

Higher National Unit Specification

General information for centres

Unit title: Materials Selection

Unit code: DT46 34

Unit purpose: This Unit is designed to enable candidates to develop knowledge and understanding of material properties and testing and to apply basic material selection concepts for a range of components. The Unit also provides candidates with the opportunity to examine materials and components with the aim of establishing basic properties.

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

- 1 Identify basic properties for a range of materials.
- 2 Outline the structure of a range of materials.
- 3 Select suitable materials for a range of products.
- 4 Investigate material and component properties.

Credit points and level: 1 HN 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 Access 1 to Doctorates.*

Recommended prior knowledge and skills: It would be an advantage for candidates to have a basic knowledge and understanding of the properties of different material types, and of basic material testing techniques. This may be evidenced by possession of the following NQ Units: Basic Engineering Materials, Engineering Materials: Properties and Treatments or Materials: Effects of Force and Protection.

Core skills: There may be opportunities to gather evidence towards the following listed Core Skill components in this Unit, although there is no automatic certification of Core Skills or Core Skills components.

Written Communication	Higher
Critical Thinking	Higher
Reviewing and Evaluating	Higher
Working with Others	Higher

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.

General information for centres (cont)

Assessment: This Unit lends itself to holistic assessment. The assessment for Outcomes 1, 2 and 3 should be combined together into one written assessment paper. This paper should be taken by candidates at a single assessment event that should last 1 hour 30 minutes. Assessment should be conducted under closed booked controlled, supervised conditions.

Outcome 4 should be assessed by two assignments in which candidates are asked to observe material test laboratory experiments, record results and write a report on the results obtained for each assignment. These may be carried out at the centre or during an industrial visit. Reports should be written up in the candidate's own time.

Centres should make every reasonable effort to ensure the assignment solution 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.

Higher National 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

Identify basic properties for a range of materials

Knowledge and/or skills

- ◆ Metallic
 - Iron
 - Steel
 - Stainless steel
 - Aluminium
 - Copper
 - Brass
 - Titanium
- ◆ Polymeric
 - Polythene
 - Nylon
 - PVC
 - PTFE
- ◆ Ceramic
 - Glass
 - Aluminium oxide
- ◆ Natural
 - Rubber
 - Wood
 - Stone
- ◆ Composite
 - GRP
 - Reinforced concrete
 - Carbon fibre

Include the properties: Malleability; ductility; toughness; hardness; tensile, compressive and shear stress, resistivity, conductivity, fatigue, creep, toxicity, stability, wear resistance where relevant.

Higher National Unit specification: statement of standards (cont)

Unit title: Materials Selection

Evidence requirements

Evidence for the knowledge and or skills in this Outcome will be provided on a sample basis. The evidence may be presented in response to specific questions. Each candidate will need to demonstrate that she/he can answer questions correctly based on a sample of the items shown above. In any assessment of this Outcome **three out of five** knowledge and/or skills items should be sampled.

In order to ensure that the candidates will not be able to foresee what items they will be questioned on, a different sample of three from five knowledge and/or skills items is required each time the Outcome is assessed. Candidates must provide a satisfactory response to all three items.

Where sampling takes place, a candidate's response can be judged satisfactory where evidence provided is sufficient to meet the requirements for each item by showing that the candidate is able to:

- ◆ **Metals:** select four out of seven from the knowledge and skills item: identify three properties of each
- ◆ **Polymers:** select three out of four from the knowledge and skills item: identify two properties of each
- ◆ **Ceramics:** select one out of two from the knowledge and skills item: identify two properties of each
- ◆ **Natural Materials:** select two out of three from the knowledge and skills item: identify two properties of each
- ◆ **Composites:** select two out of three from the knowledge and skills item: identify two properties of each

The assessment of this Outcome must be combined with that for Outcome 2 and 3 to form a single assessment paper, details of which are given under Outcome 3.

Assessment guidelines

None.

Higher National Unit specification: statement of standards (cont)

Unit title: Materials Selection

Outcome 2

Outline the structure of a range of materials

Knowledge and/or skills

- ◆ Metallic
 - Heat Treatment
 - hardening
 - tempering
 - stress relieving
 - normalising
 - annealing
- ◆ Non-metallic
 - Polymer chains
 - Softening temperatures
 - Vulcanisation
 - Non homogenous structures of natural materials
 - Woven structures

Evidence requirements

Evidence for the knowledge and or skills in this Outcome will be provided on a sample basis. The evidence may be presented in response to specific questions. Each candidate will need to demonstrate that she/he can answer questions correctly based on a sample of the items shown above. In any assessment of this Outcome **both** knowledge and/or skills items should be sampled and must include 2 heat treatment processes and three from five non metallic structures.

In order to ensure that the candidates will not be able to foresee what items they will be questioned on, a different sample of knowledge and/or skills items is required each time the Outcome is assessed. Candidates must provide a satisfactory response to all items.

