

Level 2 Diploma in Refrigeration, Air-Conditioning and Heat Pump Systems (6090- 20)

Version 1.5 (August 2018)

Qualification Handbook

Qualification at a glance

Subject area	Refrigeration and Air-conditioning
City & Guilds number	6090
Age group approved	16-19, 19+
Assessment types	Multiple Choice; Assignment
Approvals	Fast track approval
Support materials	Assessment pack; Qualification handbook
Registration and certification	Consult the Walled Garden/Online Catalogue for last dates

Title and level	GLH	TQT	City & Guilds qualification number	Ofqual accreditation number
Level 2 Diploma in Refrigeration, Air-Conditioning and Heat Pump Systems	450	525	6090-20	603/1188/5

Version and date	Change detail	Section
1.1 September 2016	Title of unit 203 amended Test Specification Titles Amended	Units Assessment
1.2 January 2017	Addition AC added to Unit 202 LO8 Range amended for Unit 202 LO8 Reviewed Test Specification for 502	Units Assessment
1.3 March 2017	QAN number added	Qualification at a Glance
1.4 June 2017	Automatic approval is given to anyone currently delivering the 6187 or 7189.	Centre Requirements - Approval
1.5 August 2018	Additional guidance added to permitted materials, provisional grade boundaries added.	Assessment

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1 Introduction

This document tells you what you need to do to deliver the qualification:

Area	Description
Who is the qualification for?	This qualification is for learners wishing to pursue a career within the Refrigeration & Air-conditioning industry.
What does the qualification cover?	<p>This qualification covers the knowledge and occupational skills required to work in installing and commissioning air-conditioning and heat pump system.</p> <p>The Refrigeration Air Conditioning and Heat Pump (RACHP) Engineering Technician is a specialist occupation involved in planning, preparing and safely carrying out work activities in process, product and space cooling.</p>
What opportunities for progression are there?	The Refrigeration Air Conditioning and Heat Pump (RACHP) Engineering Technician will enable candidates to progress within employment.
Who did we develop the qualification with?	<p>This product was developed by a number of employers within the Refrigeration & Air-conditioning industry:</p> <ul style="list-style-type: none">• Enigma Environmental Services Ltd• GEA Refrigeration• Integral UK Ltd• Mitsubishi Electric Living Environmental Systems• Star Refrigeration• Space Engineering Services• Carter Synergy• Adcock Refrigeration and Air conditioning• Epta Group• Sainsbury's• Daikin Airconditioning UK Ltd• MacWhirter Air Conditioning
Is it part of an apprenticeship framework or initiative?	The qualification is the new Trailblazer initiative set up by the government to promote apprenticeships within the Refrigeration & Air-conditioning industry.

Structure

Candidates must be taught all mandatory units (201, 202, 203, 204, 205, 206, 207).

Level 2 Diploma in Refrigeration, Air-Conditioning and Heat Pump Systems

City & Guilds unit number	Unit title	GLH
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Mandatory

201	Health and safety in RACHP industry	40
202	Fundamental principles of RACHP systems	82
203	Application of the fundamental principles of the vapour compression systems	68
204	Functions and features of RACHP systems and components	87
205	Service and maintain RACHP systems	48
206	Install and commission RACHP systems	47
207	Electrical systems for RACHP systems	48

Total Qualification Time

Total Qualification Time (TQT) is the number of notional hours which represents an estimate of the total amount of time that could reasonably be expected for a learner to achieve and demonstrate the achievement of the level of attainment necessary for the award of a qualification.

TQT is comprised of the following two elements:

- 1) The number of hours which an awarding organisation has assigned to a qualification for Guided Learning, and
- 2) an estimate of the number of hours a Learner will reasonably be likely to spend in preparation, study or any other form of participation in education or training, including assessment, which takes place as directed by - but, unlike Guided Learning, not under the Immediate Guidance or Supervision of - a lecturer, supervisor, tutor or other, appropriate provider of education or training.

Title and level	GLH	TQT
Level 2 Diploma in Refrigeration, Air-Conditioning and Heat Pump Systems	450	525

2 Centre requirements

Approval

If your Centre is approved to offer the qualification 7189-02 Level 2 Diploma in Refrigeration, Air Conditioning and Heat Pump Systems or 6187-01/02 then you will receive automatic approval for the new 6090-20 Level 2 Diploma in Refrigeration, Air-Conditioning and Heat Pump Systems

To offer these qualifications, new centres will need to gain both centre and qualification approval. Please refer to the Centre Manual - Supporting Customer Excellence for further information.

Centre staff should familiarise themselves with the structure, content and assessment requirements of the qualifications before designing a course programme.

Resource requirements

Resources

Centres can use specially designated areas within a centre to develop practical skills and to assess the simulated practical assignments. The equipment, systems and machinery must meet industrial standards and be capable of being used under normal working conditions.

Centre staffing

Staff delivering these qualifications must be able to demonstrate that they meet the following occupational expertise requirements. They should:

- be occupationally competent or technically knowledgeable in the area[s] for which they are delivering training and/or have experience of providing training. This knowledge must be to the same level as the training being delivered
- have recent relevant experience in the specific area they will be assessing
- have credible experience of providing training.

See also the assessment strategy on the role of supervisors and managers in the assessment process.

Centre staff may undertake more than one role, eg tutor and assessor or internal verifier, but cannot internally verify their own assessments.

Learner entry requirements

City & Guilds does not set entry requirements for these qualifications. However, centres must ensure that candidates have the potential and opportunity to gain the qualifications successfully.

Age restrictions

City & Guilds cannot accept any registrations for learners under 16 as these qualifications are not approved for learners under 16.

3 Delivering the qualification

Initial assessment and induction

An initial assessment of each candidate should be made before the start of their programme to identify:

- if the candidate has any specific training needs
- support and guidance they may need when working towards their qualifications
- any units they have already completed, or credit they have accumulated which is relevant to the qualifications
- the appropriate type and level of qualification.

We recommend that centres provide an induction programme so the candidate fully understands the requirements of the qualification[s], their responsibilities as a candidate, and the responsibilities of the centre. This information can be recorded on a learning contract.

