending the weld bead
- Note effects of adjusting parameters; importance of heat input
- Deposit a multi-layer pad of weld metal on plate

Outcomes

- Produce satisfactory weld beads on plate that demonstrate fusion of the parent metal
- Produce a multi-layer pad of weld metal on plate having uniform appearance

2.1.6 Making a simple welded joint (classroom and workshop) (4hr)

Objectives

- Know the basic types of welds and joints and their features, the welding positions, and how you should check your work
- Achieve single run fillet welds in tee joints in plate in the flat (PA) position having a good level of weld quality

Scope

- Fillet and butt welds
- Welding positions; designations, range; limitations
- Basic types of welded joints in plate and tube
- Control of workpiece distortion
- Visual checking and measurement of weld size, excess weld metal, penetration, undercut, profile and finish
- Use of the WPS to set parameters and select the correct consumables
- Practice to produce welds of good appearance and satisfactory fusion
- Destructive tests to reveal internal weld quality, including demonstration of macrosection and fracture tests

Outcomes

- Describe the basic types of joint produced by the welding process and identify their principal features
- Name the welding positions
- Demonstrate how the external features of the weld are checked
- Explain the causes of distortion during welding
- Explain how defects may arise in welds
- Produce fillet welds having good appearance, absence of major defects, and adequate penetration and fusion
- Understand the limits imposed by the welding procedure specification

2.2 Part 2: Specific Training Programme

The trainee will now focus on the specific objective of making fit-for-purpose welded joints in:

- A specified material
- A given thickness range
- Given positions

For employer sponsored trainees, the employer should specify the weld quality required, the welder qualification tests, and the welding procedures. In the absence of these items the training provider must:

- Agree with the employer an appropriate level of weld quality to be achieved, appropriate to the function of the product
- Agree with the employer the type of qualification test needed to confirm that objectives have been achieved
- Prepare WPSs to be used in training and qualification

For individuals not employer sponsored, the training provider will prescribe a specific programme in consultation with the client and, when appropriate, the funding source. The programme will generally aim to provide skills appropriate either to a designated employer or to the needs of local industry.

2.2.1 Employer sponsored trainees

2.2.1.1 What you need to know about the product which you are to weld (classroom) (2hr)

Objective

- Understand the nature of the product, the effect of welding on the material to be welded, what has to be achieved and the consequences of failure from faulty welds.

Scope

- Nature of the product to be fabricated
- Specific material of construction; effects of welding, defects which may occur
- Pre- and post-weld heat treatment; control of interpass temperature (if appropriate)
- Locating components for welding; fit up; control of distortion
- Types of welded joints to be made
- Weld quality and dimensional tolerances to be achieved
- Checking weld quality
- Requirements for passing the qualification test
- Dangers of faulty welds and consequences of failure

2.2.1.2 Employer specific practical training (workshop)

The specific training will be designed by the training provider to meet the employer's objectives and the duration will depend on the level of skill required. It will comprise tutorials and practice leading to the achievement of welds of the specified quality.

Note: As this part of the course will be employer specific, the following is by way of example only.

Training Specification (example)

Product: Light structural steelwork fabricated from carbon-manganese steel plate, angle and channel sections

Types of weld: Fillet welds only

Thickness range: 6-12 mm

Material: Carbon steel

Welding process: MMA

Welding positions: PA, PB

Joint types: Tee joints: plate to plate
plate to section
Lap joints: plate to section
section to section

Welding procedure specification: as supplied by the employer

Weld quality: as specified for profile, size, undercut, finish, surface breaking defects

Welder qualification testing and acceptance requirements: BS 4872 for fillet welds

Practical training

The training will comprise largely the achievement of the required quality in:

Tee joints in plate, using a single thickness in the 6-12mm range

Positions: PA and PB

Parameters: from WPS

When the correct external visual quality is achieved, a weld will be sectioned to check internal quality and penetration. If satisfactory, approval testing to BS 4872 will be conducted.

2.2.2 Individual trainees

2.2.2.1 What you need to know about the welded joints you are about to make (classroom) (2hr)

- The 'product': fillet welded T joints and butt welded joints in carbon-manganese steel plate
- Effects of welding on parent metal and defects which may occur in the welds
- Locating components for welding; fit-up; control of distortion
- Weld quality to be achieved: Level C, BS EN ISO 5817
- The qualification testing regime: BS 4872
- Checking weld quality
- Dangers of faulty welds and consequences of failure

2.2.2.2 Practical training (workshop)

The following example is by way of guidance only

Training specification

- Trainees shall weld Tee, Lap and Butt joints in 8 and 15mm plate
- Type of weld; fillet and butt
- Material: carbon-manganese steel
- Welding position; PA, PB

- Welding procedure specification; supplied by Training Provider

When correct external visual quality is achieved, a weld in each type of joint and each thickness will be cut and macro-sectioned to check internal quality and penetration. If satisfactory, qualification testing to BS 4872 will be conducted.

3 Qualification Testing and Job Knowledge Examination

3.1 Weld Quality Specification

The specification provided by or agreed with the client establishes the minimum level of weld quality required. It will provide requirements as applicable for:

Visual appearance
 Profile
 Excess weld metal
 Weld size (fillet welds only)
 Penetration
 Undercut
 Internal weld quality
 Mechanical properties

The minimum level of weld quality to be achieved in the welder qualification test pieces under CP1 for steel is that identified by Level C of BS EN ISO 5817 Part 1: Arc welded joints in steel – guidance on quality levels for inspections. For other materials, the equivalent levels given in Parts 2-5 of this Standard should be used. However weld quality must be adequate for the service conditions of the product and, for all safety critical applications, an appropriate level must be specified by the client and the testing regime presented in BS 4872 followed.