Where sampling takes place, a candidate's response can be judged satisfactory where evidence provided is sufficient to meet the requirements for each item by showing that the candidate is able to:

With the aid of a phase diagram and including details of dendritic growth describe the change in grain structure for:

- ◆ hardening
- ◆ tempering
- ◆ stress relieving
- ◆ normalising
- ◆ annealing

Higher National Unit specification: statement of standards (cont)

Unit title: Materials Selection

In addition:

- ◆ describe with the aid of sketches a polymer chain structure
- ◆ explain the process of vulcanisation
- ◆ describe the structure of one natural material
- ◆ explain the effect of temperature variation on a non metallic material
- ◆ describe with the aid of sketches the structure of a woven material

The assessment of this Outcome must be combined with that for Outcome 1 and 3 to form a single assessment paper, details of which are given under Outcome 3.

Assessment guidelines

None.

Higher National Unit specification: statement of standards (cont)

Unit title: Materials Selection

Outcome 3

Select suitable materials for a range of products

Knowledge and/or skills

- ◆ materials selection and justification for product requirements
- ◆ material selection using materials specification data
- ◆ effects of manufacturing processes on material properties

Evidence requirements

All knowledge and/or skills items should be assessed in this Outcome and in each item one metallic and one non-metallic product must be selected.

A candidate's response can be judged satisfactory where evidence provided is sufficient to meet the requirements for each item by showing that the candidate is able to:

- ◆ select a material for a given product specification
- ◆ justify the material selection for a product specification in terms of:
 - basic properties
 - cost
 - availability
 - environmental impact
 - ergonomics (eg size, weight, strength)
 - compatibility with current technology
- ◆ select the most suitable material for a given product from material specification data sheets
- ◆ identify changes to material and physical properties caused by manufacturing processes:
 - tensile strength
 - hardness
 - dimensional stability
 - thermal stability
 - resistance to fatigue

The assessment of this Outcome must be combined with that of Outcome 1 and 2 to form one assessment paper for the Unit. This single assessment paper should be taken at a single assessment event lasting 1 hour 30 minutes and carried out under controlled, supervised conditions.

Assessment guidelines

The assessment paper should be composed of an appropriate balance of short answer, restricted response and structured questions.

Higher National Unit specification: statement of standards (cont)

Unit title: Materials Selection

Outcome 4

Investigate material and component properties

Knowledge and/or skills

- ◆ tensile testing
- ◆ hardness testing
- ◆ impact testing
- ◆ torsion testing
- ◆ fatigue testing
- ◆ Non Destructive Testing (NDT) tests [dye penetrate, ultra-sonic, x-ray, Magnetic Particle Inspection (MPI)]
- ◆ environmental testing

Evidence requirements

Evidence for this Outcome will be provided by a candidate undertaking two laboratory assignments based on **two out of seven** knowledge and skills items.

For each laboratory assignment candidates must produce a report that must include:

- ◆ the test procedure
- ◆ a sketch of the test apparatus
- ◆ a table of results
- ◆ an evaluation of practical and theoretical data
- ◆ conclusion

Candidates should be supplied with the required report format. Candidates should complete written reports in their own time. It is important that candidates' progress is closely monitored to ensure work is their own. Where copying or plagiarism is suspected candidates may be interviewed to check their knowledge and understanding of the subject matter

Re-assessment will take the form of alternative material tests or the same tests using different materials/components.

Assessment guidelines

A checklist may be used to record oral evidence of the candidate's knowledge and understanding.

Administrative Information

Unit code:	DT46 34
Unit title:	Materials Selection
Superclass category:	YC
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Higher National Unit specification: support notes

Unit title: Materials Selection

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 purpose of this Unit is to provide candidates with an opportunity to acquire knowledge and understanding of the properties and structures of engineering materials, which will allow them to select appropriate materials for different components.

Outcome 1 — The aim of this Outcome is to identify basic properties for a range of engineering materials in the groupings of Metals, Polymers, Ceramics, Natural and Composites Materials. The properties of materials to be covered include malleability; ductility; toughness; hardness; tensile, compressive and shear stress, resistivity, conductivity, fatigue, creep, toxicity, stability, wear resistance where relevant.

Other properties that can be overviewed are surface finish possibilities, mass density, moisture permeability, tear resistance, impact strength, frictional properties, aesthetic, colour, optical clarity and effect of contact with other materials eg sacrificial corrosion.

Outcome 2 — The aim of this Outcome is to develop knowledge and understanding in the structure of a range of metallic and non-metallic engineering materials.

The structure of metals commences with a brief introduction to atomic structure and dendritic growth to allow an understanding of heat treatment processes of metals. The heat treatment processes are to be discussed in terms of critical temperatures, cooling rates, methods of cooling, effects on grain structure and grain size. The use of phase equilibrium diagrams are essential to give a depth of understanding of heat treatment processes including hardening, tempering, stress relieving, normalising and annealing.

The purpose of reviewing the structures of non-metallic materials is to outline the basic structures of the materials and discuss the benefits of changing the strength/structure of the materials through processing or heat treatment.

Non-metallic material processing should include the process of vulcanisation of rubber discussing cross-linking of polymer chains and improvement in tensile strength, the stress-strain curve relationship and other properties.

The structure of natural material should include wood, stone, diamond and other natural material used in engineering.

