Unit 37: Refrigeration Technology in Building Services Engineering

Unit code: T/600/0459
QCF Level 3: BTEC Nationals
Credit value: 10
Guided learning hours: 60

Aim and purpose

This unit develops an understanding of the principles, properties, technical and operational requirements of refrigeration systems, a knowledge of relevant legislation, and the skills needed to create design proposals for system installations.

Unit introduction

Modern refrigeration has many applications including the safe preservation of medicine, blood and food. However, within construction and the built environment, refrigeration technology is also widely used in air conditioning systems for the maintenance of human comfort.

People nowadays expect to live and work in a comfortable environment. Climate change threatens us all. These issues have created a demand for skilled refrigeration design engineers and technicians.

Building services design engineers and technicians must comply with the increasingly demanding requirements of the Environment Agency. They must also keep up to date with the latest developments in refrigeration and air conditioning technology. It is therefore increasingly important that they can apply a fundamental underpinning knowledge and understanding of refrigeration to their design proposals.

This unit introduces learners to the study of the thermodynamic properties of refrigerants and to the basic calculations used to determine the capacities of each of the components used in the single-stage refrigeration cycle.

The unit focuses on linking scientific principles with practical refrigeration applications and learners will require a basic understanding of the associated science, technology and mathematics contained in other units. It is anticipated that learners will either have achieved these units before studying this unit, or will be studying those units concurrently.

Learning outcomes

On completion of this unit a learner should:

1. Understand the principles that underpin basic refrigeration processes
2. Understand the properties and uses of different types of refrigeration systems
3. Be able to create project design proposals for selecting appropriate refrigeration technology
4. Understand the technical and operational requirements of safe, energy efficient system installation
5. Know the current legislation, British Standards, regulations and codes of practice applicable to safe refrigeration processes.

Unit content

1 Understand the principles that underpin basic refrigeration processes

Principles of thermodynamics: temperature scales (Celsius; Kelvin); gas laws (Dalton's Law; Boyle's Law; Charles's Law; general gas law); heat transfer; removal of heat by refrigeration processes; data tables for enthalpy; sensible and latent heat; boiling point of liquids; room temperatures; discharge and comfort temperatures; coil temperatures; storage temperatures; suction and condensing temperatures; transient heat flow; two-phase heat transfer; dew point and wet bulb temperatures

Principles of refrigeration cycles: basic vapour compression cycle; evaporation and condensation of liquids; coefficient of performance; ideal reversed Carnot cycle; modified reversed Carnot cycle; use of pressure-enthalpy diagrams; volumetric efficiency; multi-stage cycles; absorption cycle; air cycle; working fluid condition throughout the refrigeration and air conditioning cycles

2 Understand the properties and uses of different types of refrigeration systems

Refrigerants: characteristics; applications; operational features; legislation relevant to use of certain types of refrigerant; environmental impact (ozone layer and depletion potential; global warming potential); refrigerants currently in use; ideal properties of refrigerants such as ammonia and hydrocarbons; refrigerant blends; lubricants; transport handling and distribution; criteria for selection

Components: compressors; condensers; water towers; receivers; dry coolers; evaporators; expansion valves

Compressors: characteristics; applications; operational features; capacity ratings as applied to the vapour compression cycle; history of positive displacement (piston type); multi-cylinder type compressors, construction and use; valve types and applications; sliding and rotary vane compressors; screw compressors; scroll compressors; dynamic compressors; criteria for selection

Condensers and water towers: characteristics; applications; operational features; condenser capacities and manufacturers' equipment cooling capacities; rating and sizing; use of data tables; air cooled condensers; construction and materials used in manufacture; liquefied refrigerant and air flows; natural and forced convection methods; water cooled condensers; typical configurations and sizes; efficiencies and adaptability; shell and tube condensers; cooling towers; evaporation processes and water quantities; issues with spray vapour; evaporative condensers; atmospheric condensers; winter operation factors that are commonly applied to condensers; heat pump or heat reclaim systems; criteria for selection

Receivers: characteristics; applications; operational features; holding capacities; materials used; pressure vessels; requirement for safety pressure relief devices; criteria for selection

