City & Guilds Level 2 Diploma in Refrigeration, Air-conditioning and Heat Pump (RACHP) Systems (6090-21)

Version 1.5 (September 2025)

Qualification Handbook

Qualification at a glance

Subject area	Building Services Engineering (BSE)
City & Guilds number	6090-21
Age group approved	16-18, 19+
Entry requirements	N/A
Assessment	Multiple-choice test Practical assignment
Grading	Pass/Fail
Approvals	Full approval required
Support materials	Sample Assessment Materials (SAMs), Qualification Handbook
Registration and certification	Consult the Walled Garden/Online Catalogue for last dates
Occupational Standard	ST0322 Refrigeration, air-conditioning and heat pump engineering technician

Title and level	City & Guilds qualification number	Regulatory reference number	GLH	TQT
City & Guilds Level 2 Diploma in Refrigeration, Air-Conditioning and Heat Pump Systems	6090-21	610/5044/1	450	495

Version and date	Change detail	Section
1.0 November 2024	Initial version	All
1.1 March 2025	Formatting amendments	All
1.2 May 2025	Revision to Dynamic pressure formula	Unit 202 3.2.2
1.3 July 2025	Updated duration of practical on-demand assignment to 35 hours	4. Assessment
1.4 July 2025	Amplification to knowledge content elements and formatting amendments	Throughout
1.5 September 2025	Removal of duplicated content	Throughout
	Inclusion of practical assessments breakdown	4. Assessment
	Updated test specifications in line with content	4. Assessment

Contents

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 who wish to gain the knowledge and skills required to commence a career within the refrigeration, air-conditioning and heat pump (RACHP) industry. Learners will cover the underpinning skills and knowledge that will enable them to seek or gain employment within the sector and prepare them to move onto the apprenticeship programme once in employment. This qualification is suitable for those aged 16 years plus.
What does the qualification cover?	This qualification aligns to the knowledge skills and behaviours in the ST0322 Refrigeration, air conditioning and heat pump engineering technician occupational standard. Learners will cover the underpinning skills and knowledge that will enable them to seek or gain employment within the sector and prepare them to move onto the apprenticeship programme once in employment.
What opportunities for progression are there?	Learners will have the opportunity to progress onto further study or an apprenticeship or secure an entry-level role in the RACHP.
Is it part of an apprenticeship framework or initiative?	This is not part of a framework or initiative but will prepare the learner to embark on the apprenticeship programme for ST0322 Refrigeration, air conditioning and heat pump engineering technician occupational standard.

Structure

To achieve the City & Guilds Level 2 Diploma in Refrigeration, Air-Conditioning and Heat Pump (RACHP) Systems learners must achieve all mandatory units below:

City & Guilds unit number	Unit title	GLH
Mandatory units:		
201	Principles of welfare, health and safety in RACHP environments	50
202	Scientific principles in RACHP systems	100
203	Vapour compression systems (single compressor/single evaporator) in RACHP	50
204	Service, maintenance and repair of RACHP systems	80
205	Install and commission RACHP (refrigeration circuit) systems	80
206	Electrical systems (single phase) for RACHP	90

Total Qualification Time (TQT)

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 demonstrate the achievement of the level of attainment necessary for the award of a qualification.

TQT comprises of the following two elements:

1) the number of hours that an awarding organisation has assigned to a qualification for guided learning
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
City & Guilds Level 2 Diploma in Refrigeration, Air-Conditioning and Heat Pump (RACHP) Systems	450	495

2 Centre requirements

Approval

Full approval

To offer this qualification, new centres will need to gain both centre and qualification approval. Please refer to the document **Centre Approval Process: Quality Assurance Standards** for further information.

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

Or

Automatic approval

If your centre is approved to offer the 6090-20 you will be automatically approved to offer the new 6090-21. Please refer to the document **Centre Approval Process: Quality Assurance Standards** for further information.

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

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Resource requirements

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.

Continuing professional development (CPD)

Centres are expected to support their staff in ensuring that their knowledge remains current of the occupational area and of best practice in delivery, mentoring, training, assessment and quality assurance, and that it takes account of any national or legislative developments.

Quality assurance

Approved centres must have effective quality assurance systems to ensure optimum delivery and assessment of qualifications. Quality assurance includes initial centre approval, qualification approval and the centre's own internal procedures for monitoring quality. Centres are responsible for internal quality assurance and City & Guilds is responsible for external quality assurance. All external quality assurance processes reflect the minimum requirements for verified and moderated assessments, as detailed in the Centre Assessment Standards Scrutiny (CASS), section H2 of Ofqual's General Conditions. For more information on both CASS and City & Guilds Quality Assurance processes visit: the **What is CASS?** and **Quality Assurance Standards** documents on the City & Guilds website.

Standards and rigorous quality assurance are maintained by the use of:
- Internal quality assurance
- City & Guilds external quality assurance.

In order to carry out the quality assurance role, Internal Quality Assurers must
- have appropriate teaching and vocational knowledge and expertise
- have experience in quality management/internal quality assurance
- hold or be working towards an appropriate teaching/training/assessing qualification
- be familiar with the occupation and technical content covered within the qualification.

