

## SQA Advanced Unit specification

### General information for centres

**Unit title:** Plant Systems

**Unit code:** HT7V 48

**Unit purpose:** This Unit is designed to consolidate candidates' awareness of mechanical plant units, sub systems and systems used throughout industry. Candidates will be enabled to describe, explain and also correctly complete associated information gathering, including calculations. The Unit also considers commissioning techniques for plant replacement as applied to items of plant and sub systems, allowing the candidate to produce commissioning procedures and documentation. This Unit is particularly relevant for those candidates who wish to pursue a career as mechanical maintenance engineers, supervisors or technicians.

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

- 1 Explain the uses of common types of pumps and fans.
- 2 Explain the function of compressed air systems.
- 3 Explain the function of air conditioning systems.
- 4 Explain the function of steam generation and distribution systems.
- 5 Explain the function of refrigeration systems.
- 6 Produce an installation and commissioning plan for an industrial system unit.

**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.*

**Recommended prior knowledge and skills:** Candidates are expected to possess a basic knowledge and understanding of three of the mechanical plant systems included within the Unit. This may be evidenced by an appropriate group of NQ Units at Level 6 in the area of plant maintenance, or appropriate practical experience.

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

Written Communication	SCQF level 6
Using Number	SCQF level 6
Using Graphical Information	SCQF level 6
Critical Thinking	SCQF level 6
Planning and Organising	SCQF level 6

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**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.

**Assessment:** The assessment for Outcomes 1, 2, 3, 4 and 5 could be combined together into one written assessment paper. This paper should be taken by candidates at a single assessment event that should last no more than 3 hours. Assessment should be conducted under controlled, supervised and closed-book conditions.

If assessment for Outcomes 1 to 5 is combined, the assessment should be attempted towards the end of the delivery of the Unit.

The total assessment time for Outcomes 1 to 5 should not exceed three hours.

Outcome 6 should be assessed using a scenario led assignment relating to the replacement of one unit in a plant system. This assignment requires the candidate to draw up a commissioning plan matching the replacements specification with that of the original plant. The assignment should last no more than 1 hour. This assessment should be conducted under controlled, supervised conditions and should be attempted towards the end of the delivery of the Unit.

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### SQA Advanced Unit specification: statement of standards

**Unit title:** Plant Systems

**Unit code:** HT7V 48

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

Explain the uses of common types of pumps and fans.

##### Knowledge and/or skills

- ◆ Types of pump:
  - reciprocating
  - rotational
  - sizing of inlet and delivery ducts/pipes
  - working fluids
  - layout
  - impeller types and flow systems
- ◆ Characteristics of pumps:
  - reciprocating
  - rotational
  - connected in series
  - connected in parallel
- ◆ Methods of varying delivery rate of pumps:
  - speed
  - restriction (valves)
  - reciprocating (cylinder shut off)
- ◆ How fans differ from pumps

##### 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 **two out of four** 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 two out of four knowledge and /or skills items is required each time the Outcome is assessed. Candidates must provide a satisfactory response to both 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 the candidate is able to:

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- ◆ describe one type of pump
- ◆ describe two impeller designs
- ◆ explain common applications of two impeller designs (one or both could apply to a fan)
- ◆ state the characteristics of the same type of pump described in the first requirement
- ◆ perform calculations using pump characteristic curves
- ◆ state how the method of delivery can be varied again for the same type of pump

The assessment for this Outcome could be assessed on its own or could be included in an assessment paper covering Outcomes 1 to 5, details of which are provided in the Evidence Requirements of Outcome 5.

Assessment should be conducted under controlled, supervised and closed-book conditions.

If the assessment for Outcomes 1 to 5 is combined, the assessment should not exceed 3 hours.

### Assessment guidelines

None.

## Outcome 2

Explain the function of compressed air systems.

### Knowledge and/or skills

- ◆ Block diagram for the overall system:
  - inputs
  - process
  - outputs
  - distribution
- ◆ Block diagrams for each sub system:
  - compressor
  - actuators
  - air vessel
  - control system (mention briefly)
  - distribution
  - conditioning
- ◆ Operation and description of compressor characteristics:
  - pressure
  - flow rate
- ◆ Description and characteristics of:
  - filters
  - regulators
  - lubricators
  - control systems (mention briefly)
- ◆ System loading:
  - pipe work sizing (relate to system loading)

### 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

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that they can answer questions based on a sample of the items shown above. In any assessment of the Outcome **two out of five** 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 two out of five knowledge and/or skills items is required each time the Outcome is assessed. Candidates must provide a satisfactory response to both 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 the candidate is able to:

- ◆ annotate a block diagram for one compressed air distribution system
- ◆ draw and annotate two sub-system diagrams
- ◆ describe the layout of an air supply for a system using one type of compressor
- ◆ describe the layout and function of a service unit
- ◆ calculate maximum load and the normal working load for a compressed air distribution system
- ◆ determine the pipe size for a system using a nomogram diagram

The assessment for this Outcome could be assessed on its own or could be included in an assessment paper covering Outcomes 1 to 5, details of which are provided in the Evidence Requirements of Outcome 5.