Dry coolers: characteristics; applications; operational features; use; criteria for selection

Evaporators: characteristics; applications; operational features; flow patterns and function; flooded evaporators; plate evaporators; methods and requirements for defrosting; shell and tube evaporators; shell and coil evaporators; air cooling; liquid cooling; performance; efficiencies; materials used in manufacture; configuration of typical models; floor or ceiling mounted; dry expansion methods; advantages and criteria for selection; requirements for condensate pumps and drainage of condensate water

Expansion valves: characteristics; applications; operational features; importance and function of expansion valves in refrigeration systems; methods used in pressure reduction; low pressure float valves and switches; high pressure float valves; purpose and use of thermostatic level control; valves for dry expansion circuits; detection of superheat method of operation; correct selection and installation to avoid undamped proportional control; electronic expansion valve use in packaged, automatic units/systems and field use; use of thermistors to sense superheat with pulsing or modulation solenoid valve for final control as an integrated control unit

3 Be able to create project design proposals for selecting appropriate refrigeration technology

Design principles: refrigeration load estimation; load sources; removal of heat; consideration of all heat sources; consideration of sensible and latent heat gains from relevant sources; conducted heat; convected heat; internal heat sources; heat of respiration; estimate analysis; use of quantitative data; selection of design parameters; effects on human comfort and climate conditions; environmental design parameters; provision of suitable layout drawings and flow diagrams; control and wiring circuits

Calculations: requirements for air conditioning and comfort cooling; winter heating via heat pumps; sensible and latent cooling; adiabatic cooling/saturation cooling and dehumidifying coils; sensible-latent heat ratio; evaporative coolers; running time for refrigeration plant to overcome given cooling loads

Refrigeration-based air conditioning systems: characteristics; applications; operational features; importance and function of different types of air conditioning systems that use refrigeration to provide both heating and cooling; all air systems using centralised plant and ductwork with associated cooling coils in air handling equipment; direct expansion systems supplied with refrigerant from a central plant room; chilled water air handling unit taking chilled water from a central chiller; water cooled, packaged, direct expansion units using condenser water from an external tower; remote condenser (single split) air-cooled direct expansion unit; air-cooled direct expansion unit local to indoor unit; packaged air cooling units; two and three pipe split units; multi-split VRF units; criteria for selection

4 Understand the technical and operational requirements of safe, energy efficient system installation

Materials: use of standard engineering materials for refrigeration plant and equipment eg copper, (special requirements for compressors and compressor pistons); stainless steel or mild steel for piping systems; aluminium tube for ammonia

Instruments: permanently fixed instruments (pressure gauges; thermometers; electronic thermocouples); locations; use (initial commissioning; final commissioning; ongoing system maintenance); use of manometers across air filters where applicable

Operational methods: piping layout; pipe supports; vibration control; site pressure safety tests; evacuation; charging system; insulation; commissioning

Piping layouts: characteristics; applications; operational features; correct sizing and routing of pipe work systems; pipe joining methods for steel and copper; flanged and welded steel pipe work for larger commercial systems; mechanical joints for copper tube; flare type joints with annealed tube; brazing of copper tube; using copper tube on rolls to minimise jointing; attention to detail for evaporator and condenser positions above and below the compressor with relevant gravity falls and taps as required for oil return

Pipe supports: frequency of supports required limiting stress and deflection; allowances for expansion and contraction; limit damage and use access as footholds; blocking access to isolation valves; various types available for different sizes of installation

Vibration control: use of anti-vibration mounts for machinery; use of braided flexible connectors for pipe work connections

Site pressure safety tests: necessity for pressure tests on completed installations; checks for factory tested components and pressure vessels; use and supply of nitrogen and relevant pressures to test installation eg gauges used to test pressure, vented during pressure tests, checking and operation of system valves during pressure testing, maintenance time for the pressure test

Evacuation: principles of evacuation; removal of air and moisture from pipe work system; operating temperatures of refrigerants and absolute pressures; use of vacuum pump and expansion valves for connection; final working pressures purging system of air; automatic gas purgers