The structure of polymeric material is to be discussed in terms of polymer chains and the process of polymerisation producing cross-linking of chains. Thermosetting plastic and thermoplastic polymer structures are to be compared in terms of bonding and physical properties.

Higher National Unit specification: support notes (cont)

Unit title: Materials Selection

The structure of ceramic materials should include amorphous ceramics, crystalline ceramics, bonded ceramics and cements. Heat treatment of ceramics should include tempering of glass, melting points, drying/firing and nitridation discussing recrystallisation.

Outcome 3 — The aim of this Outcome is to provide candidates with a knowledge and understanding of the property requirements for a range of components.

The selection of suitable materials for a range of products should take into account materials specification data, the effects of manufacturing processes on material properties and the product requirements. The materials selection for the product is to be justified in terms of the criteria used above and also including the following factors; basic properties, cost, availability, environmental impact (eg corrosion, erosion, ultraviolet exposure, weathering) ergonomics (eg size, weight, strength), compatibility with current technology and ease of manufacture/fabrication.

Material selection should consider the changes to material and physical properties caused by manufacturing processes including, tensile strength, hardness, dimensional stability, thermal stability, resistance to fatigue and other properties relevant to component requirements and material properties.

Selection of the most suitable material for a given product should be discussed using material specification data sheets.

Outcome 4 — The investigation of material and component properties should cover the procedure and results of material tests on metallic and non-metallic materials. The range of material tests to be discussed include tensile testing, hardness testing, impact testing, torsion testing, fatigue testing, environmental testing and Non Destructive Testing (NDT) tests (eg dye penetrate, ultra-sonic, x-ray, MPI)

The candidate should observe/undertake at least two laboratory experiments depending on equipment available at the centre delivering the Unit. This may also be covered by means of an industrial visit.

For the laboratory assignment being assessed the candidates must produce a report which includes:

- ◆ the test procedure
- ◆ a sketch of the test apparatus
- ◆ a table of results
- ◆ an evaluation of practical and theoretical data
- ◆ conclusion

Candidates should be supplied with the required report format. Candidates should complete written reports in their own time. It is important that candidates' progress is closely monitored to ensure work is their own. Where copying or plagiarism is suspected candidates may be interviewed to check their knowledge and understanding of the subject matter

Re-assessment will take the form of alternative material tests or the same tests using different materials/components.

Higher National Unit specification: support notes (cont)

Unit title: Materials Selection

Guidance on the delivery and assessment of this Unit

This Unit should be delivered by a combination of lecturing and whole class and group discussions. In order to make the subject as interesting as possible centres are encouraged to use practical examples, manufacturers' data sheets and videos. Candidates should also be encouraged to explore the Internet for information on various materials. Centres should also use group discussions to allow candidates to select and justify materials for different applications.

Information on Evidence requirements and Assessment guidelines is given after Outcomes 3 and 4 in the Higher National Unit specification: statement of standards section. The written assessment should take place after Outcomes 1 to 3 have been completed and the Assignment would normally be undertaken following the written test.

Opportunities for developing Core Skills

There may be opportunities to gather evidence towards the following listed Core Skill components in this Unit, although there is no automatic certification of Core Skills or Core Skills components.

Written Communication	Higher
Critical Thinking	Higher
Reviewing and Evaluating	Higher
Working with Others	Higher

Open learning

The majority of the Unit could be delivered by distance learning, which may incorporate some degree of online support. However, with regards to assessment, planning would be required by the centre concerned to ensure the sufficiency and authenticity of candidate evidence. Arrangements would be required to be put in place to ensure that assessment, whether done at a single or multiple events, was conducted under controlled, supervised conditions.

To keep administrative arrangements to a minimum, it is recommended that for distance learning candidates the assessment paper is taken at a single assessment event.

Arrangements would also have to be made for candidates to have supervised access to material testing equipment.

Candidates with additional support needs

This Unit specification is intended to ensure that there are no artificial barriers to learning or assessment. 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. For information on these, please refer to the SQA document *Guidance on Assessment Arrangements for Candidates with Disabilities and/or Additional Support Needs*, which is available on the SQA website www.sqa.org.uk.

General information for candidates

Unit title: Materials Selection

This Unit has been designed to allow you to develop knowledge and understanding of the properties of a range of engineering materials and examine the structures of the materials and the structural changes that occur when heat treatment or processing are applied. The material groups that you will study include Metals, Polymers, Ceramics, Natural, and Composites Materials.

The Unit will also provide you with an opportunity to develop knowledge and skills in the principles of material and component testing which will be reinforced by two or more practical testing methods.

By the end of the Unit you will be expected to justify your selection of materials for particular components; selected from a set range of components and materials.

The formal assessments for this Unit consist of an assessment paper covering Outcomes 1, 2 and 3 lasting 1 hour 30 minutes and two laboratory assignments covering Outcome 4. Laboratory reports will be written up in your own time. The assessment paper for Outcomes 1, 2 and 3 will be conducted under closed book conditions in which you will not be allowed to take notes, textbooks etc. into the assessment. You will sit this assessment paper at the end of the Unit.