



National Unit Specification: general information

UNIT Welding Effects on the Structure of Materials (SCQF level 6)

CODE F5FF 12

SUMMARY

This Unit can be taken as part of a National Qualification Group Award (NQGA) in Engineering but can also be taken as a free-standing Unit by candidates who wish to enhance their skills in a fabrication and welding environment. It is also suitable for those who are studying the subject for the first time.

The Unit will enable candidates to understand the effects of carrying out joining operations on Carbon Steels joined by welding. They will also be able to understand the effects of the heating and cooling cycle, expansion and contraction of deposited weldmetal and changes in the materials structure and properties due to welding.

OUTCOMES

- 1 Explain the factors which influence the structures of weldments.
- 2 Explain the factors which influence weldability.
- 3 Explain the causes of distortion and residual stress.
- 4 Describe the effects of heat treatment on weldment structure.

RECOMMENDED ENTRY

While entry is at the discretion of the centre, it would be beneficial if candidates had some knowledge of the following, or equivalent:

- ◆ welding processes
- ◆ basic engineering materials

Administrative Information

Superclass: XE

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National Unit Specification: general information (cont)

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CREDIT VALUE

1 credit at Higher (6 SCQF credit points at SCQF level 6*).

**SCQF credit points are used to allocate credit to qualifications in the Scottish Credit and Qualifications Framework (SCQF). Each qualification in the Framework is allocated a number of SCQF credit points at an SCQF level. There are 12 SCQF levels, ranging from Access 1 to Doctorates.*

CORE SKILLS

There are opportunities to develop the Core Skills of *Communication* and *Numeracy* at SCQF level 6 in this Unit, although there is no automatic certification of Core Skills or Core Skills components.

National Unit Specification: statement of standards

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Acceptable performance in this Unit will be the satisfactory achievement of the standards set out in this part of the Unit Specification. All sections of the statement of standards are mandatory and cannot be altered without reference to SQA.

OUTCOME 1

Explain the factors which influence the structures of weldments.

Performance Criteria

- (a) The explanation of the influence of heat input and thermal cycle on carbon steel welded joints is correct.
- (b) The description of the effect of heating and cooling on grain structures is correct.
- (c) The description of the influence of single and multi run welding on grain structure is correct.

OUTCOME 2

Explain the factors which influence weldability.

Performance Criteria

- (a) The explanation of the effects of material composition of carbon steels is correct.
- (b) The explanation of the effects of heat input is correct.
- (c) The explanation of the effects of material thickness is correct.
- (d) The description of the effects of consumables is correct.

OUTCOME 3

Explain the causes of distortion and residual stress.

- (a) The explanation of how distortion is caused is correct.
- (b) The explanation of how distortion can be controlled is correct.
- (c) The description of the causes of residual stress is correct
- (d) The explanation of how residual stress can be controlled steels is correct.

OUTCOME 4

Describe the effects of heat treatment on weldment structure.

Performance Criteria

- (a) The description of how recrystallisation can be achieved is correct.
- (b) The explanation of how stress relief can be achieved is correct.
- (c) The description of heat treatment processes is correct.

National Unit Specification: statement of standards (cont)

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EVIDENCE REQUIREMENTS FOR THIS UNIT

Evidence is required to demonstrate that the candidates have achieved all of the Outcomes and Performance Criteria.

Evidence for this Unit will be in the form of closed-book, written and/or recorded oral evidence produced under controlled and supervised conditions lasting no more than two hours in total.

The evidence must be produced on one assessment occasion towards the conclusion of the Unit and the candidate will describe the:

- ◆ influences of welding on Carbon Steels resultant grain structures
- ◆ causes of distortion and residual stress and how structures can be controlled or recovered
- ◆ effects of re-crystallisation on a weldment

National Unit Specification: support notes

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This part of the Unit Specification is offered as guidance. The support notes are not mandatory.

While the exact time allocated to this Unit is at the discretion of the centre, the notional design length is 40 hours.

GUIDANCE ON THE CONTENT AND CONTEXT FOR THIS UNIT

The Unit is in the National Qualification Group Award (NQGA) in *Fabrication and Welding Engineering* but it may also be taken as a stand-alone Unit.

Current relevant International (ISO), European (BS EN) and British (BS) standards should be considered as the main teaching and learning materials although it may be helpful to include other standards or codes such as American (ASME).

The candidate should be introduced to:

- ◆ The requirement to consider the effects of the factors on the weldability of a steel — mainly will it crack during or after welding.
- ◆ The use of heat treatment to reduce the effects of the thermal cycle on the weldment.
- ◆ The factors to be used in assessing weldability — heat input, diffusible hydrogen, combined thickness and the carbon equivalent of the material composition; the use of this information in determining if a pre heat treatment is required — if so, the temperature and methods of how pre heat temperatures can be measured.
- ◆ The relationship between distortion and residual stress.
- ◆ Causes and types of distortion — angular, transverse and longitudinal.
- ◆ Prevention of distortion such as pre-setting jigs and fixtures, effects of volume of weldmetal.
- ◆ Joint design — joint configuration and weld preparation.
- ◆ Causes of residual stress — how residual stress can be controlled by allowing distortion, changing the stress state and heat treatment.
- ◆ How welding techniques such as planned wandering and backstepping can be used to control both distortion and residual stress.
- ◆ The influence of welding processes on causing or helping to control distortion and residual stress.
- ◆ The influence of the heating and cooling cycle on grain shape and size, the difference in the structures in single run and multi run welds and why they are different.
- ◆ The control of the grain size and the causes of grain growth.
- ◆ The effects of welding, residual stress and heat treatment on mechanical properties.
- ◆ Heat treatments used in fabrication and welding — normalising, annealing and stress relieving.
- ◆ The influence of carbon on the temperatures required to re-crystallise a carbon steel.
- ◆ Temperatures required to anneal and normalise a weldment, the time required for re-crystallisation to take place and the influence of heat treatment on the grain size and shape.
- ◆ Why stress relief may be required, the temperatures where stress relief is required, the time required to carry out the process.
- ◆ The changes to the weldment structure due to stress relief.

National Unit Specification: support notes

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Although not necessary for assessment it will be useful for the learner to understand the influence of alloying metals, solidification of a pure metal and how grains are formed and the influence of cooling rate and how the direction of solidification will control grain size and shape. The iron carbon phase diagram could also be included.

GUIDANCE ON LEARNING AND TEACHING APPROACHES FOR THIS UNIT

Black museums of completed welded joints showing examples of distortion would be helpful Macro examination of single and multi run welds to show the number of runs. Cut two samples from a weld, normalising one and carry out hardness survey to show the changes that takes place due to heat treatment on the other Grain structures can be viewed by microscope but probably it is easier to provide photographs from texts to show the different grain structures in welds and across a fabrication. The Welding Institute and Woodhouse Publishing are a source of text, video/CD/DVDs that can assist with a subject area that does give learners difficulty. The BBC series of videos *Engineering Craft Studies* have four or five videos on materials which can be used to reinforce learning. Welding suppliers such as Lincoln Electric and ESAB also supply welding videos/ CD/DVDs that in some cases will also show the effects of welding processes on grain structure.

This Unit should be delivered by a combination of teaching and learning approaches which could include:

- ◆ Lecturing
- ◆ Case studies
- ◆ Practical activities
- ◆ Group discussions
- ◆ Tutorials
- ◆ Directed study
- ◆ Investigation including the use of ICT
- ◆ Site visits
- ◆ Audio visual
- ◆ Guest speaker

OPPORTUNITIES FOR CORE SKILL DEVELOPMENT

Access to and evaluation of complex technical literature and current information, including health and safety requirements, should provide and support knowledge and understanding of the effects of welding operations on the structure of materials. Although skills in written *Communication* are not formally assessed candidates should present responses accurately and objectively, using correct terminology and appropriate tone and style. Formative work for the Unit could include group discussion of case studies. Such an approach could enhance oral skills and be particularly beneficial to candidates with limited industrial experience.

National Unit Specification: support notes (cont)

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The ability to calculate and work to data which is presented numerically and graphically will underpin competencies developed. Candidates focus on practical analysis of factors which influence structures and weldability to in order to calculate the effects of heating and cooling cycles and determine potential changes in materials structure and properties. Exercises to support development of skills are undertaken under guided supervision as part of formative work across the award, with an emphasis on *Numeracy* as a tool to be used and applied efficiently and critically in working contexts. The provision of appropriate reference materials in numeric and graphic format could support the process.

GUIDANCE ON APPROACHES TO ASSESSMENT FOR THIS UNIT

Opportunities for the use of e-assessment

E-assessment may be appropriate for some assessments in this Unit. By e-assessment we mean assessment which is supported by information and communications technology (ICT), such as e-testing or the use of e-portfolios or e-checklists. Centres which wish to use e-assessment must ensure that the national standard is applied to all candidate evidence and that conditions of assessment as specified in the Evidence Requirements are met, regardless of the mode of gathering evidence. Further advice is available in *SQA Guidelines on Online Assessment for Further Education (AA1641, March 2003)*, *SQA Guidelines on e-assessment for Schools (BD2625, June 2005)*.

Holistic assessment is recommended for this Unit, rather than assessment by individual Outcome or Performance Criteria. It would be of benefit to the learner in an end test/s that approach determining understanding of the subject in a problem as it would be presented for a required solution in an industrial application requiring a meaningful solution. Industrial standard pro formas and those dictated by standards and specifications should be used. The questions should be structured in a manner that should lead the learner through the assessment process. There should an opportunity for assessment on demand where appropriate.

It is recommended that there should be **four** structured questions with each having at least **four** questions directed to the stem of the question. Each candidate will have a choice of any **three** from **four** of the **structured** questions. Assessments should include questions across all Outcomes.

CANDIDATES WITH DISABILITIES AND/OR ADDITIONAL SUPPORT NEEDS

The additional support needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments, or considering alternative Outcomes for Units. Further advice can be found in the SQA document *Guidance on Assessment Arrangements for Candidates with Disabilities and/or Additional Support Needs* (www.sqa.org.uk).