Charging system: operational procedures for charging system with refrigerant as a liquid; allowance of refrigerant for systems with receivers and changes in seasonal loads; checking charging weights for small systems; replenishing of oil in system; checking sight glasses

Insulation: application of insulating material to low pressure pipe work and materials currently available; methods of application to pipe work and/or equipment where necessary; elimination of air and moisture; creating a vapour barrier; sealing of joints; use of specialist trades for application

Commissioning: completion stage of contract; checking design specification requirements; setting to work procedures and logical sequence of events; calibration and final checks; commissioning records

5 Know the current legislation, British Standards, regulations and codes of practice applicable to safe refrigeration processes

Regulations: BS 4434:1989, BS 5720:1979 (no longer current but still cited in Building Regulations); DD 9999:2005; BS EN 378-2:2000; BS EN 378-1:2000; BS 5422:1990; BS 6880-1:1988; BS 6880-2: 1988; Building Regulations 2000; Approved Document L2; all currently revised standards and regulations as applicable

Legislation: importance of health and safety standards; current and applicable legislation under the Health and Safety at Work Act (1974); implications of breaches of applicable laws; adherence to national and international protocols and environmental legislation relating to the use, provision and handling of refrigerants; requirements for training qualified and competent personnel for installation, commissioning and testing procedures

Codes of practice and other references: relevance and application of information contained within eg Institute of Refrigeration Safety Codes for Refrigerating Systems utilising groups of HCFC/HFC and hydrocarbons, (A1, A2, A3) type refrigerants, minimisation of refrigerant emissions, use of all relevant CIBSE Guides and Commissioning codes, Code of Practice for Compression Refrigerating Systems using Ammonia 1, use of current HVCA guides and ASHRAE Handbooks, use of BRE documents for energy and efficient designs

Safety: safe installation and use of electrical plant and equipment (preventing electrical shock; earthing requirements; fuses; safety devices); storage and handling of gas cylinders; use and correct application of dangerous and flammable chemicals eg oil, solvents, spilt mercury; disposal of waste chemicals; manual handling and lifting of plant and equipment; hazard warning and identification; first aid; correct operational, installation and testing procedures; personal protective equipment

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P1 describe the principles of thermodynamics applicable to refrigeration [IE1, IE2, IE4, IE6]	**M1** analyse how refrigeration cycles work	
P2 explain the principles of refrigeration cycles [IE1, IE2, IE4, IE6, RL6]		
P3 compare modern refrigerants in terms of how they achieve the criteria required of modern refrigeration systems [IE1, IE2, IE4, IE6, CT1, CT2, CT6, RL5, RL6]		
P4 explain how the principal components of refrigeration systems are configured to achieve their design purpose [IE1, IE2, IE4, IE6, CT1, CT2, RL5, RL6, SM3]		
P5 use appropriate design principles and relevant calculations to determine sensible and latent heat gains for two proposed air conditioning systems [IE1, IE2, IE4, IE6, CT1, CT2, RL5, RL6, SM3]	**M2** produce a schedule of the plant and equipment required for two proposed air conditioning systems	**D1** justify the specification of modern refrigerants and modern refrigeration systems in terms of performance-in-use and cost
P6 produce specifications for refrigeration-based air conditioning for two proposed air conditioning systems [IE1, IE2, IE4, IE6, CT1, CT2, RL5, RL6, SM3]		

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P7 compare the materials and instruments used in the installation, testing and commissioning of typical refrigeration systems [IE1, IE2, IE4, IE6, CT1, CT2, RL5, RL6, SM3]	**M3** evaluate the materials, equipment and methods used in a typical refrigeration systems in terms of current legislation.	**D2** justify emerging national and international legislation and protocols in terms of the environmental impact of refrigeration technology.
P8 discuss the methods used to install, test and commission a typical refrigeration system [IE1, IE2, IE4, IE6, CT1, CT2, RL5, RL6, TW2, SM3]		
P9 describe the important requirements of the current regulations, legislation and codes of practice applicable to safety aspects of refrigeration systems. [IE1, IE2, IE4, IE6, CT1, CT2, RL5, RL6, SM3]		

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills which are embedded in the assessment of this unit. By achieving the criteria, learners will have demonstrated effective application of the referenced elements of the skills.

