National Unit Specification: general information

UNIT Engineering Material Removal Principles (SCQF level 6)

CODE F5KH 12

SUMMARY

This Unit may form part of a National Qualification Group Award or may be offered on a free-standing basis.

This Unit is designed to provide candidates with knowledge and understanding of engineering material removal principles. During delivery of the Unit candidates will develop the knowledge and understanding to explain metal cutting processes and identify tool selection criteria. They will also learn about tool geometries, materials used in tool construction and the purpose and application of cooling fluids used in machining processes. Candidates will develop the knowledge and skills to determine speeds and feeds for selected cutting tools and materials. They will also learn to explain and compare non-traditional machine cutting technologies.

This Unit is suitable for candidates training to be manufacturing, mechanical or multi-disciplinary engineering fitters or technicians.

OUTCOMES

1 Explain metal cutting processes and state tool selection criteria.
2 Explain tool geometries, materials and cutting fluids used in machining operations.
3 Determine speeds and feeds for given cutting tools and materials.
4 Explain and compare non-traditional machining technologies.

Administrative Information

Superclass: XF

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National Unit Specification: general information (cont)

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RECOMMENDED ENTRY

Whilst entry is at the discretion of the centre candidates would normally be expected to have attained one of the following, or equivalent:

- the NQ Unit in *Engineering Material Removal Principles* (SCQF level 5)
- appropriate industrial experience in the area of engineering material removal principles

CREDIT VALUE

1 credit at SCQF level 6 (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 is no automatic certification of Core Skills in this Unit.

The Unit provides opportunities for candidates to develop aspects of the following Core Skills:

Communication (SCQF level 6)

Numeracy (SCQF level 5)

These opportunities are highlighted in the Support Notes of this Unit Specification.

National Unit Specification: statement of standards

UNIT Engineering Material Removal Principles (SCQF level 6)

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 metal cutting processes and state tool selection criteria.

Performance Criteria

(a) Explain correctly the basic principles involved in metal cutting using a single point tool.
(b) Explain correctly the types of chips produced in metal cutting processes.
(c) State correctly the factors and constraints involved in tool selection.
(d) State correctly the elements involved in the selection of an effective tool.

OUTCOME 2

Explain tool geometries, materials and cutting fluids used in machining operations.

Performance Criteria

(a) Identify correctly the main tool geometry involved in a single point lathe cutting tool.
(b) State correctly the advantages and disadvantages of positive and negative tool rake angles in lathe cutting tools.
(c) Describe correctly the operation of a multi-point cutting tool.
(d) State correctly the names and applications of materials used in cutting tools.
(e) Explain correctly the purpose of cutting fluids in machining processes.
(f) State correctly different types of cutting fluids used in machining processes and the way these fluids are applied in such processes.

OUTCOME 3

Determine speeds and feeds for given cutting tools and materials.

Performance Criteria

(a) Calculate correctly speeds for given machine cutting tools and materials.
(b) Calculate correctly feeds for given machine cutting tools and materials.
(c) Use information correctly from charts and nomograms to determine speeds and feeds.

National Unit Specification: statement of standards (cont)

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OUTCOME 4

Explain and compare non-traditional machining technologies.

Performance Criteria

(a) Explain correctly the way in which non-traditional machining technologies remove material.
(b) Compare the advantages and disadvantages of non-traditional machining technologies in terms of accuracy, applications, cost, materials, flexibility, cycle time and waste removal.

EVIDENCE REQUIREMENTS FOR THIS UNIT

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

Written and/or recorded oral evidence should be produced to demonstrate that a candidate has achieved all Outcomes and Performance Criteria.

Outcomes 1, 2 and 3 may be assessed on an individual basis, as a combination of Outcomes or as a single, holistic assessment. Outcome 4 must be assessed on its own. Total assessment time for Outcomes 1, 2 and 3 must not exceed 2 hours. Assessment(s) for Outcomes 1, 2 and 3 must be conducted under supervised, closed-book conditions in which candidates may use reference materials provided by the centre but are not allowed to bring their own notes, handouts, textbooks or other materials into the assessment. Candidates should be allowed to use a non-programmable scientific calculator during assessment.

