

SQA Advanced Unit Specification

General information for centres

Unit title: Design Analysis: Fabrication and Welding

Unit code: HV3T 47

Unit purpose: This Unit is designed to enable candidates to develop knowledge and understanding and apply basic concepts to the preliminary analysis and design of structural elements relating to fabrication and welding. The unit provides the candidate with the opportunity to develop knowledge and understanding of beam and frame analysis and simple strut design, as well as the design of bolted and welded connections.

On completion of the Unit the candidate should be able to:

- 1 Apply beam theory to the solution of design problems.
- 2 Apply vectors to the analysis of two dimensional frameworks.
- 3 Apply strut theory to the solution of design problems.
- 4 Design bolted and welded connections subjected to uniaxial direct loads.

Credit points and level: 1 SQA Credit at SCQF level 7: (8 SCQF credit points at SCQF level 7*)

**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 National 1 to Doctorates.*

Recommended prior knowledge and skills: Candidates should possess prior general engineering and mathematical skills.

Core Skills: There may be opportunities to gather evidence towards the Core Skills of Communication, Numeracy and Problem Solving in this Unit, although there is no automatic certification of Core Skills or Core Skills components.

Context for delivery: If this Unit is delivered as part of a Group Award, it is recommended that it should be taught and assessed within the subject area of the Group Award to which it contributes.

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Assessment: Assessment will be by an end of unit test of two hours duration and should be undertaken in controlled, supervised conditions. The test should include questions relating to all four Outcomes.

Outcome 1 one question on the analysis of either a simply supported or a cantilever beam.

Outcome 2 one question on the analysis of a two dimensional frame.

Outcome 3 two questions on the analysis and design of two struts of differing end conditions.

Outcome 4 a) one question on the identification of properties of bolted and welded joints.
b) two questions on the design of one bolted and one welded connection, or one question on the design of a composite connection.

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SQA Advanced Unit specification: statement of standards

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The sections of the Unit stating the Outcomes, knowledge and/or skills, and evidence requirements are mandatory.

Where evidence for Outcomes is assessed on a sample basis, the whole of the content listed in the knowledge and/or skills section must be taught and available for assessment. Candidates should not know in advance the items on which they will be assessed and different items should be sampled on each assessment occasion.

Outcome 1

Apply beam theory to the solution of design problems

Knowledge and/or skills

- ◆ calculation of beam support reaction forces
- ◆ drawing and interpretation of shear force and bending moment diagrams
- ◆ calculation of maximum stress in the beam due to bending
- ◆ calculation of required beam section modulus

Evidence Requirements

Evidence for the knowledge and/or skills in this outcome will be provided on a sample basis. The evidence may be provided in response to specific questions. Each candidate will need to demonstrate that they can answer questions based on a sample of the items shown above. In any assessment of this outcome at least 60% of the knowledge and/or skills items should be sampled.

A different sample question should be asked each time the Outcome is assessed. Candidates must provide a satisfactory response to assessed questions.

For one simply supported or one cantilever beam, the candidate is required to determine the support reactions, draw the shear force and bending moment diagrams, calculate the maximum stress due to bending and calculate the required beam section modulus.

Outcome 2

Apply vectors to the analysis of two dimensional frameworks

Knowledge and/or skills

- ◆ calculation of magnitude and direction of reactions
- ◆ labelling of space diagrams in accordance with Bow's Notation
- ◆ drawing of vector diagrams
- ◆ determination of the magnitude and nature of forces on framework members
- ◆ selection of suitable section for structural member from tables

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Evidence Requirements

Evidence for the knowledge and/or skills in this outcome will be provided on a sample basis. The evidence may be provided in response to specific questions. Each candidate will need to demonstrate that they can answer questions based on a sample of the items shown above. In any assessment of this outcome at least 60% of the knowledge and/or skills items should be sampled.

A different sample question should be asked each time the outcome is assessed. Candidates must provide a satisfactory response to assessed questions.

For a two dimensional frame, the candidate is required to determine the magnitude and direction of the support reactions, label the space diagram in accordance with Bow's Notation, draw the vector diagrams, determine the magnitude and nature of the forces on the framework members and select a suitable section for one member of the frame using structural tables.