Key	IE – independent enquirers	RL – reflective learners	SM – self-managers
	CT – creative thinkers	TW – team workers	EP – effective participators

Essential guidance for tutors

Delivery

Tutors delivering this unit have opportunities to use a wide range of techniques. Lectures, discussions, seminar presentations, site visits, supervised practicals, research using the internet and/or library resources and use of personal and/or industrial experience are all suitable. Delivery should stimulate, motivate, educate and enthuse learners. Visiting expert speakers could add to the relevance of the subject.

It is important to ensure that learners are aware of the planned and progressive structure that exists across the learning outcomes. Before the next step in the learning process can be taken, learners should achieve the knowledge and understanding from the previous learning outcome. There may be instances where learners have gained adequate knowledge and experience previously but this should be determined through assessment.

Learners should clearly appreciate that each aspect and topic form a stage in the overall process of designing and specifying refrigeration plant and equipment and associated installations.

The unit focuses on refrigeration within the context of air conditioning and does not deal explicitly with the application of refrigeration technology in relation to cold stores or food and product storage. However, the underlying principles of the thermodynamic and refrigeration processes are much the same and could be applied to this area of design.

This unit should not be seen as an academic exercise. It should be based on real-life applications and should reflect industry best practice. The method of delivery should, as far as possible, be activity based and use learning activities that include laboratory work, case studies, site visits, product investigations, and design exercises. The delivery process should balance calculations, knowledge, understanding, creativity and application. Appropriate attention should be paid to health, safety and welfare requirements.

Learners should be encouraged to refer to documents such as CIBSE guides, ASHRAE handbooks, codes of practice, British Standards and Building Regulations, to gain knowledge of a wide and confirmed range of advice on best practices for design and installation requirements. The use of manufacturers' current product information is also encouraged to help learners apply the principles and procedures that would be used in industry.

Emphasis on the need for learners to understand how to access and use particular charts and diagrams to aid manual calculations is very important. Industry-standard software can be used to perform certain design functions in the process of assembling a project. However, it is important that learners can challenge any results gained from the software by carrying out either 'rule of thumb' or longhand manual calculations.

The unit links principles with practical applications and this means that learners should have achieved a basic understanding of any relevant science and mathematics before starting this unit. This should include the underlying principles of thermal comfort, heat transfer, processes that harm the natural environment, psychrometric properties of moist air, flow of fluids, and control principles and strategies for building engineering services.

Group activities are permissible, but tutors will need to ensure that individual learners have equal experiential and assessment opportunities.

Health, safety and welfare issues are paramount and should be reinforced through close supervision of all workshops and activity areas, and risk assessments must be undertaken before practical activities are taken. Centres are advised to read the *Delivery approach* section in the specification, and *Annexe H: Provision and Use of Work Equipment Regulations 1998 (PUWER).*

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Introduction by tutor Tutor-led discussion of principles of thermodynamics and refrigeration cycles Learners to carry out practical work on basic principles where equipment is available Demonstrations by the tutor and the use of secondary sources of equipment are acceptable as is the use of relevant audio-visual aids
Tutor-led session on the criteria for refrigerants and issues associated with their use. Small-group exercise with each group being given one refrigerant to research and explore the properties. These should include modern refrigerants and discredited CFCs. Each group to present their findings to the whole-class, with guidance and summary by the tutor. Tutor-led session on the characteristics and uses of refrigeration system components. Small-group exercise with each group being given one type of component to research. These should include compressors; condensers; water towers; receivers; dry coolers; evaporators; expansion valves. Each group to present their findings to the whole-class with guidance and summary by the tutor Site visit to component manufacturer, building services merchant and refrigeration installations, either under production or installed, tested and commissioned, as appropriate and as available
Assignment 1: Thermodynamics, Refrigeration Cycles, Refrigerants and Components
Extended tutor input on technical aspects of design, use of calculations and drawings. Individual learner research into characteristics of available systems using the internet. Learners to practise design calculations and drawings under close supervision from the tutor. Tutor to comment, suggest, amend, praise and redirect learners as appropriate.
Assignment 2: Design of Refrigeration Systems
Presentation by visiting speaker from the refrigeration technology sector Tutor-led, whole-class session on installation techniques. Emphasis on health and safety Visit to installation work in progress, use college workshops where access is available
Individual learner research into specified legislation, file sharing and group discussion Whole-class session to collate findings, guidance and commentary by tutor
Assignment 3: Installing, Testing and Commissioning Refrigeration Systems
Review of unit and assignment feedback

