

SQA Advanced Unit Specification

General information for centres

Unit title: Heating, Ventilation and Air Conditioning Practice and Design

Unit code: HT7X 48

Unit purpose: This Unit is designed to allow candidates to develop knowledge and understanding of the principles of operation of refrigeration and HVAC (Heating, Ventilation and Air Conditioning) systems. Candidates will also develop the knowledge and understanding of the criteria used to select suitable system units and the skills to test the performance of systems.

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

- 1 Identify the current legislation and its use with regard to the environment, safety and maintenance of refrigeration and HVAC systems.
- 2 Design a refrigeration system and select appropriate system units.
- 3 Design a HVAC system and select appropriate system units.
- 4 Analyse the performance of a refrigeration system or a HVAC system.

Credit points and level: 1 SQA Credit at SCQF level 8: (8 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 should possess a good knowledge and understanding of thermodynamic principles. This may be evidenced by the possession of SQA Advanced Units: Thermofluids, Dynamics and Plant Systems and NQ Units: Thermofluids, Principles of Refrigeration and Refrigeration and Air Conditioning.

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	SCQF level 6
Use of Numbers	SCQF level 6
Critical Thinking	SCQF level 6
Reviewing and Evaluating	SCQF level 6
Working with Others	SCQF level 6

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 and 3 in this Unit should be combined together into one written paper. This paper should be taken by candidates at one single assessment event that should last no more than 2 hours. The assessment should be conducted under controlled, supervised conditions.

Outcome 4 should be assessed by means of an assignment in which candidates are asked to complete a laboratory experiment on a refrigeration or HVAC system and write a report on the results obtained. Candidates should be allowed no more than 2 hours for the laboratory experiment which should include writing up the report.

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

Identify the current legislation and its use with regard to the environment, safety and maintenance of refrigeration and HVAC systems.

Knowledge and/or skills

- ◆ current legislation
- ◆ environmental effect
- ◆ health and safety
- ◆ charging and recovery of refrigerants
- ◆ disposal of refrigerant
- ◆ leak detection of refrigerants

Evidence Requirements

Evidence for the knowledge and/or skills in this Outcome will be provided on a sample basis. The evidence may be provided in response to specific questions. Each candidate 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 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 the candidate is able to:

- ◆ state current legislation relevant to refrigeration and HVAC
- ◆ identify environmental dangers such as CFC and ozone layer
- ◆ state health and safety measures to be taken when working on refrigerators and HVAC systems
- ◆ outline the procedures for charging and recovery of refrigerants
- ◆ identify steps in the proper disposal of refrigerants
- ◆ describe methods of leak detection

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The assessment of this Outcome must be combined together with that of Outcomes 2 and 3 to form one assessment paper for the Unit, details of which are provided in the Evidence Requirement section of Outcome 3.

Assessment guidelines

None.

Outcome 2

Design a refrigeration system and select appropriate system units.

Knowledge and/or skills

- ◆ working pressure or temperatures
- ◆ compressor, condenser and evaporator sizing
- ◆ ancillary equipment
- ◆ insulators and conductors
- ◆ coefficient of performance
- ◆ heat pumps
- ◆ thermodynamic tables and charts for refrigerants
- ◆ thermodynamic, load and other associated calculations
- ◆ industrial system units from manufacture's data sheets or software programmes
- ◆ two-stage systems diagrams
- ◆ applications

Evidence Requirements

Evidence for the knowledge and/or skills in this Outcome will be provided on a sample basis. The evidence may be provided in response to specific questions. Each candidate 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 eleven** 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 eleven knowledge and/or skills items is required each time the Outcome is assessed. Candidates must provide a satisfactory response to all six 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:

- ◆ calculate or determine working pressures or temperature from refrigeration charts
- ◆ calculate compressor, condenser and evaporator size
- ◆ outline ancillary equipment required
- ◆ calculate thickness of insulators and conductors or select materials from known U-values
- ◆ calculate coefficient of performance
- ◆ draw diagram of a heat pump circuit layout
- ◆ use tables and charts to calculate refrigerant properties
- ◆ calculate load and other cycle parameters
- ◆ select an industrial system using calculations and manufacturers' data sheets or software programmes
- ◆ draw two-stage diagrams
- ◆ state one application of a refrigeration system or heat pump system

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The assessment of this Outcome must be combined together with that of Outcomes 1 and 3 to form one assessment paper for the Unit, details of which are provided in the Evidence Requirement section of Outcome 3.

Assessment guidelines

None.