3.2 Qualification Testing and Certification

Test pieces: the form shall be agreed with the client as being appropriate to the application and should preferably conform to BS 4872 or an equivalent standard. Test pieces shall be clearly identified and recorded.

Welding: test pieces shall be welded in relevant positions according to the specified welding procedure, witnessed and signed for by the Independent Examiner.

Testing: Test pieces shall be checked in the presence of the Independent Examiner by the following methods:

- For all test pieces
 - i) Visually, for surface appearance
 - ii) Measurement, as appropriate to the type of joint, for excess weld metal, penetration, undercut, throat and leg length. A dedicated weld size measuring gauge should be used
 - iii) Fracture testing (may be omitted if radiographic or ultrasonic testing is specified)
- As required by the specification
 - iv) Macro examination
 - v) Dye penetrant or magnetic particle testing for surface breaking or near surface defects
 - vi) By ultrasonic or radiographic testing for internal defects
 - vii) By removal of specimens for mechanical testing

The results shall be recorded and signed for by the Independent Examiner.

Certification: Trainees who are successful in the practical and knowledge tests will be awarded an NWTs Welding Operative Certificate, which identifies the scope and range of approval gained in terms of:

Qualification testing regime e.g. BS 4872

Material Group

Form of material

Process

Consumables

Type of joint

Thickness range

Pipe outside diameter (if applicable)

Position range

Weld quality assessment standard, e.g. BS EN ISO 5817 Level C

Note: It is recommended that qualification testing be carried out in accordance with a recognised standard wherever possible

3.3 Assessment of knowledge and understanding

The trainee shall be assessed for knowledge and understanding of the theoretical content of the course in the presence of the Independent Examiner. The assessment is by a multi-choice answer paper, which is divided into two parts:

Part A: Safety in welding: Pass mark 90%

Part B: Pass mark 70%

In this assessment the trainee must demonstrate that he/she:

- Understands how electricity is used for arc welding
- Understands how a weld is formed
- Knows how the welding process works and the parameters involved
- Knows the principal components of the welding equipment and their function
- Knows the hazards of arc welding and their effects, and understand how to work safely in the fabrication shop
- Knows the key Regulations governing welding activities
- Understands the meaning of confined spaces and the hazards involved
- Is wearing the correct personal protective equipment
- Can assess the risks of given situations
- Can set up the equipment correctly, check it for safety and maintain it in good condition
- Knows the different types of consumables and requirements for their use and storage
- Understands the principles of the Welding Procedure Specification
- Can explain the causes of distortion and methods for control
- Can identify and check the external features of the weld
- Knows the positions of welding
- Knows the type of product to be fabricated
- Understands the effects of welding on the material of construction of the product
- Knows the types of defects that may occur and their avoidance
- Knows the principal types of welded joints and their features
- Can apply the specific Welding Procedure Specification
- Understands the significance of weld quality
- Understands the role of welder qualification tests
- Knows how weld quality is checked
- Understands the dangers of faulty welds and the consequences of failure

3.4 Independent Examiner

The Examiner shall be independent of the client and training organisation and shall be appointed by the certifying authority, see Section 6.

4 Adequate Training

This Code of Practice has been submitted to the Health and Safety Executive as the benchmark for Welding Operative training which meets the minimum requirements for 'adequate training' given in the work equipment regulations (see Foreword).

5 Requirements for Training Organisations

Training organisations seeking approval to run CP1 courses must firstly gain certification under the Certification Scheme for Welder Training Organisations see www.cswip.com.

5.1 Training programmes

NWTS based programmes shall be specified in writing to employers and trainees.

5.2 Weld quality requirements

The weld quality to be achieved by each trainee shall be agreed with the employer or sponsor, or specified by the training provider, and recorded.

The qualification testing regime is similarly agreed/specified, and copied to the employer and trainee, and recorded.

5.3 Identification of test pieces and specimens

Each qualification test piece is identified by a unique reference which is stamped on each test piece and test specimen. The numbers are recorded on the trainee's record.

5.4 Welding procedure specification/instructions

All practical welding training and welding of qualification test pieces shall be covered by written WPS or instructions identified by a reference system.

5.4.1 Testing equipment and personnel

Any destructive or non-destructive testing required must be carried out at a UKAS accredited test house.

If evaluation of welded specimens is carried out in house, a schedule records the equipment available and the qualification of those who will operate it and interpret the results.

If testing is carried out externally, details of the arrangements, facilities and personnel must be recorded.

6. Scheme Management

The NWTS scheme documentation, criteria, etc, are the responsibility of AWFTE. Implementation of the scheme is the responsibility of TWI Certification Ltd, an independent body, accredited by UKAS for the certification of personnel and companies.

6.1 NWTS Documentation and Criteria

The AWFTE Management Committee shall:

- Review and approve all scheme documentation.
- Review proposed amendments to the Codes of Practice in the light of operating experience.

- Review proposals for new requirements as perceived necessary.
- Report to the Membership, Education and Registration Committee of The Welding Institute.

6.2 Implementation

The Certification Management Board of TWI Certification Ltd will be responsible for:

- Evaluation and approval of training providers via the CSWTO (see www.CSWTO.com)
- Appointment of Independent Examiners, to maintain a list of Independent Examiners and to arrange appropriate training to achieve uniformity in the conduct of their activities
- Issue of NWTS certificates
- Maintaining records of all the above.

7. Addresses

7.1 NWTS Documentation and Criteria

All correspondence should be addressed to:

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7.2 Implementation

Training Providers should contact:

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 Web: www.cswip.com