Outcome 3

Apply strut theory to the solution of design problems

Knowledge and/or skills

- ◆ the effect end fixing conditions have on strut length
- ◆ calculation of the maximum load that can be carried
- ◆ specification of a strut to conform to a simple design requirement using given variables

Evidence Requirements

Evidence for the knowledge and/or skills in this outcome will be provided on a sample basis. The evidence may be provided in response to specific questions. Each candidate will need to demonstrate that they can answer questions based on a sample of the items shown above. In any assessment of this outcome at least 60% of the knowledge and/or skills items should be sampled.

A different sample question should be asked each time the outcome is assessed. Candidates must provide a satisfactory response to assessed questions.

For two struts of differing end conditions the candidate is required to calculate the maximum load that can be carried and specify suitable strut sections using given variables.

Outcome 4

Design bolted and welded connections subjected to uniaxial direct loads

Knowledge and/or skills

- ◆ properties of a bolted joint which contribute to strength
- ◆ properties of a welded joint which contribute to strength
- ◆ calculation of joint strength for given connections in accordance with current British Standard specifications
- ◆ design of a connection to meet the requirements of a given specification

Evidence Requirements

Evidence for the knowledge and/or skills in this outcome will be provided on a sample basis. The evidence may be provided in response to specific questions. Each candidate will need to demonstrate that they can answer questions based on a sample of the items shown above. In any assessment of this outcome at least 60% of the knowledge and/or skill items should be sampled.

A different sample question should be asked each time the outcome is assessed. Candidates must provide a satisfactory response to assessed questions.

The candidate is required to identify the properties of bolted and welded joints which contribute to strength, calculate joint strength for two given connections (one bolted and one welded), **or** one composite connection, in accordance with current BS specifications, and design one connection (either bolted or welded) to meet the requirements of a given specification.

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Administrative Information

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| Unit code: | Design Analysis: Fabrication and Welding |
| Unit title: | HV3T 47 |
| Superclass category: | VF |
| Date of publication: | November 2017 |
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FURTHER INFORMATION: Call SQA's Customer Contact Centre on 44 (0) 141 500 5030 or 0345 279 1000. Alternatively, complete our [Centre Feedback Form](#).

SQA Advanced Unit specification: support notes

Unit title: Design Analysis: Fabrication and Welding

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 has been written to allow candidates to develop knowledge, understanding and skills in the following areas of fabrication and welding:

- 1 Application of beam theory to the solution of design problems.
- 2 Application of vectors to the analysis of two dimensional frameworks.
- 3 Application of strut theory to the solution of design problems.
- 4 Design of bolted and welded connections subjected to uniaxial direct loads.

Guidance on the delivery and assessment of this Unit

This unit should be delivered predominantly using practical calculations and graphical exercises that will allow candidates to learn and develop skills in the mathematical and structural analysis of fabrication and design problems.

Assessment will be by an end of unit test of two hours duration and must be undertaken in controlled, supervised conditions.

Outcome 1

The function of a beam should be defined. Both simply supported and cantilever beams should be covered.

Practical examples of beams should be discussed and illustrated.

The idealisation of loads as point loads and uniformly distributed loads (UDL) should be explained and illustrated.

The principle of moments and the conditions of equilibrium should be covered.

The reasons for the occurrence of shearing forces and bending moments within a beam should be discussed and explained.

The distribution of stresses at a beam cross-section should be explained by the production of a stress distribution diagram. Stress calculations should be undertaken by using the formula: $f = My/I$.

Section Modulus calculations should be undertaken by using the formula: $Z = f.M$

Beam cross-sections considered should be limited to standard shapes (I-section and square/rectangular hollow section).

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Reference to structural tables for sectional properties is recommended.

Guidance on assessment: Candidates will need evidence to demonstrate their knowledge and/or skills by showing that they can:

- ◆ analyse a beam accurately by calculating support reactions and drawing and interpreting shear force and bending moment diagrams
- ◆ calculate the maximum stress in the beam due to bending
- ◆ calculate the required beam section modulus

Outcome 2

The function of a frame should be defined, making reference to practical examples and their uses. The differences and relationship between Scalar and Vector quantities should be discussed.

The function of and reactions for roller and pinned supports should be covered. Simple frameworks requiring the use of the triangle of forces should be covered prior to the analysis of more complex structures requiring the use of the polygon of forces.