Assessment

Evidence for this unit may be gathered from a variety of sources, including well-planned investigative assignments, case studies or reports of practical assignments.

There are many suitable forms of assessment that could be used, and tutors are encouraged to consider and adopt these where appropriate. Some example assessment approaches are suggested below. However, these are not intended to be prescriptive or restrictive, and are provided as an illustration of the alternative forms of assessment evidence that would be acceptable.

Some criteria can be assessed directly by the tutor during practical activities. If this approach is used then suitable evidence would be observation records or witness statements.

The unit allows for flexibility in the types of assessment methods that can be used throughout. Certain criteria, however, require well-planned laboratory work, assignments that involve calculations, diagrams and text, or design project work.

The fundamental principles of the refrigeration processes are often best witnessed and demonstrated in order for learners to see the effects and results. Experiments in a laboratory to demonstrate different processes and the use of equipment could be carried out by learners with evidence for formative and summative assessments presented as a combination of a visual record by the tutor and preparation and maintenance of suitable learner logbooks. Learners could also provide work-based evidence for assessment provided that this is appropriate and authenticated as the learner's own work.

Any buildings selected to support assignments should be typical of those encountered and designed in industry so that they can be related to normal practice in the workplace. They should have a variety of spaces and areas with differing requirements to stimulate learners' thinking. They should be capable of being air conditioned using the option of stand-alone refrigeration systems or plant and equipment that is integrated into larger centralised systems.

Learners should, preferably, be given a range of the architectural drawings they need to extract the required information including plans, elevations, sections and details. If centres want to use a building of their own design, it should meet current building design standards and contain the same information as would be expected from professionally produced architectural drawings.

To achieve a pass grade learners must meet the nine pass criteria listed in the grading grid.

For P1, learners must describe the principles of thermodynamics relevant to the general uses of refrigeration. Learners will calculate the differences in moisture in given quantities of air and be familiar with the processes of evaporation and condensation of water. They must also identify how different thermodynamic laws relate to the provision of refrigeration technology. Evidence could be in the form of a presentation and/or a report, supported by standard charts and graphs and appropriate calculations.

For P2, learners must explain the principles of refrigeration cycles. They are expected to identify the different behaviour of liquid and vapours under different situations and the processes and phases that refrigerants undergo during the removal of heat. Evidence should be as for P1.

For P3, learners must compare modern refrigerants in terms of how they achieve the performance required of modern refrigeration systems. Learners are expected to identify the refrigerants currently used in air conditioning systems and discuss their advantages and disadvantages. Learners are expected to determine the refrigerants that meet current environmental standards and protocols. They should also discuss the reasons why certain refrigerants are either no longer viable options for use at all or are only suitable in certain types of systems. Evidence could be in the form of a presentation, a report or through oral questioning.

For P4, learners must explain how the principal components of refrigeration systems are configured to achieve their design purpose. Learners need to produce diagrams, sketches and descriptions of the components and discuss their location, function and features in systems and how they assist in providing solutions for air conditioning. They must provide evidence of having considered environmental issues and health, safety and welfare aspects. Suitable evidence could be as for P1 and P3.

For P5, learners must use appropriate design principles and relevant calculations to determine sensible and latent heat gains for two different building locations requiring air conditioning. The buildings should have quite different requirements that learners are expected to consider in order to develop a brief. They should be able to use given data on heat loads, and/or assess other incidental heat loads that may be present, in order to manually calculate sensible and latent heat gains. This could be used as an integral part of a design project. Suitable evidence could be a report supported by text, diagrams, sketches, drawings, specifications and schedules as appropriate.