Outcome 3

Design a HVAC system and select appropriate system units.

Knowledge and/or skills

- ◆ wet and dry bulb temperature
- ◆ relative humidity and dew point
- ◆ ducting design sizing and heat recovery
- ◆ summer or winter cycle
- ◆ control systems
- ◆ comfort zone
- ◆ humidifier/dehumidifier
- ◆ heater and preheater
- ◆ chiller
- ◆ thermodynamic, psychometric, load and other associated calculations
- ◆ industrial system units from manufacture's data sheets or software programmes
- ◆ application

Evidence Requirements

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

- ◆ determine or calculate wet and dry bulb temperatures
- ◆ determine or calculate relative humidity and dew point
- ◆ calculate ducting size
- ◆ select or identify summer or winter cycle
- ◆ describe, with the aid of a diagram, a control system
- ◆ state the comfort zone and state its relevance
- ◆ calculate system parameters for humidity and air changes
- ◆ calculate heating loads
- ◆ calculate cooling loads
- ◆ calculate load effects on the HVAC system

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- ◆ select an industrial system using calculations and manufacturers' data sheets or software programmes
- ◆ state a typical application of an HVAC system

The assessment of this Outcome must be combined together with that of Outcomes 1 and 2 to form one assessment paper for the Unit. This single assessment paper should be taken at a single assessment event lasting no more than 2 hours and carried out under supervised, controlled conditions. Assessment should be conducted under closed-book conditions and as such candidates should not be allowed to bring any textbooks, handouts or notes to the assessments. However, candidates must have access to Psychometric Charts. Candidates will be permitted to use scientific, but not programmable, calculators during the assessment.

Assessment guidelines

The assessment paper should be composed of an appropriate balance of short answer, restricted response and structured questions. The questions used to assess Outcomes 2 and 3 would normally be structured questions.

Outcome 4

Analyse the performance of a refrigeration system or a HVAC system.

Knowledge and/or skills

- ◆ coefficient of performance
- ◆ cooling load
- ◆ heat transfer
- ◆ working pressures
- ◆ motor efficiency and system losses
- ◆ working load
- ◆ control
- ◆ setpoint/desired value
- ◆ thermodynamic, load and other associated calculations
- ◆ record readings from practical experiment
- ◆ report writing, discussion and conclusion

Evidence Requirements

All knowledge and/or skills items should be assessed in this Outcome. Evidence must be generated by candidates carrying out a practical experiment on a refrigeration system or HVAC system subjected to increased and reduced working loads. Candidates must record results and undertake calculations to determine system performance. Candidates must also prepare a written report which clearly details the following:

- ◆ aims of experiment
- ◆ results
- ◆ any sources of error
- ◆ calculations
- ◆ conclusions

The time to be allocated for the experiment, including writing up the report, should be no more than 2 hours. The experiment and report writing should be conducted under supervised, controlled

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conditions in which candidates are expected to write up their own conclusions. The laboratory experiment should be undertaken at the end of the Unit.

Assessment guidelines

The equipment used in the experiment can be either ‘in-house’ to the centre or a suitable industrial unit where access is available.

It is recommended that centres develop checklists to support the assessment requirement for this Outcome.

Administrative information

Unit code:	HT7X 48
Unit title:	Heating, Ventilation and Air Conditioning Practice and Design
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FURTHER INFORMATION: Call SQA's Customer Contact Centre on 44 (0) 141 500 5030 or 0345 279 1000. Alternatively, complete our Centre Feedback Form.

SQA Advanced Unit specification: support notes

Unit title: Heating, Ventilation and Air Conditioning Practice and Design

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 gain knowledge and understanding about refrigeration and heating ventilation and air conditioning (HVAC) systems. Unit content and context should be based on systems in the centre and visits to industrial systems where appropriate.

Outcome 1 — should cover current legislation taking into account health and safety, the environment including CFCs and the ozone layer. Human comfort, Legionnaires disease, oil contamination and disposal of refrigerant should also be covered in this Outcome.

Procedures for maintenance of systems should be identified including charging and recovery of refrigerants. Leak detection from refrigeration and HVAC systems should be outlined and the effects of refrigerant leaks summarised.

Outcome 2 — the aim of this Outcome is to perform design calculations on a refrigeration system and select appropriate system units.

System parameters should be given for an industrial refrigeration system which should be analysed by the candidate to justify selection of system units from manufacturer's data sheets or manufacturer's software programmes.

