

SQA Advanced Unit specification: general information

Unit title: Manufacturing: Process and Equipment Selection

Unit code: HT84 48

Superclass: WA

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Unit purpose

This Unit is designed to enable candidates to develop their knowledge, understanding and skills of manufacturing planning by undertaking such activities as planning the sequence of manufacturing operations and determining times, analysing specialist machining operations and justifying the selection of new equipment or processes.

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

- 1 review and categorise manufacturing and process equipment
- 2 determine the sequence of manufacturing operations, set ups and estimate times
- 3 analyse specialist machining operations in terms of applications
- 4 explain and justify the selection of new equipment or processes to manufacture a product

Recommended prior knowledge and skills

Candidates should have some knowledge and understanding of engineering drawing, engineering materials, economics, engineering processes and work holding devices. This may be evidenced by the possession of the following SQA Advanced Units: *Engineering Drawing, CAD for Engineering, Materials Selection, Economics of Manufacture, Plastic Component Manufacture, Metal Component Manufacture, Jig and Fixture Design and Tool Design.*

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Credit points and level

2 SQA Credits at SCQF level 8: (16 SCQF credit points at SCQF level 8*)

**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.*

Core Skills

Opportunities to develop aspects of Core Skills are highlighted in the support notes of this Unit specification.

There is no automatic certification of Core Skills or Core Skill components in this Unit.

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.

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

Review and categorise manufacturing and process equipment.

Knowledge and/or skills

- ◆ forming
- ◆ shape changing by cutting
- ◆ shape changing by addition
- ◆ property changes
- ◆ holding, manipulation and parts feeding devices
- ◆ product inspection and testing processes

Evidence Requirements

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

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

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

- ◆ identify the manufacturing process, or processes, most suitable to manufacture each of the four different products
- ◆ explain the reasons for equipment selection for the manufacture of the four products
- ◆ describe the principle of operation of selected equipment
- ◆ state the skills requirements to operate the different equipment
- ◆ state alternative ways of manufacturing the chosen products (where possible)
- ◆ state methods used to inspect and test products

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Assessment should be conducted under controlled, supervised closed-book conditions in which candidates should not be allowed to take any hand-outs, notes, textbooks, etc, into the assessment. The assessment must last no longer than one hour.

Outcome 2

Determine the sequence of manufacturing operations, set ups and estimate times.

Knowledge and/or skills

- ◆ drawings and specifications
- ◆ tolerances
- ◆ capabilities
- ◆ measurement and work holding devices
- ◆ operation sequencing
- ◆ set up of processes and machines
- ◆ recording methods
- ◆ estimation of times and costs

Evidence Requirements

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

In order to ensure that candidates will not be able to foresee which items they will be questioned on a different sample of **six out of eight** knowledge and/or skills items is required each time the Outcome is assessed.

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

- ◆ interpret and understand drawings and specifications
- ◆ select a process capable of achieving the required tolerances/surface finishes
- ◆ uses a process capability calculation to check the above
- ◆ select the correct work holding device(s)
- ◆ prepare an operation sequence with at least five different operations
- ◆ explain the set up procedure for the processes and machines
- ◆ produce necessary records as required
- ◆ calculate the times and costs for productive and non-productive operations

Assessment should be conducted under controlled, supervised open-book conditions in which candidates should be allowed to take any hand-outs, notes, textbooks, etc, into the assessment. Assessment must last no longer than two hours.

Outcome 3

Analyse specialist machining operations in terms of applications.

Knowledge and/or skills

- ◆ electro-discharge machining
- ◆ electro-chemical machining
- ◆ ultrasonic machining
- ◆ laser machining
- ◆ high-pressure water-cutting
- ◆ rapid prototyping
- ◆ alternative new techniques

Evidence Requirements

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

In order to ensure that candidates will not be able to foresee which items they will be questioned on a different sample of **four out of seven** knowledge and/or skills items is required each time the Outcome is assessed.

When sampling takes place, a candidate's response can be judged to be satisfactory where evidence provided is sufficient to meet the requirements for each item by showing that the candidate is able to for four selected products, select the most appropriate specialist machine technology to manufacture each products in terms of:

- ◆ describing process operations
- ◆ specifying process capabilities
- ◆ determining the costs involved in purchasing equipment
- ◆ determining production costs
- ◆ identify skills required to operate equipment
- ◆ identifying the advantages and limitations of the specialist machining process

Evidence for this Outcome should be produced under open-book conditions. While candidates are not required to prepare the evidence under controlled, supervised conditions, Centres should make every reasonable effort to ensure that the evidence 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.