Assessment should be conducted under controlled, supervised and closed-book conditions.

If the assessment for Outcomes 1 to 5 is combined, the assessment should not exceed 3 hours.

### Assessment guidelines

None.

## Outcome 3

Explain the function of air conditioning systems.

### Knowledge and/or skills

- ◆ Block diagram for the overall system:
  - inputs
  - process
  - outputs
  - distribution
- ◆ Block diagrams for each sub system:
  - chiller (refrigerator sub-system)
  - pre-heaters and heaters
  - actuators
  - fan
  - control system (mention briefly)
  - distribution
  - conditioning (humidifiers and dehumidifiers)
- ◆ Operation and description system type:
  - multiple outlet systems
  - single unit system

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- ◆ Description and characteristics of:
  - filters
  - pre-heater/heater
  - humidifiers/dehumidifiers
  - control systems (mention briefly)
  - heat exchanger

### 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 **two out of four** 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 two out of four knowledge and/or skills items is required each time the Outcome is assessed. Candidates must provide a satisfactory response to both 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 the candidate is able to:

- ◆ annotate a block diagram for one air conditioning system
- ◆ draw and annotate two sub-system diagrams
- ◆ describe the layout and operation of one type of air conditioning system (eg single or multiple system)
- ◆ describe the function of two items listed under bullet point 4

The assessment for this Outcome could be assessed on its own or could be included in an assessment paper covering Outcomes 1 to 5, details of which are provided in the Evidence Requirements of Outcome 5.

Assessment should be conducted under controlled, supervised and closed-book conditions.

If the assessment for Outcomes 1 to 5 is combined, the assessment should not exceed 3 hours.

### Assessment guidelines

None.

## Outcome 4

Explain the function of steam generation and distribution systems

### Knowledge and/or skills

- ◆ Block diagram for the overall system:
  - inputs
  - process
  - outputs
  - distribution
- ◆ Block diagrams for each sub system:
  - steam generation
  - feed pump

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- condenser
- prime movers (mention briefly)
- process steam plant
- space heating
- ◆ Operation and description of steam boiler
- ◆ Description of the function of:
  - water treatment
  - safety valves
  - water traps
  - boiler control systems (mention briefly)

### 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 she/he can answer questions based on a sample of the items shown above. In any assessment of the Outcome **two out of four** 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 two out of four knowledge and/or skills items is required each time the Outcome is assessed. Candidates must provide a satisfactory response to both 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 the candidate is able to:

- ◆ annotate a block diagram for one steam distribution system
- ◆ draw and annotate two sub-system diagrams
- ◆ with the aid of an incomplete diagram of a system generation and distribution system complete the diagram showing the fluid and air flows at all points in the system and label each unlabelled unit in the system
- ◆ describe the function of two items listed under bullet point 4

The assessment for this Outcome could be assessed on its own or could be included in an assessment paper covering Outcomes 1 to 5, details of which are provided in the Evidence Requirements of Outcome 5.

Assessment should be conducted under controlled, supervised and closed-book conditions.

If the assessment for Outcomes 1 to 5 is combined, the assessment should not exceed 3 hours.

### Assessment guidelines

None.

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### Outcome 5

Explain the function of refrigeration systems.

#### Knowledge and/or skills

- ◆ Block diagram for the overall system (vapour compression cycle only):
  - inputs
  - process
  - outputs
  - distribution
- ◆ Describe the function of each sub system:
  - compressor
  - thermostatic expansion valve
  - condenser
  - evaporator
  - control system / ancillary equipment (sight glass, temperature cut-out relay and high and low pressure cut-out relays, etc)
- ◆ Operation and description of system types:
  - primary – refrigerant operated systems
  - secondary – heat exchanger operated system
  - heat pump
- ◆ Calculations on single stage refrigeration systems:
  - cycle parameters (including use of charts and/or tables):
    - condenser load
    - evaporator load (refrigeration effect)
    - compressor input
  - Coefficient of Performance (COP)

#### 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, **bullet point 4 must always be assessed plus any two out of the first three** 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 the first two out of the three knowledge and/or skills items is required to be sampled each time the Outcome is assessed. Bullet point 4 must always be assessed. Candidates must provide a satisfactory response to all 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 the candidate is able to:

- ◆ annotate a block diagram for one refrigeration system showing the sub-systems and flows at all points in the system
- ◆ describe the function of each sub-system
- ◆ describe the layout and operation of one type of refrigeration system
- ◆ describe the operation and function of two of the items listed under bullet point 2
- ◆ calculate the COP for one refrigeration system



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The assessment for Outcomes 5 could be assessed on its own or could be combined together into a single assessment paper covering Outcomes 1 to 5.