For P6, learners must produce specifications for two refrigeration-based air conditioning systems for simple buildings. They must assemble a full design proposal for the provision of the air conditioning systems, incorporating refrigeration technology in any form that they feel is applicable for the chosen situation. This will include the creation of layout drawings to indicate the system proposals, plant and equipment schedules, pipe work routes and plant and equipment detail drawings. This could be used as an integral part of a design project. Evidence could take the same form as P5 and build on the evidence.

For P7, learners must compare the materials and instruments used to install, test and commission typical refrigeration systems. They are expected to prepare an outline installation specification for the design proposal created in P6, detailing all the materials and ancillary equipment needed for onsite installation.

For P8, learners must discuss the methods used to install, test and commission a given refrigeration system. This should be provided by the tutor and should not relate to P6 and P7. Evidence could be in the form of a written report.

For P9, learners must describe the most important requirements of current regulations, legislation and codes of practice related to the safe design, installation and use of refrigeration systems and all associated substances. They are expected to identify the main documents that detail the important legislation, regulations and codes of practice relevant to refrigeration. Learners must show their understanding of the implications of these requirements for the designer, installer and end user, in terms of the environment, financial cost and personal health and safety.

To achieve a merit grade learners must meet all the pass grade criteria and the three merit grade criteria.

For M1, learners must analyse how the refrigeration cycle works and explain and illustrate the thermodynamic changes within the working during the operation of the cycle and its variants. This could be through written descriptions about the actual processes of the gases and liquids. They should use clear diagrams to indicate the various cycles that exist and the components used to create the cycles. Learners will be able to build and expand on knowledge gained for P1.

For M2, learners must produce a schedule of the plant and equipment required for two proposed air conditioning systems. This could build on the evidence required for P5.

For M3, learners must evaluate the materials, equipment and methods used in a typical refrigeration system in terms of current legislation. This should relate closely to the evidence produced for P9.

To achieve a distinction grade learners must meet all of the pass and merit grade criteria and the two distinction grade criteria.

For D1, learners must justify the specification of modern refrigerants and modern refrigeration systems in terms of performance-in-use and cost. The costs need not be absolute and relative costs are acceptable. Performance-in-use should be discussed in terms of these costs.

For D2, learners must justify the impact of emerging national and international legislation and protocols. They should relate this to the impact on designers, installers and end users in terms of the intended impact on design choices and on environmental issues such as global warming and ozone depletion.

Programme of suggested assignments

The following table shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Edexcel assignments to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment method
P1, P2, P3, P4, M1	Thermodynamics, Refrigeration Cycles, Refrigerants and Components	A client is keen to understand the principles behind the refrigeration technology your firm has proposed. You have been given the job of compiling a presentation to address the client's request.	A presentation supported by a report to include text, calculations, diagrams, charts, graphs and tables as appropriate.
P5, P6, M2, D1	Design of Refrigeration Systems	Your firm asks you to produce a design solution for an air-conditioning system for a non-complex low-rise building.	A report to include text, diagrams, sketches, drawings, specifications and schedules as appropriate.
P7, P8, P9, M3, D2	Installing, Testing and Commissioning Refrigeration Systems	Your firm tasks you with the post-design production phase of the design solution produced for the above.	A report to include a text, diagrams, sketches, drawings, specifications and schedules as appropriate.

Links to National Occupational Standards, other BTEC units, other BTEC qualifications and other relevant units and qualifications

This unit forms part of the BTEC Construction and the Built Environment sector suite. This unit has particular links with the following unit titles in the Construction and the Built Environment suite:

Level 1	Level 2	Level 3
		Building Services Science
		Electrical Principles in Building Services Engineering

- This unit links to the Edexcel Level 3 Technical and Professional NVQs for Construction and the Built Environment.
- The contents of this unit covers some of the knowledge and understanding associated with SummitSkills National Occupational Standards, particularly Unit 008: Design RAC systems – small commercial refrigeration and air conditioning systems.
- The content of this unit covers some of the knowledge and understanding associated with Summit Skills N/SVQ Level 3: Building Services Engineering Technology and Project Management, particularly, Unit SST/NOS 3: Apply Design Principles to Building Services Engineering Projects, Unit SST/NOS 5: Monitor Commissioning and Testing Procedures for Building Services Engineering Projects and Unit SST/NOS 7: Provide Technical and Functional Information to Relevant People.