Outcome 4

Explain and justify the selection of new equipment or processes to manufacture a product.

Knowledge and skills

- ◆ function and requirements
- ◆ process rating/ranking
- ◆ supplier rating/ranking
- ◆ justification for selection

Evidence Requirements

All knowledge and/or skills items must be assessed in this Outcome.

A candidate's response can be judged to be satisfactory where evidence provided is sufficient to meet the requirements for each item by showing that, for a selected product type and demand, the candidate is able to:

- ◆ detail current requirements for manufacturing the product such as demand, function, quantity, quality, volume or mass or capability
- ◆ review existing equipment and processes identify any limitations in these
- ◆ rank suppliers of equipment based on a clear set of criteria
- ◆ justify the selection of new or different equipment or process

Evidence for this Outcome should be produced under open-book conditions. While candidates are not required to prepare the evidence under controlled, supervised conditions, centres should make every reasonable effort to ensure that the evidence 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.

SQA Advanced Unit specification: support notes

Unit title: Manufacturing: Process and Equipment 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 80 hours.

Guidance on the content and context for this Unit

This Unit is designed to enable candidates to describe processes or equipment and to use this knowledge plus knowledge of other attributes (such as speeds, feeds, axis type, swept volume, load/unload, programming and set up, compatibility, maintenance, services, floor area, physical installation, manning, training, demand, H&S, future trends and, most of all, cost) to select processes and equipment for given applications.

In **Outcome 1** candidates should consider a range of processes or equipment used in manufacturing. The list below aligns closely with the knowledge and/or skills in Outcome 1. Centres may also like to consider additional processes or equipment particularly where the Unit is delivered to employed candidates where their company has specific manufacturing processes.

Shape changing — (primary process) by forming:

- ◆ Casting, plastic moulding, forging, extrusion, rolling, production of powder or granules for plastics or sintering

Shape change by cutting (secondary processes):

- ◆ cylindrical turning, grinding, polishing
- ◆ rectilinear by sawing, milling, grinding, cutting
- ◆ flame-cutting, water and sand jet
- ◆ press tools
- ◆ surface finishing processes: chemical, blasting, polishing

Shape change by addition:

- ◆ assembly, adhesives, welding and fasteners
- ◆ welding (metals and non-metals), brazing and soldering

Property changes (heat treat and coatings):

- ◆ corrosion protection — painting, metal coatings
- ◆ heat treatment for hardening, wear protection, toughness
- ◆ aesthetics of the finished product

Holding, manipulation and parts feeding devices:

- ◆ jigs, fixtures, pick and place, robots, hoppers, magazines, etc

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Product testing/inspection processes:

- ◆ CMM, in process or post-process inspection, functional tests, measurements, material tests

Candidates should be introduced to processes that they are unfamiliar with and they should be encouraged to develop the skills to classify or assess their use or purpose, when compared to other processes. It may be helpful to score the attributes of manufacturing processes as Low, Medium or High, desirable or not, or rated A to F in order of usefulness.

In **Outcome 2** candidates should plan the sequence of manufacturing operations and determine estimate times. Candidates are expected to complete a job card (operation sequence) for a product or part or assembly.

Centres may wish to arrange for candidates to observe a centre technician or lecturer setting up a process (explaining what they are doing as they go along). The process may involve:

- ◆ the operator in double lifting
- ◆ looking for tools
- ◆ trial and error setting
- ◆ extra measurements
- ◆ low feeds and speeds
- ◆ over designed work holding devices with time consuming clamping using a spanner
- ◆ produce accurate records

Candidates should be provided with opportunities to estimate fixed and variable costs for the operation (as delivered in the *Economics of Manufacture Unit*) based on typical costs supplied by the centre.