Support materials

The following resources are available for these qualifications:

Description	How to access
Assessment pack	www.cityandguilds.com

Recording documents

Candidates and centres may decide to use a paper-based or electronic method of recording evidence.

City & Guilds endorses several ePortfolio systems, including our own, Learning Assistant, an easy-to-use and secure online tool to support and evidence learners' progress towards achieving qualifications. Further details are available at: www.cityandguilds.com/eportfolios.

City & Guilds has developed a set of *Recording forms* including examples of completed forms, for new and existing centres to use as appropriate. Recording forms are available on the City & Guilds website.

Although new centres are expected to use these forms, centres may devise or customise alternative forms, which must be approved for use by the external verifier, before they are used by candidates and assessors at the centre. Amendable (MS Word) versions of the forms are available on the City & Guilds website.

4 Assessment

Summary of assessment methods

Candidates must:

- successfully complete assignments for the units 205, 206 and 207
- successfully complete evolve tests; 501, 502 and 204 for the units 201, 202, 203, 204.

Available assessments/assignments

City & Guilds has written the following assessments to use with this qualification:

- assignments for the units 205, 206 and 207
- evolve tests, 501, 502 and 204 for the units 201-204

Assessment Types

Unit	Title	Assessment method	Where to obtain assessment materials
201	Health and safety in RACHP industry	Assignment	6090 web page on City and Guilds website.
204	Functions and features of RACHP systems and components	Multiple Choice Test	Evolve, City and Guilds On-screen Assessment Platform
205	Service and maintain RACHP systems	Assignment	6090 web page on City and Guilds website.
206	Install and commission RACHHP systems	Assignment	6090 web page on City and Guilds website.
207	Electrical systems for RACHP systems	Assignment	6090 web page on City and Guilds website.
501	Health and safety in RACHP industry	Multiple Choice Test	Evolve, City and Guilds On-screen Assessment Platform
502	Synoptic Knowledge Test on the Application of Fundamental Principals of RACHP systems.	Multiple Choice Test	Evolve, City and Guilds On-screen Assessment Platform

Time constraints

Each assessment will have it's own time constraint. Details of assignment timings can be found within the assessment pack.

Evolve Test Durations are as follows;

Unit Number	Unit Title	Test Duration (Minutes)
501	Health and safety in RACHP industry	45
502	Synoptic Knowledge Test on the Application of Fundamental Principals of RACHP systems.	120
204	Functions and features of RACHP systems and components	50

The following must be applied to the assessment of this qualification:

- Assignments should take no longer than 8 hours. If they do, centres should consider why this is, and make sure that they are not trying to gather too much evidence.

Assessment strategy

Tables and content pertaining to the assessment strategy

Test Specifications

The way the knowledge is covered by each test is laid out in the table(s) below:

6090-204 Level 2 Functions and features of RACHP systems and components

Unit	Outcome	Number of questions	%
204	1 Know the function of a range of RACHP system components.	6	22
204	2 Know the operating principles for a range of RACHP system applications.	4	15
204	3 Know the properties of refrigerants.	5	19
204	4 Know the properties of oils.	4	15
204	5 Know the operating principles of a range of system controls.	5	19
204	6 Know the function and operation of a range of test instruments used in the RACHP industry	3	11
	Total	27	100

Assessment Method: e-volve online MC test

Duration: 50 minutes

Approximate Grade Boundaries: P (60%)

6090-501 Level 2 Health and Safety in RACHP industry

Unit	Outcome	Number of questions	%
201	1 Know health and safety legislation	4	14
201	2 Know how to handle hazardous situations	9	32
201	3 Know electrical safety requirements when working in the RACHP industry	6	21
201	4 Know the safety requirements for working with gases and heat producing equipment	6	21
201	6 Know the safety requirements for working safely in excavations and confined spaces in the RACHP industry	3	11
Total		28	100

Assessment Method: e-volve online MC test

Duration: 45 minutes

Approximate Grade Boundaries: P (70%)

6090-502 Level 2 Synoptic Knowledge Test on the Application of Fundamental Principles of RACHP systems

Unit	Outcome	Number of questions	%
202	1 Know the standard units of measurement used in the RACHP sector.	2	3
202	2 Know fundamental thermodynamics.	10	16
202	3 Know the forms of heat as found in RACHP systems	5	8
202	4 Know the principles of pressure.	7	11
202	5 Understand the saturated pressure temperature relationship.	3	5
202	6 Understand the vapour compression cycle.	3	5
202	7 Understand the psychrometric processes in RACHP systems.	6	10
202	8 Know the general properties of materials used in the RACHP sector.	2	3
203	1 Know the fundamentals of the vapour compression system.	6	10
203	2 Know characteristics of line and pipe systems used in RACHP systems.	5	8
203	3 Know how properties of air are changed by cooling or heating systems.	5	8
203	4 Know the principles of operation of heat pumps.	3	5
203	5 Know the impact of operating conditions on system performance	4	7
Total		61	100

Assessment Method: e-volve online MC test

Duration: 120 minutes

Approximate Grade Boundaries: P (60%), M (70%), D (80%)

Other instructions: 300 mm ruler, fine point pen/pencil and A3 psychrometric chart must be provided by the centre for this test. The A3 psychrometric chart is available on the 6090 web page.

Recognition of prior learning (RPL)

Recognition of prior learning means using a person's previous experience, or qualifications which have already been achieved, to contribute to a new qualification.

If candidates have previously

For this qualification, RPL is allowed and is not sector specific.

5 Units

Structure of the units

These units each have the following:

- City & Guilds reference number
- Title
- Level
- Guided learning hours (GLH)
- Learning outcomes, which are comprised of a number of assessment criteria

Centres must deliver the full breadth of the range. Specialist equipment or commodities may not be available to all centres, so centres should ensure that their delivery covers their use. This may be covered by a practical demonstration (e.g. video). For the practical assessments for this qualification, centres should ensure that there are sufficient resources to complete the task but are not required to use all the equipment or commodities in the range.