Outcome 4 must be assessed under open-book conditions in which candidates are allowed to access their notes, handouts, textbooks or other relevant materials. Candidate evidence must be between 750 and 1,000 words in length plus diagrams.

With regard to Outcome 1:

- candidates must explain types of chips produced in metal cutting processes in terms of a suitable categorisation (eg Discontinuous, continuous and continuous with built up edge)
- candidates must identify four of the following tool selection factors:
  - material to be cut
  - type of cut to be made
  - part size and geometry
  - batch size
  - machinability data
  - quality required
  - past experience of tool designer and machinist
  - other relevant factors

- candidates must identify three of the following constraints on tool selection:
  - manufacturing practice
  - machine condition
  - finish part requirements
  - workholding devices
  - process time
  - other relevant factors

- Candidates must state three of the following elements involved in the selection of an effective tool:
  - high levels of hardness/resistance to abrasion and wear
  - strength to resist bulk deformation
  - effective thermal properties
  - consistent tool life
  - correct geometry
  - other relevant factors

With regard to Outcome 2

- candidates may either draw a single point lathe tool and label the parameters or may be given a drawing of a tool and asked to identify the parameters. Candidates must identify four of the following parameters:
  - top rake angle
  - side rake angle
  - front clearance angle
  - side clearance angle
  - wedge angle
  - nose radius

Acceptable alternative names to those shown above may be used.

- candidates must state two advantages and two disadvantages of both positive and negative rake angles
- candidates must use a twist drill, or milling cutter or a suitable alternative to explain the operation of one multi-point cutting tool
- candidates should name and state a use of four of the following materials used in tool construction:
  - High Carbon Steel
  - High Speed Steel (HSS)
  - Cobalt
  - Carbides
  - Ceramics
  - Carbon Boron Nitride (CBN)
  - Industrial Diamond
- candidates must explain three purposes of cutting fluids in machine cutting processes
- candidates must identify three different cutting fluids used in machining processes and state three ways in which cutting fluids are applied to machining operations

National Unit Specification: statement of standards (cont)

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With regard to Outcome 3:

- candidates must calculate two speeds for two different cutting tools (eg drill, milling cutter, lathe tool) used on two different materials (eg low carbon steel, brass, aluminium, non-metallic etc)
- candidates must calculate two feeds for two different cutting tools (eg drill, milling cutter, lathe tools) used on two different materials (eg low carbon steel, brass, aluminium, non-metallic etc)
- candidates must use charts and nomograms to determine two speeds and two feeds

With regards to Outcome 4

- candidates must select two non-traditional machining technologies from the following list:
  - electro-chemical machining (ECM)
  - electro-discharge machining (EDM)
  - laser cutting
  - abrasive flow machining (AFM)
  - water jet machining
  - ultrasonic machining (USM)

The Assessment Support Pack for this Unit provides sample assessment material. Centres wishing to develop their own assessments should refer to the Assessment Support Pack to ensure a comparable standard.

National Unit Specification: support notes

UNIT Engineering Material Removal Principles (SCQF level 6)

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

This Unit forms part of the National Qualification Group Award (NQGA) in Manufacturing Engineering at SCQF level 6, but may also be offered on a free-standing basis.

The aim of this Unit is to provide candidates with a knowledge and understanding of engineering material removal principles. On successful completion of the Unit candidates will have developed the knowledge and understanding to explain metal cutting processes and identify tool selection criteria. They will also be able to explain basic tool geometries, state materials used in cutting tool and explain the purpose and applications of cutting fluids used in machining processes. Candidates will be able to determine speeds and feeds for selected cutting tools and materials. They will also be able to explain and compare non-traditional machining technologies.

This Unit is particularly suitable for candidates who have successfully completed the *Engineering Material Removal Principles* SCQF level 5 Unit.

In Outcome 1 candidates should be introduced to the principles behind material cutting processes by examining what takes place when a single point tool cuts a material. They should also explore the various forms of chip generation that occur as a result of different tool geometries cutting different materials. Candidates should be provided with an overview of material cutting processes in terms of the factors and constraints that affect tool selection in general and the elements that lead to effective tool cutting in particular.