Candidates should sit the assessment paper at one single assessment event. The assessment should be conducted under supervised, controlled conditions. Candidates should not be permitted to take textbooks, notes etc into the assessment event but may use scientific calculators.

If the assessment for Outcomes 1 to 5 is combined, the assessment should not exceed 3 hours.

### Assessment guidelines

The assessment should be composed of both short answer questions, mainly concerned with factual recall, followed by longer structured questions, mainly concerned with reasoned responses and calculations.

## Outcome 6

Produce an installation and commissioning plan for an industrial system unit

### Knowledge and/or skills

- ◆ Pre-arrival considerations:
  - date of arrival
  - decommissioning requirements of existing plant
  - space required
  - human resource requirements
  - tooling requirements
  - required services (air, gas, electrical, oil, etc)
  - safety considerations (including risk assessment and/or permits to work)
  - lifting and handling requirements
  - commissioning
- ◆ Documentation:
  - removal plan
  - checking procedure before assembly
  - planning sheet for assembly
  - commissioning check list

### Evidence Requirements

Both knowledge and/or skills items in this Outcome must be assessed. The candidate must be provided with a scenario led assignment relating to one replacement plant sub-system. The assignment must require the candidate to draw up an installation and commissioning plan matching the replacements specification with that of the original plant.

A candidate's response can be deemed to be satisfactory when evidence provided for each item shows an ability to:

- ◆ consider all pre-arrival considerations
- ◆ produce installation and commissioning plan

Candidate evidence should be in the form of a completed installation and commissioning plan plus associated documentation. Evidence should be produced under controlled, supervised conditions and

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should involve closed-book conditions where no textbooks, wall charts, handouts or notes should be permitted into the room where the assessment takes place.

### **Assessment guidelines**

While centres may give candidates advice on the format of their installation and commissioning plan the exact format will depend on the item of sub-plant to be installed and commissioned.

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### Administrative information

**Unit code:** HT7V 48  
**Unit title:** Plant Systems  
**Superclass category:** VG  
**Date of publication:** August 2017  
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### History of changes:

Version	Description of change	Date

**Source:** SQA

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### SQA Advanced Unit specification: support notes

#### Unit title: Plant Systems

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

The Unit has been designed to familiarise candidates with current mechanical plant systems. It has been written for those candidates who wish to work as mechanical maintenance engineers, supervisors or technicians. Outcomes 1 to 5 cover the description, operation and uses of:

- ◆ pumps and fans
- ◆ compressed air systems
- ◆ air conditioning systems
- ◆ steam generating and distribution systems
- ◆ refrigeration systems

Outcome 6 allows candidates to plan and comment on the installation and commissioning of a sub-system for one of the plant systems above.

Although safety is only specifically mentioned in Outcome 6, safety considerations should be covered when considering the operation and description of all types of mechanical plant systems.

#### Guidance on the delivery and assessment of this Unit

The Unit should be delivered with a minimal emphasis on the historical aspects of mechanical plant systems or maintenance techniques.

Video coverage of plant systems operating or being commissioned would be a useful aid to understanding overall concepts and how the system outputs and inputs can be varied to work efficiently together. Candidates must develop the ability to critically consider plant systems and components, questioning the selection of particular elements or sub-system design.

This Unit could be delivered in parallel with the SQA Advanced Unit: Applied Industrial Plant Maintenance or possibly in an integrated presentation.

Further details of the delivery of the Unit are provided on an Outcome-by-Outcome basis.

#### Outcome 1 (10 hours)

In many ways this can be treated as an introduction to the methods used for the delivery of the Unit:

- ◆ Types of pumps and their characteristics:
  - reciprocating: layout, working fluids, series and parallel connections
  - rotational: layout, working fluids, series and parallel connection
- ◆ Delivery: factors affecting delivery rates, eg speed, restricters, variable blade angles on impellers or guide vanes, cutting out cylinders

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- ◆ Pipe sizes: duct or pipe sizing using charts and calculations
- ◆ How pumps and fans differ
  - differences in: how they are used, their descriptions

### Outcome 2 (12 hours)

Use a systems approach to best follow the requirements of knowledge and skills, but use the block diagrams to explain causes of change in the variables and how the sub systems are affected by these changes.