Unit 201

Health and safety in RACHP industry

Unit level:	Level 2
GLH:	40
Unit aim:	This combination unit provides learners with the essential health and safety knowledge and skills to demonstrate best practice in a RACHP engineering environment. The unit provides learners with an awareness of relevant legislation and should underpin all RACHP engineering activities learners take part in.

Learning outcome

The learner will:

- 1 Know health and safety legislation

Assessment criteria

The learner can:

- 1.1 state the aims of health and safety legislation
- 1.2 identify the responsibilities of individuals under health and safety legislation
- 1.3 identify statutory and non-statutory health and safety documentation
- 1.4 identify the different roles of Health and Safety Executive in enforcing health and safety legislation.

Range

- (AC1.1) **Health and safety legislation:** The Health & Safety at Work Act, The Electricity at Work Regulations, Control of Substances Hazardous to Health (COSHH) Regulations, Working at Heights Regulations, Personal Protective Equipment at Work Regulations (PPE), Lifting and Manual Handling Operations Regulations, Provision and Use of Work Equipment Regulations (PUWER), Control of Asbestos at Work Regulations, Health, Safety and Welfare Regulations, Health and Safety (First Aid) Regulations, Confined Spaces Regulations, Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR)
- (AC1.2) **Individuals:** Employers, employees and contractors, visitors to site
- (AC1.3) **Health and safety documentation:** Acts of Parliament, regulations, approved codes of practice, HSE Guidance notes.
- (AC1.4) **Roles:** Improvement notice, prohibition notice, powers of prosecution, providing advice and guidance

Learning outcome

The learner will:

- 2 Know how to handle hazardous situations

Assessment criteria

The learner can:

- 2.1 identify common hazardous situations found on site
- 2.2 describe safe systems at work
- 2.3 identify the categories of safety signs
- 2.4 identify symbols for hazardous substances
- 2.5 list common hazardous substances used in the RACHP industry
- 2.6 list precautions to be taken when working with hazardous substances
- 2.7 identify the types of asbestos that may be encountered in the workplace
- 2.8 identify the actions to be taken if the presence of asbestos is suspected
- 2.9 describe the implications of being exposed to asbestos
- 2.10 state the application of different types of personal protective equipment
- 2.11 identify the procedures for manually handling heavy and bulky items
- 2.12 identify the actions that should be taken when an accident or emergency is discovered
- 2.13 state procedures for handling injuries sustained at work
- 2.14 state the procedures for recording accidents and near misses at work.

Range

- (AC2.1) **Hazardous situations:** Trailing leads, slippery or uneven surfaces, presence of dust and fumes, handling and transporting equipment or materials, contaminants and irritants, fire, working at heights, malfunctioning equipment, improper use and storage of tools and equipment, potential presence of asbestos
- (AC2.2) **Safe systems at work:** Method statements, permit to work systems, risk assessments, safety signs and notices
- (AC2.3) **Categories:** Mandatory, prohibition, information, warning
- (AC2.4) **Symbols:** Toxic, harmful, corrosive, irritant, oxidising, extremely flammable
- (AC2.5) **Hazardous substances:** Solvents and lubricants, fluxes, jointing compounds, sealants, gases – LPG, oxy-acetylene and carbon dioxide, cleaning agents
- (AC2.6) **Precautions:** PPE, ventilation, risk assessment, method statements, safe systems of work.
- (AC2.7) **Types of asbestos:** White asbestos (Chrysotile), brown or grey asbestos (Amosite), blue asbestos (Crocidolite), asbestos cement materials
- (AC2.8) **Actions:** Stop working immediately, report to supervisor.
- (AC2.9) **Implications:** Long-term health implications (mesothelioma, asbestosis)
- (AC2.10) **Personal protective equipment:** Protection for: clothing (high visibility), eyes, hands, head, feet, hearing, respiratory system
- (AC2.11) **Procedures for manual handling:** Single, two-person lift, mechanical lift

- (AC2.12) **Actions:** Raising the alarm, contact emergency services, follow typical emergency evacuation procedures, inform supervisor.
- (AC2.13) **Procedures for handling injuries:** Make self safe, make area safe, contact nominated first aid person and/or emergency services, report to the responsible person.
- (AC2.14) **Procedures for recording accidents:** RIDDOR, the use of company accident books, details to be recorded.
-

Learning outcome

The learner will:

- 3 Know electrical safety requirements when working in the RACHP industry

Assessment criteria

The learner can:

- 3.1 identify the common electrical dangers to be aware of at work
- 3.2 list different sources of electrical supply for tools and equipment
- 3.3 describe reasons for using reduced voltage electrical supplies for tool and equipment at work
- 3.4 identify how to conduct a visual inspection of portable electrical equipment for safe condition before use
- 3.5 state actions to take when portable electrical equipment fails visual inspection
- 3.6 outline the Safe Isolation Procedure
- 3.7 state the procedures for dealing with electric shocks.
-

Range

- (AC3.1) **Electrical dangers:** Faulty electrical equipment, damaged electrical equipment, exposed conductors, damaged insulation, worn electrical cables and cords, trailing cables, proximity of cables, buried/hidden cables
- (AC3.2) **Sources:** Battery powered supplies, 110 volt supplies, 230 volt supplies, generating sets
- (AC3.3) **Reasons:** Increased likelihood for damage to equipment, operative in better contact with earth, protect from electric shock, reduces trailing leads.
- (AC3.4) **Visual inspection:** Checking for a valid PAT test, Inspection for general condition
- (AC3.5) **Actions:** Remove from use, report to supervisor
- (AC3.6) **Safe Isolation Procedure:** Working live is only permitted under special circumstances
- (AC3.7) **Procedures:** Removal from supply, CPR method, contact emergency services, report to supervisors, treatment of minor burns
-

Learning outcome

The learner will:

- 4 Know the safety requirements for working with gases and heat producing equipment

Assessment criteria

The learner can:

- 4.1 identify different types of gases used at work
 - 4.2 describe how gas cylinders and equipment should be safely transported and stored
 - 4.3 describe how to conduct a visual inspection on heat producing equipment for safe condition
 - 4.4 describe how combustion takes place
 - 4.5 state the dangers of working with heat producing equipment
 - 4.6 state the procedures to follow on discovery of fires at work
 - 4.7 identify different classifications of fires
 - 4.8 identify types of fire extinguisher for different classifications of fires.
-