In Outcome 2 candidates should be introduced to tool geometry by examining a lathe cutting tool. In order to reinforce the importance of tool geometry candidates should be introduced to the effects of varying the rake angle in a lathe tool (both positively and negatively). Candidates should also be introduced to the ideas behind multi-point cutting by considering suitable examples of this cutting process such as a twist drill and milling tool. Candidates should also examine the different types of materials and their applications used in tools. Candidates may be introduced to the idea of inserts while considering the materials used in tools. Finally in this Outcome candidates should consider the purpose of cutting fluids in machining processes, the different types of fluids available commercially and the way these are applied during machining processes (eg flooding, mist, manual etc).

In Outcome 3 candidates should learn to calculate speeds and feeds for selected machine processes (eg lathe, drilling machine, milling machine processes) and materials and also use charts and nomograms to determine speeds and feeds.

In Outcome 4 candidates should be allowed to explore how non-traditional machining processes remove materials and the relative advantages and disadvantages of these processes in terms of accuracy, applications, cost, materials, flexibility, cycle time and waste removal.

National Unit Specification: support notes (cont)

UNIT Engineering Material Removal Principles (SCQF level 6)

GUIDANCE ON LEARNING AND TEACHING APPROACHES FOR THIS UNIT

It is recommended that the Unit is delivered in the same sequence the Outcomes are presented in the National Unit Specification: statement of standards section of the Unit. The Unit may be delivered by a combination of lectures, tutorials, investigations, practical demonstrations and industrial visits. This Unit may be delivered primarily in a classroom but should include visits to engineering workshops to examine different machining operations involving different tool geometries, different work materials etc. Such visits should also include practical demonstrations where the impact of using different tools (eg use of different rake angles, use of tools made from different materials etc.) in machining processes can be examined. Practical demonstrations may also investigate the effects of oils, emulsions and pastes on tool life and surface finish.

The internet contains a rich source of information on metal cutting processes, tool geometries, materials used in tool construction etc.

Industrial visits or manufacturers video/DVDs may be particularly helpful in allowing candidates to learn about some non-traditional machining processes.

Wall charts and tool displays illustrating different machine tools, different tools (highlighting various geometries) can be a very useful learning and teaching aid.

The Unit should be fully supported with relevant learning materials (eg handouts in paper and electronic form, textbooks, on-line materials etc.)

OPPORTUNITIES FOR CORE SKILL DEVELOPMENT

Candidates will evaluate, summarise and convey complex technical information on tool cutting principles and technologies as they undertake the Unit. They could be encouraged during formative work to research and discuss manufacturing processes and develop oral skills in an engineering environment. Guidance should be given to ensure that written and/or spoken evidence is formally expressed to acceptable industry standards.

Numeracy skills will be naturally enhanced as the Unit is undertaken. Candidates take into account graphic and written information on tools, materials and conditions to perform accurate calculations for working conditions. Formative activities should be contextualised with a focus on the practical interpretation, use and application of number and graphics in engineering.

National Unit Specification: support notes (cont)

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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 Communication 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).*

Formative assessment can play a particularly important role in helping candidates to develop their knowledge and understanding of aspects of engineering material removal principles, including material cutting processes, tool geometries, materials used in tools, determination of speeds and feeds and non-traditional machining processes.

Outcomes 1, 2 and 3 may be assessed by a single assessment paper taken at a single assessment event lasting no more than 2 hours. The assessment paper may comprise of a suitable balance of short answer, restricted response and structured questions or objective questions (eg multi-choice questions) or a combination of both. This assessment may be suitable for on-line delivery.

Outcome 4 may be assessed by candidates investigating two non-traditional machining methods and producing a written report of between 750 and 1,000 words plus diagrams. Candidates may write the report in their own time. Centres should make every reasonable effort to ensure that the report is the candidate's own work. Where copying or plagiarism is suspected candidates may be interviewed to check their knowledge and understanding of the subject matter. A checklist should be used to record oral evidence of the candidate's knowledge and understanding.

DISABLED CANDIDATES AND/OR THOSE WITH ADDITIONAL SUPPORT NEEDS

The additional support needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments, or considering whether any reasonable adjustments may be required. Further advice can be found on our website **www.sqa.org.uk/assessmentarrangements**