In **Outcome 3** candidates should review some of the following characteristics of specialist machining operations:

Electro-discharge machining describe:

- ◆ process characteristics: spark generator, dielectric fluid — mineral oil, work piece material, electrode material, electrode shape, accuracy, removal rates, surface finish
- ◆ specific applications: injection mould tools, high speed turbines, micro-machining

Electro-chemical machining describe:

- ◆ processes: electrolysis, machining, grinding
- ◆ process characteristics: power supply, tool-to-work piece relationship, extraction system
- ◆ electrolyte, accuracy, removal rates, surface finish
- ◆ specific applications: batch production, 3D features, deburring, grinding

For Ultrasonic machining describe:

- ◆ process characteristics: oscillation generation, tooling, abrasive circulation
- ◆ specific applications: non-metallic materials machining, welding, semi-conductor slicing, deep hole drilling

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For laser machining describe:

- ◆ process characteristics: laser beam generation, pulsing, carbon dioxide laser
- ◆ specific applications: laser cutting, welding

For high-pressure water-cutting describe:

- ◆ processes: pure water and abrasive water-jet cutting
- ◆ process characteristics: orifice, pump, minimal heat, simple fixturing and no tool change
- ◆ specific applications prototypes, batch production, 2-d or 3-d, soft or hard materials

For rapid prototyping:

- ◆ processes: stereolithography, 3D printing, selective laser sintering, fused deposition modelling
- ◆ process benefits: reduced lead time on prototype, decreased product development time, increased product complexity

Where opportunities arise other new technologies should be investigated.

In **Outcome 4** the candidate should be offered a number of choices of equipment and suppliers that are likely to fulfil the manufacturing application. Ideally, equipment should be chosen from a process that the candidate is familiar with (such as that found in the Engineering Skills Units).

Based on supplied criteria of function, cost and quality the candidate should score alternatives and finally make a selection giving reasons for his/her choice. The scoring system could be similar to a Vendor Rating system. Terms such as demand, production rates, process capability, function and cost should be included in the rating.

Guidance on the delivery of this Unit

Unit content may be delivered by a combination of lectures, case studies, group discussions, investigations and practical observations of manufacturing processes. Candidates should use both paper-based and electronic (eg Internet, DVD, etc) sources of information whilst undertaking investigations of manufacturing processes and equipment. Structured industrial visits would enhance delivery in the classroom by allowing candidates to observe manufacturing processes at first hand whilst also permitting them to speak to engineers about the planning of the processes they have observed.

It is recommended that each Outcome is delivered and assessed in approximately 20 hours. There is an overlap in the content of the Outcomes, as is the case with this subject in industry, and lecturers should look for every opportunity to integrate knowledge and understanding across the four Outcomes.

Guidance on the assessment of this Unit

Formative assessment should be used throughout Unit delivery to develop candidate knowledge, understanding and skills in process and equipment selection and prepare candidates for summative assessment.

It is recommended that summative assessment is conducted on an Outcome-by-Outcome basis. Information on recommended summative assessments is given below.

Assessment guidelines

Outcome 1

The assessment for this Outcome may comprise of a written/oral test. The test paper should consist of a balance of short answer and restricted response questions. Test duration must not exceed one hour.

Outcome 2

Assessment of this Outcome may involve a test paper in which candidates respond to short answer and restricted response questions, undertake calculations and complete an operation sequence. The test should last no longer than two hours.

Outcome 3

The assessment for this Outcome may comprise of candidates being given details of four different products and investigating the most appropriate specialist technique to manufacture each product. Candidate evidence may be in the form of a written/oral report which satisfies the knowledge and/or skills items and Evidence Requirements.

Where written reporting is used as a means of assessing candidates, it is recommended that reports should be a minimum of 1,000 words (250 per product) and should contain sketches, diagrams or pictures. Candidates should be encouraged to use internet sources or company literature/manuals where possible and any other means of getting information on the materials from which their products are manufactured. Candidates should be permitted to use software packages to produce documentation for their report.

Outcome 4

Where written reporting is used as a means of assessing candidates, it is recommended that reports should be a minimum of 1,000 to 1,500 words plus appendices and references. Sketches and diagrams may also be included. Candidates should be encouraged to use internet sources or company literature/manuals where possible and any other means of getting information on the materials from which their products are manufactured. Candidates should be permitted to use software packages to produce documentation for their report.

Candidates should be encouraged to use internet sources or company literature/manuals where possible and any other means of getting information on the materials from which their products are manufactured. Candidates should be permitted to use software packages to produce documentation for their report.

