Unit 70: Refrigeration Technology in Building Services Engineering

Unit code: T/600/0459

QCF Level: 3

Credit value: 10

Guided learning hours: 60

Unit aim

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

Learning outcomes and assessment 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 determine the standard required to achieve the unit.

Learning outcomes	Assessment criteria
1 Understand the principles that underpin basic refrigeration processes	1.1 Describe the principles of thermodynamics applicable to refrigeration
	1.2 Explain the principles of refrigeration cycles
2 Understand the properties and uses of different types of refrigeration systems	2.1 Compare modern refrigerants in terms of how they achieve the criteria required of modern refrigeration systems
	2.2 Explain how the principal components of refrigeration systems are configured to achieve their design purpose
3 Be able to create project design proposals for selecting appropriate refrigeration technology	3.1 Use appropriate design principles and relevant calculations to determine sensible and latent heat gains for two proposed air-

	conditioning systems
	3.2 Produce specifications for refrigeration-based air conditioning for two proposed air conditioning systems
4 Understand the technical and operational requirements of safe, energy efficient system installation	4.1 Compare the materials and instruments used in the installation, testing and commissioning of typical refrigeration systems
	4.2 Discuss the methods used to install, test and commission a typical refrigeration system
5 Know the current legislation, British Standards, regulations and codes of practice applicable to safe refrigeration processes	5.1 Describe the important requirements of the current regulations, legislation and codes of practice applicable to safety aspects of refrigeration systems

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