Range

(AC4.1) **Types of gases:** Propane, butane, oxy-acetylene, nitrogen

(AC4.3) **Visual inspection:** Inspection for general condition

(AC4.4) **Combustion:** Three elements of the fire triangle

(AC4.5) **Dangers:** Fires, burns, fumes, equipment damage, explosions

(AC4.6) **Procedures:** Raise the alarm, follow safety evacuation procedures, call emergency services

(AC4.7) **Classifications of fires:** Class A, B, C, D, electrical fires

(AC4.8) **Fire extinguisher:** Carbon dioxide, water, powder, foam

Learning outcome

The learner will:

- 5 Know the safety requirements for using access equipment

Assessment criteria

The learner can:

- 5.1 identify different types of access equipment
 - 5.2 select suitable equipment for carrying out work at heights based on the work being carried out
 - 5.3 describe the safety checks to be carried out on access equipment
 - 5.4 describe safe erection methods for access equipment.
-

Range

(AC5.1) **Types of access equipment:** Step ladders, ladders, roof ladders and crawling boards, mobile tower scaffolds, podiums fixed scaffolds and edge protection, mobile elevated work platforms including scissor lifts and cherry pickers, telescopic ladders

- (AC5.2) **Work being carried out:** Duration at work, action points for heights
- (AC5.3) **Safety checks:** Visual, tagging, fit for purpose, secure level ground, operative's competency for use of equipment
- (AC5.4) **Access equipment:** Step ladders, ladders, roof ladders, mobile tower scaffolds, podiums, telescopic ladders
-

Learning outcome

The learner will:

- 6 Know the safety requirements for working safely in excavations and confined spaces in the RACHP industry

Assessment criteria

The learner can:

- 6.1 identify the situations in which it may be necessary to work in excavations
- 6.2 describe how excavations should be prepared for safe working
- 6.3 state precautions to be taken to make excavations safe
- 6.4 identify areas in which may become a confined space
- 6.5 state safety considerations when working in confined spaces.
-

Range

- (AC6.2) **Prepared:** Safe access into the excavation, trench support systems
- (AC6.3) **Precautions:** Use of warning signs, use of barriers, vehicle proximity to excavation edges
- (AC6.4) **Confined space:** Drainage systems, plant rooms, main service duct-rooms, in tanks, cylinders, boilers or cisterns, under suspended timber floors, in roof spaces.
- (AC6.5) **Safety considerations:** Ventilation, lighting, PPE, evacuation procedures, medical conditions, lone working
-

Learning outcome

The learner will:

- 7 Be able to apply safe working practice.

Assessment criteria

The learner can:

- 7.1 perform manual handling techniques
- 7.2 demonstrate the safe method of assembly of access equipment
- 7.3 use access equipment safely.

Range

(AC7.1) **Manual handling:** Single, two-person lift, using mechanical lifting aids

(AC7.2) **Access equipment:** Step ladders, ladders, mobile tower scaffolds

Unit level:	Level 2
GLH:	82
Unit aim:	This unit provides learners with the fundamental underpinning knowledge of refrigeration, air conditioning and heat pumps systems. It is structured by first introducing the units of measurement followed by their application to the principles of vapour compression systems and psychrometrics

Learning outcome

The learner will:

- 1 Know the standard units of measurement used in the RACHP sector.

Assessment criteria

The learner can:

- 1.1 define the System International (SI) units of measurement.

Range

(AC1.1) **SI units of measurement:Base units:** Metre (length) m., kilogram (mass) kg., second (time) s., Kelvin(temperature) K, ampere (electrical current) A.

(AC1.1) **Derived units:** Area (m²), volume (m³), litres (L), density (kg/m³), velocity (m/s), acceleration (m/s²), pressure (Pascal), specific volume (m³/kg) energy (J), enthalpy (kJ/kg), conductivity (W/mk), energy rate (W)

Learning outcome

The learner will:

- 2 Know fundamental thermodynamics.

Assessment criteria

The learner can:

- 2.1 describe the concept of temperature
- 2.2 describe temperature scales
- 2.3 define absolute zero
- 2.4 convert values between temperature scales

- 2.5 define the laws of thermodynamics
 - 2.6 describe the concept of heat as energy in transition
 - 2.7 describe how heat is transferred
 - 2.8 state the unit of heat
 - 2.9 state the unit used to describe the rate of heat transfer
 - 2.10 calculate rate of heat transfer
-

Range

(AC2.2, **Temperature scales:** Celsius, Kelvin

AC2.4)

(AC2.5) **Laws of thermodynamics:** First law, second law

(AC2.7) **Heat is transferred:** Conduction, convection, radiation.

Learning outcome

The learner will:

- 3 Know the forms of heat as found in RACHP systems

Assessment criteria

The learner can:

- 3.1 describe latent heat processes
 - 3.2 describe sensible heat processes
 - 3.3 define specific heat capacity
 - 3.4 define latent heat capacity
 - 3.5 use formulae to calculate quantity and rate of heat transfer.
-

Range

(AC3.1) **Latent heat processes :** Melting (Fusion), freezing, sublimation, condensation, evaporation, boiling

(AC3.2) **Sensible heat processes:** Super heating, sub-cooling, cooling, heating

(AC3.5) **Formulae:** $Q=mCt$, $Q=mL$, $Q/s=W$

Learning outcome

The learner will:

- 4 Know the principles of pressure.

Assessment criteria

The learner can:

- 4.1 define pressure
- 4.2 describe how units of pressure are derived

- 4.3 convert units of pressure
 - 4.4 describe pressure scales.
 - 4.5 describe the ideal gas laws
 - 4.6 describe Dalton's Law of partial pressures
 - 4.7 calculate a variable using the Combined Gas Law.
-

Range

(AC4.2, **Units of pressure:** Pascal, Bar, Millimetres of Hg

AC4.3)

(AC4.4) **Pressure scales :** Absolute, vacuum, gauge.