Guidance on assessment: Candidates will need evidence to demonstrate their skills and/or knowledge by showing that they can:

- ◆ analyse two-dimensional frameworks accurately
- ◆ select a suitable section size from structural tables

Outcome 3

The function of a strut should be defined. Practical examples of struts should be discussed and illustrated. The end fixing conditions covered should be pin/pin; pin/fixed; fixed/fixed; fixed/free. The importance of these end fixing conditions in contributing to the strut strength should be explained and illustrated. The difference between crushing and buckling failure should be discussed.

Guidance on assessment: Candidates will need evidence to demonstrate their knowledge and/or skills by showing that they can:

- ◆ analyse struts of differing end conditions
- ◆ specify a suitable strut section to conform to design requirements using given variables

Outcome 4

The properties that contribute to the joint strength for both bolted and welded connections should be explained. The examples given should be related to framework connections where possible to tie in with Outcome 2. In addition to the determination of joint strength, the candidates should be required to design a joint to safely support a given load.

Bolted Connections — simple pinned connections using Grade 4.6 bolts should be covered. Modes of failure and their remedies should be discussed e.g. shearing of the bolt, bearing failure of the plate or tensile failure of the plate. Calculations on checking the suitability of a bolted connection should be undertaken.

Welded Connections — strength of butt and fillet welds and what affects strength should be covered eg throat thickness, effective length, end returns, grade of steel, design strength of weld. Calculations on checking the suitability of fillet and butt welded connections should be undertaken.

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Composite Bolted/Welded Connections — eg flush end plate beam-to-column connection where fillet weld is used to connect end plate to beam and bolts are used to connect beam to column. Calculations to check suitability of a connection should be undertaken.

Guidance on assessment: Candidates will need evidence to demonstrate their knowledge and/or skills by showing that they can:

- ◆ identify the properties of bolted and welded connections which contribute to strength
- ◆ calculate joint strength in accordance with current BS specifications
- ◆ design a connection to meet specific requirements

Opportunities for developing Core Skills

There may be opportunities to gather evidence towards the Core Skills of Communication, Numeracy and Development in this Unit.

Open learning

The Unit could be delivered by open, flexible or distance learning. However, with regard to assessment the centres will need to arrange for this to be undertaken in controlled conditions.

Equality and inclusion

This unit specification has been designed to ensure that there are no unnecessary barriers to learning or assessment. The individual needs of learners should be taken into account when planning learning experiences, selecting assessment methods or considering alternative evidence.

Further advice can be found on our website www.sqa.org.uk/assessmentarrangements.

General information for candidates

Unit title: Design Analysis: Fabrication and Welding

The Unit has been designed to allow you to gain knowledge, understanding and skills in the following areas of fabrication and welding:

- 1 Application of beam theory to the solution of design problems
You will develop knowledge and/or skills in :
 - ◆ calculating beam support reaction forces
 - ◆ drawing and interpreting shear force and bending moment diagrams
 - ◆ calculating the maximum stress in the beam due to bending
 - ◆ calculating the required beam section modulus

- 2 Application of vectors to the analysis of two dimensional frameworks
You will develop knowledge and/or skills in :
 - ◆ calculating magnitude and direction of reactions
 - ◆ labelling space diagrams in accordance with Bow's Notation
 - ◆ drawing vector diagrams
 - ◆ determining the magnitude and nature of forces on framework members
 - ◆ selecting suitable section for member from structural tables

- 3 Application of strut theory to the solution of design problems
You will develop knowledge and/or skills in :
 - ◆ the effect end fixing conditions have on strut length
 - ◆ calculation of the maximum load that can be carried
 - ◆ specification of a strut to conform to a simple design requirement using given variables

- 4 Design of bolted and welded connections subjected to uniaxial direct loads
You will develop knowledge and/or skills in :
 - ◆ the properties of a bolted joint which contribute to strength
 - ◆ the properties of a welded joint which contribute to strength
 - ◆ calculating joint strength for given connections in accordance with current British Standard specifications
 - ◆ the design of a connection to meet the requirements of a given specification

Assessment will be by an end of unit test of 2 hours duration and must be undertaken in controlled, supervised conditions.