- The content of this unit will also provide a developmental stage in acquiring some of the knowledge and understanding associated with Summit Skills N/SVQ Level 4 Building Services Engineering Technology and Project Management, particularly SSTE/NOS 7: Prepare and Advise on Building Services Engineering Project Design Recommendations and SSTE/NOS 8: Prepare and Agree Detailed Building Services Engineering Project Designs.

Essential resources

Centres should have access to a wide range of current hard copy or online technical and manufacturers' literature. The availability of visual aids, such as the range of refrigeration plant and components indicated for learning outcome 2 is considered advantageous. These can be in the form of models but preferably should be part of live installations. Centres should have access to sets of architectural drawings, refrigeration system installations and schematic drawings to support the learning process and facilitate assessment. Where these drawings are used as part of the assessment process it is recommended that repeated use of the same building is avoided to maintain the freshness and validity of the assessment process. Learners should be made familiar with industry-recognised software used to size, select and specify pipework, plant and equipment. It is vital, however, that if such software is used, learners can complete the calculations required using recognised manual procedures.

Employer engagement and vocational contexts

Support to enable centres to initiate and establish links to industry, and to networks arranging visits to industry and from property practitioners is given below:

- Learning and Skills Network – www.vocationallearning.org.uk
- National Education and Business Partnership Network – www.nebpn.org
- The Royal Institution of Chartered Surveyors – www.rics.org
- Work Experience/Workplace learning frameworks – Centre for Education and Industry (CEI University of Warwick) – www.warwick.ac.uk/wie/cei/

Indicative reading for learners

Textbooks

Chadderton D – *Air Conditioning: A Practical Introduction, 2nd Edition* (Spon Press, 1999) ISBN 0419226109

Chadderton D – *Building Services Engineering, 5th Edition* (Taylor & Francis, 2007) ISBN 0415413559

Chartered Institute of Building Services Engineers – *Energy Efficiency in Buildings* (CIBSE, 2006) ISBN 1903287340

Chartered Institute of Building Services Engineers – *Environmental Design, 7th Edition* (CIBSE, 2006) ISBN 1903287669

Chartered Institute of Building Services Engineers – *Ventilation and Air Conditioning* (CIBSE, 2001) ISBN 1903287162

Cook N – *Refrigeration and Air-conditioning Technology* (Macmillan Education, 1995) ISBN 0333609581

Kaminski D and Jensen M – *Introduction to Thermal and Fluid Engineering* (John Wiley & Sons, 2004) ISBN 0471268739

Martin P, Oughton D and Hodkinson S – *Faber and Kell's Heating and Air-conditioning of Buildings, 9th Edition* (Architectural Press, 2001) ISBN 075064642X

Trott A and Welch T – *Refrigeration and Air Conditioning, 3rd Edition* (Butterworth-Heinemann, 1999) ISBN 075064219X

Journals

ACR News – Faversham House press

ACR Today: Air Conditioning and Refrigeration for Today's People – Battlepress

Refrigeration and Air Conditioning Magazine – Emap

Websites

www.cibse.org	Chartered Institution of Building Services Engineers
www.hvca.org.uk	Heating and Ventilation Contractors' Association
www.ior.org.uk	Institute of Refrigeration
www.summitskills.org.uk	SummitSkills

Delivery of personal, learning and thinking skills (PLTS)

The following table below identifies the personal, learning and thinking skills (PLTS) opportunities that have been included within the assessment criteria of this unit.