- ◆ Block diagrams:
  - for both overall system and sub system diagrams describe each element stating its purpose and its interaction with the other elements
- ◆ Compressors:
  - describe several current types of compressor, where they are used, their characteristics
  - techniques to vary pressure and delivery rates
- ◆ Other system elements:
  - describe current equipment
  - explain function
  - where appropriate consider the characteristics of different types
  - only decide pipe work sizes where the techniques or sources of information are different from the work completed in Outcome 1
  - consider alternatives to a particular unit or sub-system

### Outcome 3 (12 hours)

Treat this Outcome very much in the same way as Outcome 2 and either fully explain the function of a refrigerator here or in Outcome 5 where COP calculations will require to be done.

### Outcome 4 (13 hours)

Although this Outcome may look more complex than the others it should be treated in the same way as Outcome 2 resisting the temptation to describe too many types of boiler or to match generator capacity to outputs using calculations.

### Outcome 5 (14 hours)

Again this Outcome can be treated in much the same way as Outcome 2 and may be delivered either before or after Outcome 2 if desired. Calculations using information extracted from charts and thermodynamic tables need not necessarily be restricted to C.O.P. and could involve, for example, the volumetric efficiency of the compressor.

### Outcome 6 (15 hours)

This Outcome should allow the candidate to apply the knowledge and understanding gained from the other Outcomes

- ◆ Pre-arrival considerations:
  - it should be emphasised these form an important part of the commissioning procedure
  - ideally three different types of sub system replacement, one each of a different plant system, should be considered as being replaced perhaps even in different circumstances such as, breakdown, planned replacement, increased capacity requirement

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- ◆ Documents:
  - several ‘real’ administrative systems could be looked at and their strengths and weaknesses compared
  - several scenarios could then be considered, perhaps related to the sub systems already considered and the paperwork prepared by three or more teams. A presentation by each team could then be given and the other teams could critically discuss their opinions with the presenters.

Assessment — 4 hours

Assessment for Outcomes 1 to 5 could be done on an Outcome-by-Outcome basis or combined together into a single assessment paper.

If the assessment for Outcomes 1 to 5 is combined, the assessment should not exceed 3 hours and should be attempted towards the end of the delivery of the Unit.

Outcome 6 should be assessed using a scenario led assignment relating to the replacement of one unit in a plant system. This assignment requires the candidate to draw up a commissioning plan matching the replacements specification with that of the original plant. The assignment should last no more than 1 hour. This assessment should be conducted under controlled, supervised conditions and should be attempted towards the end of the delivery of the Unit

### Opportunities for developing Core Skills

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

Written Communication	SCQF level 6
Using Number	SCQF level 6
Using Graphical Information	SCQF level 6
Critical thinking	SCQF level 6
Planning and organising	SCQF level 6

### Open learning

This Unit would be suitable to be used in an open learning format. As a pre-requirement, particular candidates may require extensive background information on the description, function and development of current components, sub-systems and plant systems mentioned in the Unit.

With regard 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 into place to ensure that the assessments paper for Outcomes 1–5 and the industrial scenario for Outcome 6 are sat at single events, conducted under controlled, supervised conditions. For further information and advice please refer to *Assessment and Quality Assurance for Open and Distance Learning* (SQA, February 2001 – Publication code A1030).

### 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](http://www.sqa.org.uk/assessmentarrangements).

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### General information for candidates

#### Unit title: Plant Systems

During this Unit you will widen your knowledge of plant systems including:

- ◆ pumps and fans
- ◆ compressed air
- ◆ air conditioning
- ◆ steam generation and distribution
- ◆ refrigeration
- ◆ plant commissioning

You will use a systems approach (that is input → process →output) to look at all these plant systems in order to describe the system and its parts, explain the function and behaviour of each sub-system, as well as how changes in one part of the system affect the other parts.

You will learn how to decide the capacity of each sub-system and the pipe/duct sizes used in cyclical systems.

Finally, you will consider the planning of the replacement of sub-systems of a plant, how it will be done, requirements such as manpower and tooling, testing to check the replacement is working satisfactorily and to produce the paperwork necessary to record this whole replacement and checking procedure.

Assessment will take the form of structured questions covering all the plant systems you have looked at. You will also complete an assessment based on a scenario describing a plant sub-system which requires to be replaced. You will be required to produce the necessary documents to allow this replacement to take place. The documents will also have provision to leave a record of what was done and by whom, and also what testing procedures were employed including the test results.