An example of the type of assessment that would be suitable for Outcome 4 is as follows: a machine is being considered for replacement in a manufacturing area. Assess the existing machine according to the list of points below and from vendors supplied data add to this list. Candidates should be given appropriate information on the existing machine but much less information on the proposed machine. The lecturer may act in the role of vendor for the supply of further information.

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The table or checklist could involve the following details:

Volume size of component possible (l x b x h)	Ave set up time (mins)
Axis travel speed (mm/rev)	Programmable (Y/N)
Floor area (mm ²)	Capital cost (A–F)
Annual Maintenance requirement (£)	Training required (days or £)
Cycle times (mins)	Process capability (mm)
Mass of machine	Mass of part possible
Availability of spares or machine	Integration with existing equipment A–F
Does it add to our manufacturing capabilities (Y/N)	

Online and distance learning

This Unit could be delivered by distance learning, which may incorporate some degree of online support. With regard to assessment, planning would be required by the centre concerned to ensure the sufficiency and authenticity of candidate evidence.

Opportunities for developing Core Skills

Whilst there is no automatic certification of Core Skills or Core Skills components in this Unit candidates will have opportunities, in particular, to develop the Core Skills components and Core Skill identified below as part of the delivery and assessment of the Unit.

The Core Skill component *Written Communication* at SCQF level 6 may be developed whilst candidates prepare their written reports in Outcomes 3 and 4. Lecturers should encourage candidates to produce reports that are well laid out, technically correct and free from spelling and grammatical errors.

Candidates may develop the Core Skill component *Planning and Organisation* at SCQF level 6 when determining the sequence of manufacturing operations in Outcome 2 and when planning their investigations and reports in Outcomes 3 and 4.

The Core Skill components of *Critical Thinking* and *Review and Evaluation* at SCQF level 6 may be developed in Outcomes 3 and 4 whilst candidates are analysing the suitability of various specialist machine operations in manufacturing different products and when justifying the selection of new equipment or processes to manufacture a product.

Working with others, especially as part of a team, is very much a common feature of how employees work in modern manufacturing companies. During the delivery of this Unit candidates should be encouraged to work with others, particularly during group discussions and when analysing case studies. Such an approach will allow candidates to develop the Core Skill of *Working with Others* at SCQF level 6.

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.

History of changes

Version	Description of change	Date

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SQA acknowledges the valuable contribution that Scotland's colleges have made to the development of SQA Advanced qualifications.

FURTHER INFORMATION: Call SQA's Customer Contact Centre on 44 (0) 141 500 5030 or 0345 279 1000. Alternatively, complete our Centre Feedback Form.

General information for candidates

Unit title: Manufacturing: Process and Equipment Selection

This Unit will provide you with an opportunity to bring together much of what you have studied in manufacturing engineering. Such studies might have included topics such as welding, electrical, measurement, jigs and fixtures, materials, economics, quality and automation. In the first Outcome of the Unit you will review and categorise both manufacturing and process equipment. In Outcome 2 you will learn how to determine the sequence of manufacturing operations, set ups and estimate times to manufacture a product. In Outcome 3 you will be introduced to what are termed specialist machining operations which include such technologies as electro-discharge and electro-chemical machining, ultrasonic machining and laser machining, water jet cutting and rapid prototyping. In the final Outcome you will learn how to explain and justify the selection of new equipment or processes to manufacture a product.

The centre where you study this Unit will probably deliver this Unit by a combination of lectures, case studies, group discussions, investigations and practical observations of manufacturing process. The centre may also arrange one or more industrial visits for on-site demonstrations of manufacturing process including specialist machining operations.

Formal Assessment in this Unit is likely to comprise of a short written/oral test for Outcome 1, a longer written test for Outcome 2 in which you will have to respond to short answer and restricted response questions, undertake calculations and complete an operation sequence. Outcomes 3 and 4 are likely to involve you in undertaking investigations on specialist machine operations and justifying the selection of new equipment or processes to manufacture a product. You will have to produce separate reports for each Outcome.

If you are studying the SQA Advanced Diploma in Manufacturing Engineering, this Unit will provide very useful preparation for the 2-credit Graded Unit *Manufacturing Engineering Project*.

By the end of this Unit you will be able to identify manufacturing types, plan operational sequences, estimate some times and costs, critically examine how things are done, suggest cost reductions and state the case for equipment change or the introduction of new equipment.