(AC4.5) **Ideal gas laws :** Boyle's law, Charles' law, Combined gas law, Daltons law

Learning outcome

The learner will:

- 5 Understand the saturated pressure temperature relationship.

Assessment criteria

The learner can:

- 5.1 describe the impact of changing pressures on saturation temperatures for a range of substances
 - 5.2 describe two phase mixes
 - 5.3 describe sensible heating processes in terms of superheat and sub-cooling
-

Range

(AC5.1) **Range of substances:** Water, refrigerants.

Learning outcome

The learner will:

- 6 Understand the vapour compression cycle.

Assessment criteria

The learner can:

- 6.1 understand the vapour compression cycle.
 - 6.2 plot the vapour compression cycle using a pressure enthalpy chart
 - 6.3 calculate using a pressure enthalpy chart a range of variables
-

Range

(AC6.2) **Pressure enthalpy chart:** Pressure, temperature, constant quality/dryness fraction, enthalpy, specific volume, latent, superheated and sub-cooled zones

(AC6.3) **Range of variables:** Work done, refrigeration effect, total heat rejected, Coefficient of Performance, mass flow rate, pressure ratio, compressor power input, specific volume at suction, cooling capacity, heating capacity (total rate of heat rejection)

Learning outcome

The learner will:

- 7 Understand the psychrometric processes in RACHP systems.

Assessment criteria

The learner can:

- 7.1 describe the properties of air
 - 7.2 define the relationship between specific volume and specific density
 - 7.3 differentiate between wet and dry bulb temperatures
 - 7.4 describe devices used for measuring wet and dry bulb temperatures
 - 7.5 plot a point on the psychrometric chart using any two given variables
 - 7.6 define from a given point on the psychrometric chart the values of remaining variables
 - 7.7 plot a process on a psychrometric chart
 - 7.8 calculate using a psychrometric chart a range of variables.
-

Range

- (AC7.1) **Properties of air:** Physical make-up, moisture content, temperature
- (AC7.4) **Devices:** Sling psychrometer, hygrometer
- (AC7.5, AC7.6) **Psychrometric chart :** Wet bulb temperature, dry bulb temperature, percentage saturation, moisture content, specific volume
- (AC7.8) **Range of variables:** Cooling capacity, heating capacity, quantity of condensate over time
-

Learning outcome

The learner will:

- 8 Know the general properties of materials used in the RACHP sector.

Assessment criteria

The learner can:

- 8.1 describe the common use of a range of materials
 - 8.2 describe the properties of a range of materials
-

Range

- (AC8.1) **Range of materials:** Steels (common varieties), copper and cuprous based alloys, aluminium and its alloys, natural and synthetic rubbers
- (AC8.2) **Properties of materials:** ductility, malleability, conductivity, tensile strength, compressive, strength, durability

Unit 203

Application of the fundamental principles of the vapour compression systems

Unit level:	Level 2
GLH:	68
Unit aim:	This unit enables learners to apply scientific principles to practical refrigeration systems. The unit commences with the theory of vapour compression systems in a practical environment discussing the important components and their operation. At its completion learners will have studied from basic systems through to system performance evaluation.

Learning outcome

The learner will:

- 1 know the fundamentals of the vapour compression system.

Assessment criteria

The learner can:

- 1.1 describe the function of an evaporator as defined by the pressure enthalpy chart
- 1.2 describe the function of a condenser as defined by the pressure enthalpy chart
- 1.3 describe the function of a compressor as defined by the pressure enthalpy chart
- 1.4 describe the impact of refrigerant state at the compressor inlet
- 1.5 describe the function of a metering device as defined by the pressure enthalpy chart
- 1.6 describe the impact of refrigerant state entering the metering device.

Range

(AC1.4, **Impact:** mass flow rate, cooling capacity, energy efficiency
AC1.6)

(AC1.4, **Refrigerant state:** Sub-cooled liquid, saturated liquid, saturated two phase mixture,
AC1.6) saturated vapour, superheated vapour

Learning outcome

The learner will:

- 2 know characteristics of line and pipe systems used in RACHP systems.

Assessment criteria

The learner can:

- 2.1 describe how **pipe characteristics** affect refrigerant and oil flow
 - 2.2 describe the impact of pressure drop on **system performance**
 - 2.3 describe the importance of pipe sizing for **system performance**
 - 2.4 describe how oil can be returned to the compressor using refrigerant vapour velocity.
 - 2.5 describe the impact of velocity changes on **system performance**. –
-

Range

(AC2.1) **Pipe characteristics:** Diameter, length, bends, fittings, orientation, equation of continuity

(AC2.2, **System Performance:** Flash gas, oil return, velocity, saturation temperature, mass flow
AC2.5) rate, cooling/heating capacity, refrigerants, operating temperatures and pressures, efficiency, pressure drop vs velocity

Learning outcome

The learner will:

- 3 know how properties of air are changed by cooling or heating systems.

Assessment criteria

The learner can:

- 3.1 describe how vapour compression systems change the properties of air using a psychrometric chart
 - 3.2 describe the range of air conditioning systems in common use
 - 3.3 describe the effect of air temperature on its moisture content.
-

Range

(AC3.1) **Vapour compression systems:** Split system for a single room cooling application, fruit and vegetable chill store system, freezer cold room system

(AC3.1) **Properties:** Air temperature, moisture content

(AC3.2) **Air conditioning systems:** Human comfort cooling/heating, close control, data system cooling de-humidification

Learning outcome

The learner will:

- 4 know the principles of operation of heat pumps.

Assessment criteria

The learner can:

- 4.1 describe the operation of heat pumps using a pressure enthalpy chart

4.2 compare potential heat pump efficiency against traditional heating methods

Range

(AC4.1) **Heat pumps:** Ground source, air source

(AC4.2) **Traditional heating methods:** Gas boiler, electric heating

Learning outcome

The learner will:

5 know the impact of operating conditions on system performance

Assessment criteria

The learner can:

5.1 describe how system performance is affected when both internal and external environmental conditions change using a pressure enthalpy chart

5.2 describe how system performance is affected by common system faults using a pressure enthalpy chart.