Skill	When learners are …
Independent enquirers	identifying questions to answer and problems to resolve, planning and carrying out research, analysing and evaluating information and supporting conclusions using reasoned arguments and evidence, as they: • describe the principles of thermodynamics applicable to refrigeration • explain the principles of refrigeration cycles • compare modern refrigerants in terms of how they achieve the criteria required of modern refrigeration systems • evaluate the principal components of refrigeration systems in terms of how they are configured to achieve their design purpose • determine sensible and latent heat gains for two proposed air conditioning systems using appropriate design principles and relevant calculations • specify refrigeration-based air conditioning for two proposed air conditioning systems • compare the materials and instruments used in the installation, testing and commissioning of typical refrigeration systems • discuss the methods used to install, test and commission a typical refrigeration system • describe the important requirements of the current regulations, legislation and codes of practice applicable to refrigeration systems
Creative thinkers	generating ideas and exploring possibilities, asking questions to extend their thinking and adapting ideas as circumstances change, as they: • compare modern refrigerants in terms of how they achieve the criteria required of modern refrigeration systems • evaluate the principal components of refrigeration systems in terms of how they are configured to achieve their design purpose • determine sensible and latent heat gains for two proposed air conditioning systems using appropriate design principles and relevant calculations • specify refrigeration-based air conditioning for two proposed air conditioning systems • compare the materials and instruments used in the installation, testing and commissioning of typical refrigeration systems • discuss the methods used to install, test and commission a typical refrigeration system • describe the important requirements of the current regulations, legislation and codes of practice applicable to refrigeration systems

Skill	When learners are …
Reflective learners	evaluating experiences and learning to inform future progress and communicating their learning in relevant ways for different audiences, as they: • compare modern refrigerants in terms of how they achieve the criteria required of modern refrigeration systems • evaluate the principal components of refrigeration systems in terms of how they are configured to achieve their design purpose • determine sensible and latent heat gains for two proposed air conditioning systems using appropriate design principles and relevant calculations • specify refrigeration-based air conditioning for two proposed air conditioning systems • compare the materials and instruments used in the installation, testing and commissioning of typical refrigeration systems • discuss the methods used to install, test and commission a typical refrigeration system • describe the important requirements of the current regulations, legislation and codes of practice applicable to refrigeration systems
Team workers	reaching agreements and managing discussions to achieve results, as they: • discuss the methods used to install, test and commission a typical refrigeration system
Self-managers	organising time and resources and prioritising actions, as they: • evaluate the principal components of refrigeration systems in terms of how they are configured to achieve their design purpose • determine sensible and latent heat gains for two proposed air conditioning systems using appropriate design principles and relevant calculations • specify refrigeration-based air conditioning for two proposed air conditioning systems • compare the materials and instruments used in the installation, testing and commissioning of typical refrigeration systems • discuss the methods used to install, test and commission a typical refrigeration system • describe the important requirements of the current regulations, legislation and codes of practice applicable to refrigeration systems.

Functional Skills — Level 2

Skill	When learners are …
ICT – Use ICT systems	
Select, interact with and use ICT systems independently for a complex task to meet a variety of needs	using the internet to research refrigeration saving material electronically using email to communicate with the tutor and other learners
Manage information storage to enable efficient retrieval	downloading and saving internet files and their own work electronically
ICT – Find and select information	
Select and use a variety of sources of information independently for a complex task	using the internet to research into refrigeration, saving material electronically using email to communicate with the tutor and other learners
ICT – Develop, present and communicate information	
Enter, develop and format information independently to suit its meaning and purpose including: • text and tables • images • numbers • records	producing reports and presentations for both formative and summative assessment purposes
Bring together information to suit content and purpose	
Present information in ways that are fit for purpose and audience	
Select and use ICT to communicate and exchange information safely, responsibly and effectively including storage of messages and contact lists	using email to communicate with the tutor and other learners
Mathematics	
Identify the situation or problem and the mathematical methods needed to tackle it	performing calculations relating to thermodynamics, refrigeration cycles and refrigeration design for air conditioning
Select and apply a range of skills to find solutions	
Use appropriate checking procedures and evaluate their effectiveness at each stage	
Draw conclusions and provide mathematical justifications	

Skill	When learners are …
English	
Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts	discussing the methods used to install, test and commission a typical refrigeration system
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	researching refrigeration principles and practices from books, journals, CD ROMs and websites
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	producing reports for assessment purposes.