Unit selection should include: compressor, condenser and evaporator sizing and also ancillary equipment. The choice of refrigerant, materials for insulation and conduction of heat should be evaluated.

Calculations should cover the maximum and minimum working pressures and operating temperatures, coefficient of performance, condenser and evaporator loads and other associated calculations. Thermodynamic tables and charts should be used to resolve problems.

A range of industrial applications should be outlined, including heat pumps and two-stage systems,

Outcome 3 — the aim of this Outcome is to perform design calculations for a HVAC system and select appropriate system units.

System parameters should be given for an industrial HVAC system which are analysed by the candidate to justify the selection of system units from manufacturer's data sheets or manufacturer's software programmes.

Ducting design sizing and heat recovery unit selection should include: humidifier/dehumidifier, heater and preheater, chiller and evaporator sizing, control systems and ancillary equipment. The choice of refrigerant, materials for insulation and conduction of heat should be evaluated.

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Calculations should cover the wet and dry bulb temperatures, relative humidity, dew point, heating and cooling loads and summer and winter cycles and other associated calculations.

Thermodynamic tables and psychometric charts should be used to resolve problems.

Comfort zone should be considered alongside system parameters during calculations. Dalton's Law of partial pressures should be discussed as the use of psychometric charts takes this into account.

A range of industrial applications should be outlined.

Outcome 4 — the performance of a refrigeration or a HVAC system should be analysed covering the coefficient of performance, cooling load, heat transfer, working pressures, motor efficiency and system losses, working load and control and set point/desired value.

Candidates should record readings from the practical experiment and use these results to perform calculations to ascertain thermodynamic values and loads using tables and charts where appropriate.

Candidates should write a report discussing results and drawing up conclusions on system performance.

Guidance on the delivery and assessment of this Unit

This Unit may be delivered mainly by a combination of whole class teaching and tutorial based work. Structured visits to industrial locations are strongly recommended to enhance candidate learning. Experimental work on refrigeration or HVAC systems should be included, where practical, to enhance candidate learning. Lecturers should encourage candidates to make appropriate references to manufacturers' catalogues and data sheets as this will help to set the subject within a practical context.

Formative assessment in the form of tutorial exercises on the design of refrigeration and HVAC systems will be very important in enhancing candidate learning.

The written assessment should take place after Outcomes 1 to 3 have been completed and the laboratory assignment would normally be undertaken following the written test.

With regard to Outcomes 2 and 3 in the written test if structured questions are used a new value in the region of the answer can be given for the next stage of the structured question allowing the candidate to continue the design calculations whether or not their answer was correct for the previous stage of the structured question.

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	SCQF level 6
Use of Numbers	SCQF level 6
Critical Thinking	SCQF level 6
Reviewing and Evaluating	SCQF level 6
Working with Others	SCQF level 6

Open learning

Outcomes 1, 2 and 3 in this Unit could be delivered on an open, flexible or distance learning basis, which may incorporate some degree of online support.

However, 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 assessment paper for Outcomes 1, 2 and 3, which is required to be sat at a single event, was conducted under controlled conditions

Outcome 4 involving a practical laboratory experiment plus the preparation of a report requires to be taken at a centre or in an industrial location.

The use of simulation software can supplement but cannot fully replace the practical element of the experiment.

Equality and inclusion

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

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

General information for candidates

Unit title: Heating, Ventilation and Air Conditioning Practice and Design

In this Unit you will have an opportunity to study the design of refrigeration and HVAC (Heating, Ventilating and Air Conditioning) systems and apply the criteria used to select appropriate system units from manufacturer's data.

Your studies of refrigeration and HVAC systems will begin with a look at current legislation, which is continually being updated to take account of, for example, damage to ozone layer caused by refrigerants and the introduction of ATEX legislation. You will then work through the calculations involved in designing refrigeration and HVAC systems also using thermodynamic tables and psychometric charts to size compressors, evaporators and condensers and other equipment used in these systems. You will also perform experiments on a refrigeration or HVAC system to confirm system performance.

By the end of the Unit you should be able to select appropriate system units for refrigeration and HVAC systems.

Formal assessments for this Unit will consist of a written assessment paper covering Outcomes 1, 2 and 3 which will last no more than 2 hours and a practical laboratory experiment covering Outcome 4 in which you will be expected to write up a report. The written assessment paper will be conducted under closed-book conditions in which you will not be allowed to take notes, textbooks etc. into the assessment. However, you will be allowed to use a scientific calculator. You will sit the assessment paper at the end of the Unit.