Range

(AC5.1) **Environmental conditions:** Higher than design ambient temperatures, lower than design ambient temperatures for condensers and evaporators

(AC5.2) **Common system faults:** Blocked condenser, blocked evaporator, shortage of refrigerant, reduced air flow

Unit 204

Functions and features of RACHP systems and components

Unit level:	Level 2
GLH:	87
Unit aim:	The purpose of this unit is to provide learners with the knowledge of a range of RACHP systems and their components. Learners will be able to use their knowledge of systems and their components in order to relate to and analyse systems related problems.

Learning outcome

The learner will:

- 1 know the function of a range of RACHP system components.

Assessment criteria

The learner can:

- 1.1 describe the construction of system components used in the RACHP industry
- 1.2 describe the function of system components used in the RACHP industry
- 1.3 describe the operating principles of system components used in the RACHP industry

Range

(AC1.1, **System components:**

AC1.2, Compressors:

AC1.3) Reciprocating, rotary

Condensers:

Air, liquid cooled, evaporative.

Evaporators:

Forced draft, induced draft, natural convection, liquid cooling, direct expansion, flooded

Expansion devices:

Capillary tube restrictor, thermostatic expansion valves (internally and externally equalised), linear/electronic expansion valves, liquid level control.

Ancillary components:

Liquid and suction line driers, pressure relief valves, strainers, oil separators, moisture indicating sight glass, service valves.

Storage vessels:

Suction line accumulator, high pressure receivers.

Control valves:

Four way reversing, solenoid, evaporator, crankcase, differential pressure regulators, non return valves.

Fans:

Axial, centrifugal.

Learning outcome

The learner will:

- 2 know the operating principles for a range of RACHP system applications.

Assessment criteria

The learner can:

- 2.1 describe the operating principles of RACHP systems
 - 2.2 describe how operating principles apply in a range of system applications
-

Range

- (AC2.1) **Operating principles:** Temperature difference (TD), airflow, defrost methods, system controls, 1st and 2nd law of thermodynamics
- (AC2.2) **System applications:** Blast freezing, cold storage, chill storage, liquid chillers, air conditioning, dehumidifiers, heat pumps
-

Learning outcome

The learner will:

- 3 know the properties of refrigerants.

Assessment criteria

The learner can:

- 3.1 assess how well primary refrigerants meet ideal properties
 - 3.2 assess how well secondary refrigerants meet ideal properties
 - 3.3 select refrigerants for a range of applications with respect to their environmental impact
 - 3.4 explain the differences between pure fluids, azeotropic and zeotropic refrigerants
 - 3.5 describe the hazard groups for toxicity and flammability
-

Range

- (AC3.1) **Primary refrigerant ideal properties:** Has an odour, non-flammable, non-toxic, miscible with oil, high latent heat value, easily leak detectable, efficient pressure ratio, non-ozone depleting, non-global warming potential, high dielectric strength, high density
- (AC3.1) **Primary refrigerants:** HFC, HFO, HC, natural refrigerants
- (AC3.2) **Secondary refrigerant ideal properties:** Low viscosity, non-toxic, non-flammable, high specific heat value, low cost, non-corrosive, low freezing point
- (AC3.2) **Secondary refrigerants:** Water, propylene glycol, ethylene glycol, brines
-

(AC3.3) **Range of applications:** Air conditioning, cold storage, chill storage, heat pumps, blast freezing.

(AC3.3) **Environmental impact:** Ozone depletion, global warming /climate change

(AC3.5) **Hazard groups:** A, B.
1, 2L, 2, 3.

Learning outcome

The learner will:

4 know the properties of oils.

Assessment criteria

The learner can:

- 4.1 describe the properties of an ideal oil
 - 4.2 explain why oils must be matched with the system refrigerant
 - 4.3 explain the differences between synthetic and mineral oils.
-

Range

(AC4.1) **Properties :** Low floc point, low pour point, low viscosity, high dielectric strength, low foaming tendency, high flashpoint, low hygroscopic effect, low acidity, low moisture content, low toxicity, high miscibility with refrigerant

Learning outcome

The learner will:

5 know the operating principles of a range of system controls.

Assessment criteria

The learner can:

- 5.1 describe the operating principles of system controls
 - 5.2 describe the operating principles for defrost systems.
 - 5.3 describe control circuits for a variety of applications.
-

Range

(AC5.1) **System controls:** Pressure controls, temperature controls (for cooling, for heating), time controls, sequence controllers, flow switches

(AC5.1) **System control operating principles:** Electro-mechanical, electronic

(AC5.2) **Defrost operating principles:** Initiation, termination, defrost sequence

(AC5.2) **Defrost systems:** Off cycle, electric, hot gas, saturated gas

(AC5.3) **Control circuits:** Refrigeration, air conditioning, heat pump applications

Learning outcome

The learner will:

- 6 know the function and operation of a range of test instruments used in the RACHP industry

Assessment criteria

The learner can:

- 6.1 identify the function of test instruments
- 6.2 describe how test instruments operate
- 6.3 describe how test instruments are used.

Range

(AC6.1, **Test instruments:** Pressure gauges, service manifolds, thermometers, anemometers, AC6.2, sling psychrometers, hydrometers, scales, leak detectors AC6.3)

Unit 205

Service and maintain RACHP systems

Unit level:	Level 2
GLH:	48
Unit aim:	The purpose of this unit is for learners to gain knowledge of the principles of servicing and maintaining RACHP systems and develop the skills needed to apply those principles. The skills developed will enable them to carry out service and maintenance tasks on a variety of systems. This unit refers to mechanical fault finding. Fault finding on electrical circuits is addressed in Electrical systems for RACHP unit.

Learning outcome

The learner will:

- 1 know service and maintenance principles for RACHP systems.

Assessment criteria

The learner can:

- 1.1 identify faults on RACHP system components
- 1.2 describe symptoms of component faults in RACHP systems
- 1.3 describe maintenance requirements for RACHP systems
- 1.4 identify effects of component failure on other RACHP system components
- 1.5 identify sources of information which aid service and maintenance of RACHP systems
- 1.6 identify information included in documentation when completing service and maintenance activities on RACHP systems.

Range

(AC1.1) **RACHP system:** Single stage vapour compression systems

(AC1.2, **System components:** Compressors:

AC1.4) Reciprocating, rotary

Condensers:

Air, liquid cooled, evaporative.

Evaporators:

Forced draft, induced draft, natural convection, liquid cooling, direct expansion, flooded

Expansion devices:

Capillary tube restrictor, thermostatic expansion valves (internally and externally equalised), linear/electronic expansion valves, liquid level control.

Ancillary components:

Liquid and suction line driers, pressure relief valves, strainers, oil separators, moisture indicating sight glass, service valves.

Storage vessels:

Suction line accumulator, high pressure receivers.

Control valves:

Four way reversing, solenoid, evaporator, crankcase, differential pressure regulators, non return valves.

Fans:

Axial, centrifugal.

(AC1.3) **Maintenance:** Preventative or reactive maintenance

(AC1.3) **Requirements:** Cleaning, component replacement, leak testing, visual inspection

(AC1.5) **Sources of information:** Previous service reports, operations manuals, customer, senses.

(AC1.6) **Documentation:** Log books, job sheets, certificates, site logs, permits to work, maintenance sheets, parts requisition sheets

Learning outcome

The learner will:

2 be able to service and maintain RACHP system

Assessment criteria

The learner can:

2.1 identify faults on RAC HP systems

2.2 prepare RAC HP systems for service and maintenance

2.3 rectify RACHP systems faults

2.4 restore original state of RACHP systems following service and maintenance

2.5 assess fitness for purpose of tools and equipment

2.6 record service and maintenance activities

2.7 comply with regulations and standards while carrying out service and maintenance.

Range

(AC2.3) **Rectify:** Replace components, cleaning components, calibrate, adjust, align

Unit 206

Install and commission RACHP systems

Unit level:	Level 2
GLH:	47
Unit aim:	This unit aims to develop in learners the ability to apply a range of skills related to installation and commissioning of single stage RACHP systems.

Learning outcome

The learner will:

- 1 be able to prepare for installation of RACHP systems.

Assessment criteria

The learner can:

- 1.1 collate information available prior to planning the installation activities
- 1.2 list resources required for installation activities
- 1.3 identify roles and responsibilities of persons involved
- 1.4 conduct risk assessment for installation activities
- 1.5 complete permit to work
- 1.6 identify variations to original planned work
- 1.7 identify safe storage for all resources prior to commencement of the installation
- 1.8 identify services required for the installation.

Range

- (AC1.1) **Information:** Regulatory documents, industry codes of practice, manufacturers' instructions, installation specifications
- (AC1.2) **Resources:** Tools, equipment and materials, documentation.
- (AC1.3) **Persons involved:** Self, colleagues, supervisor, client, general public, health and safety officer
- (AC1.5) **Complete:** Prior to installation, on completion
- (AC1.8) **Services:** Electricity, water, drainage, ventilation, gas

Learning outcome

The learner will:

- 2 be able to install RACHP systems.

Assessment criteria

The learner can:

- 2.1 form pipework using a range of jointing methods
 - 2.2 position system components
 - 2.3 assemble interconnecting pipework
 - 2.4 fix pipework
 - 2.5 use oxygen free nitrogen for purging during flame brazing operations
 - 2.6 use protective measures when flame brazing temperature sensitive system components
 - 2.7 apply insulation to pipework systems
 - 2.8 compare installed system with system drawings.
-

Range

- (AC2.1) **Form:** Braze (oxy -fuel), flare, bend, swage, other mechanical joints
- (AC2.1) **Jointing methods:** Similar and dissimilar metals with hot and cold joints – mechanical and compression, Cu/Al joints
- (AC2.2) **System components:** Condensing units, evaporators, condensate drains, valves, electrical cabling, drier, pressure switches, pumps, sight glass, vessels
- (AC2.4) **Fix:** Vibration damping clamps, pipe saddles, pipe clips, insulated clamps
- (AC2.6) **Protective measures:** Wet rag, non-conductive foam, temporary removal of low melting point items
- (AC2.6) **Temperature sensitive system components:** Thermostatic expansion valves, solenoid valves, vibration eliminators, schrader valves, pressure transducers
- (AC2.7) **Apply:** Pre-insulated, cut and glue, continuous, mitred, insulated tape
-

Learning outcome

The learner will:

3. be able to commission RACHP systems

Assessment criteria

The learner can:

- 3.1 record commissioning activities
-

Learning outcome

The learner will:

- 4 be able to handover RACHP systems.

Assessment criteria

The learner can:

- 4.1 demonstrate system operation
 - 4.2 explain maintenance requirements for the system
 - 4.3 document installation activities
-

Range

(AC4.1) **System operation:** Set system controls

(AC4.3) **Document:** Job sheet/card, commissioning sheet, F gas records

Unit 207

Electrical systems for RACHP systems

Unit level:	Level 2
GLH:	48
Unit aim:	This unit applies knowledge and related practical skills required to undertake safe testing and fault finding on single phase RACHP systems. This unit refers to fault finding on electrical circuits. Mechanical fault finding is addressed in Service and maintain RACHP systems.

Learning outcome

The learner will:

- 1 Know the fundamental principles of electrical systems used in RACHP systems.

Assessment criteria

The learner can:

- 1.1 identify the fundamental principles of electricity
- 1.2 identify the fundamental principles of electrical circuits used in RACHP circuits
- 1.3 identify the fundamental working principles of electrical controls
- 1.4 identify the working principles of electrical components
- 1.5 identify the starting arrangements for single phase compressor motors.
- 1.6 describe the requirements of the Electricity at work regulations for safe working

Range

- (AC1.1) **Principles of electricity:** Ohms Law, direct current and alternating current, potential difference, resistance, capacitance, frequency, impedance, current, power, electrical shock potential and its consequences
- (AC1.2) **Principles of circuits:** Single phase, earthing and bonding, series, parallel
- (AC1.3) **Electrical controls:** Pressure switches, thermostats, flow switches, over current/over temperature (bimetal, PTC, NTC), relays (current, potential, solid state)
- (AC1.4) **Electrical components:** Single phase motors, coils, transformers, heaters, lights
- (AC1.5) **Starting arrangements:** Resistance start induction run (RSIR), capacitor start induction run (CSIR), capacitor start and run (CSR)
- (AC1.6) **Electricity at Work Regulations:** Safe isolation – not working live.

Learning outcome

The learner will:

- 2 Know the requirements of electrical test instruments.

Assessment criteria

The learner can:

- 2.1 identify the test instruments used to measure electrical circuits
- 2.2 identify scales used to measure electrical circuits
- 2.3 state when it is appropriate to carry out an insulation resistance test using a megaohm meter
- 2.4 describe importance of Guidance Note GS38 for use of electrical test instruments.

Range

(AC2.1, **Electrical circuits:** Continuity, short circuit, open circuit, insulation resistance, polarity, AC2.2) current, voltage, capacitance.

Learning outcome

The learner will:

- 3 Be able to test electrical circuits.

Assessment criteria

The learner can:

- 3.1 select testing instruments
- 3.2 check testing instruments are calibrated
- 3.3 use testing instruments on electrical circuits
- 3.4 record measurements

Range

(AC3.1, **Testing instruments:** Multimeter, ammeter, voltmeter, megaohm meter, capacitance AC3.2) tester
(AC3.3) **Electrical circuits:** Continuity, short circuit, open circuit, insulation resistance, polarity, current, voltage (a.c, d.c), capacitance
(AC3.3) **Use:** Use appropriate scales, operate safely

Learning outcome

The learner will:

- 4 Be able to fault find in electrical circuits for RACHP systems.

Assessment criteria

The learner can:

- 4.1 carry out safe isolation
 - 4.2 identify electrical faults on RACHP system components
 - 4.3 replace faulty components
 - 4.4 carry out tests
 - 4.5 record recommissioning activities and test values.
-

Range

(AC4.2, **Components:** Motors, switches, heaters, relays, conductors, thermistors, transformers, AC4.3) coils
(AC4.4, **Tests:** Visual inspection, earth continuity and resistance, load circuit continuity and AC4.5) resistance, insulation resistance, polarity, functionality.

Learning outcome

The learner will:

- 5 Fix and terminate cabling.

Assessment criteria

The learner can:

- 5.1 fix cabling
 - 5.2 terminate cabling
-

Range

(AC5.1) **Cabling:** Multi-core flex, steel wire armoured, single conductor, twin and earth, braided sheath cable, screened.
(AC5.2) **Terminate:** Insulated crimps, non-insulated crimps

Appendix 1 Relationships to other qualifications

Links to other qualifications

Centres are responsible for checking the different requirements of all qualifications they are delivering and ensuring that candidates meet requirements of all units/qualifications.

Literacy, language, numeracy and ICT skills development

This [these] qualification[s] can develop skills that can be used in the following qualifications:

- Functional Skills (England) – see www.cityandguilds.com/functionalskills
- Essential Skills (Northern Ireland) – see www.cityandguilds.com/essentialskillsni
- Essential Skills Wales – see www.cityandguilds.com/esw

Appendix 2 Sources of general information

The following documents contain essential information for centres delivering City & Guilds qualifications. They should be referred to in conjunction with this handbook. To download the documents and to find other useful documents, go to the Centres and Training Providers homepage on www.cityandguilds.com.

Centre Manual - Supporting Customer Excellence contains detailed information about the processes which must be followed and requirements which must be met for a centre to achieve 'approved centre' status, or to offer a particular qualification, as well as updates and good practice exemplars for City & Guilds assessment and policy issues.

Specifically, the document includes sections on:

- The centre and qualification approval process
- Assessment, internal quality assurance and examination roles at the centre
- Registration and certification of candidates
- Non-compliance
- Complaints and appeals
- Equal opportunities
- Data protection
- Management systems
- Maintaining records
- Assessment
- Internal quality assurance
- External quality assurance.

Our Quality Assurance Requirements encompasses all of the relevant requirements of key regulatory documents such as:

- SQA Awarding Body Criteria (2007)
- NVQ Code of Practice (2006)

and sets out the criteria that centres should adhere to pre and post centre and qualification approval.

Access to Assessment & Qualifications provides full details of the arrangements that may be made to facilitate access to assessments and qualifications for candidates who are eligible for adjustments in assessment.

The **centre homepage** section of the City & Guilds website also contains useful information on such things as:

- **Walled Garden:** how to register and certificate candidates on line
- **Events:** dates and information on the latest Centre events
- **Online assessment:** how to register for e-assessments.

Centre Guide – Delivering International Qualifications contains detailed information about the processes which must be followed and requirements which must be met for a centre to achieve 'approved centre' status, or to offer a particular qualification.

Specifically, the document includes sections on:

- The centre and qualification approval process and forms

- Assessment, verification and examination roles at the centre
- Registration and certification of candidates
- Non-compliance
- Complaints and appeals
- Equal opportunities
- Data protection
- Frequently asked questions.

Appendix 3 Useful contacts

UK learners General qualification information	E: learnersupport@cityandguilds.com
International learners General qualification information	E: intcg@cityandguilds.com
Centres Exam entries, Certificates, Registrations/enrolment, Invoices, Missing or late exam materials, Nominal roll reports, Results	E: centresupport@cityandguilds.com
Single subject qualifications Exam entries, Results, Certification, Missing or late exam materials, Incorrect exam papers, Forms request (BB, results entry), Exam date and time change	E: singlesubjects@cityandguilds.com
International awards Results, Entries, Enrolments, Invoices, Missing or late exam materials, Nominal roll reports	E: intops@cityandguilds.com
Walled Garden Re-issue of password or username, Technical problems, Entries, Results, e- assessment, Navigation, User/menu option, Problems	E: walledgarden@cityandguilds.com
Employer Employer solutions, Mapping, Accreditation, Development Skills, Consultancy	E: business@cityandguilds.com

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City & Guilds

1 Giltspur Street

London EC1A 9DD

www.cityandguilds.com