External quality assurance for the qualification will be provided by City & Guilds EQA process. EQAs are appointed by City & Guilds to approve centres, and to monitor the assessment and internal quality assurance carried out by centres. External quality assurance is carried out to ensure that assessment is valid and reliable, and that there is good assessment practice in centres.

The role of the EQA is to:
- provide advice and support to centre staff
- ensure the quality and consistency of assessments and marking/grading within and between centres by the use of systematic sampling
- provide feedback to centres and to City & Guilds.

Learner entry requirements

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

This qualification is approved for learners aged 16 or above.

Access arrangements and reasonable adjustments

City & Guilds has considered the design of this qualification and its assessments in order to best support accessibility and inclusion for all learners. We understand however that individuals have diverse learning needs and may require reasonable adjustments to fully participate. Reasonable adjustments, such as additional time or alternative formats, may be provided to accommodate learners with disabilities and support fair access to assessment.

Access arrangements are adjustments that allow learners with disabilities, special educational needs, and temporary injuries to access the assessment and demonstrate their skills and knowledge without changing the demands of the assessment. These arrangements must be made before assessment takes place.

The Equality Act 2010 requires City & Guilds to make reasonable adjustments where a disabled person would be at a substantial disadvantage in undertaking an assessment.

It is the responsibility of the centre to ensure at the start of a programme of learning that learners will be able to access the requirements of the qualification.

Please refer to the JCQ access arrangements and reasonable adjustments and Access arrangements - when and how applications need to be made to City & Guilds for more information. Both are available on the City & Guilds website:
http://www.cityandguilds.com/delivering-our-qualifications/centre-development/centre-document-library/policies-and-procedures/access-arrangements-reasonable-adjustments

3 Delivering the qualification

Initial assessment and induction

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

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

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

Inclusion and diversity

City & Guilds is committed to improving inclusion and diversity within the way we work and how we deliver our purpose which is to help people and organisations develop the skills they need for growth.

More information and guidance to support centres in supporting inclusion and diversity through the delivery of City & Guilds qualifications can be found here:

Inclusion and diversity | City & Guilds (cityandguilds.com)

Sustainability

City & Guilds are committed to net zero. Our ambition is to reduce our carbon emissions by at least 50% before 2030 and develop environmentally responsible operations to achieve net zero by 2040 or sooner if we can. City & Guilds is committed to supporting qualifications that support our customers to consider sustainability and their environmental footprint.

More information and guidance to support centres in developing sustainable practices through the delivery of City & Guilds qualifications can be found here:

Our Pathway to Net Zero | City & Guilds (cityandguilds.com)

Centres should consider their own carbon footprint when delivering this qualification and consider reasonable and practical ways of delivering this qualification with sustainability in mind. This could include:

- reviewing purchasing and procurement processes (such as buying in bulk to reduce the amount of travel time and energy, considering and investing in the use of components that can be reused, instead of the use of disposable or single use consumables)

- reusing components wherever possible
- waste procedures (ensuring that waste is minimised, recycling of components is in place wherever possible)
- minimising water use and considering options for reuse/salvage as part of RACHP activities wherever possible.

Support materials

The following resources are available for this qualification:

Description	How to access
Qualification handbook	**www.cityandguilds.com**
Sample assessments	**www.cityandguilds.com**

Time constraints

Qualification registration is valid for five years.

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.

RPL is allowed and is also sector specific.

4 Assessment

Assessment of the qualification

For City & Guilds Level 2 Diploma in Refrigeration, Air-Conditioning and Heat Pump (RACHP) (Diploma), learners must successfully complete the following assessments:

Assessment component	Method	Duration	Marks	Marking approach	Grading
250	On-demand E-volve online MCQ	60 minutes	35	Externally set and externally marked	Pass/Fail
251	On-demand practical assignment	35 hours	N/A	Internally marked and externally verified	Pass/Fail
	Assessment 1 – Install a RACHP system	17 hours			
	Assessment 2 – Service and maintain RACHP systems	9 hours			
	Assessment 3 – Install electrical systems for RACHP	9 hours			

Learners must pass **all** assessment components to achieve the qualification.

Test specifications

The assessment specifications outlined in the following tables highlight at high level the way that the qualification content will be assessed within the different assessment components.

The table below highlights at high level the way that the knowledge is covered within the **250 test**.

Permitted materials: Permitted materials (A3 psychrometric chart recommended, pen, ruler and calculator) will be given to learners by centres.

Graded: Pass/Fail

Pass mark: the pass mark for this examination is set at approximately 58%.

This boundary may be subject to slight variation to ensure fairness should any variations in the difficulty of the individual assessment versions be identified.

Test: 250	Duration: 60 minutes		
Unit	**Outcome**	**Number of questions per unit**	**Percentage % (rounded to nearest %)**
201	LO1 Understand health and safety regulations, roles and responsibilities in RACHP LO2 Understand accident and emergency reporting procedures and documentation LO3 Manage workplace hazards and risks LO4 Know safe storage requirements for materials and equipment LO5 Understand access requirements and equipment when working at heights LO6 Understand safety considerations when working with electricity and gas LO7 Know Personal Protective Equipment (PPE) responsibilities LO8 Understand factors that impact on physical and mental welfare maintenance and management	10	29%
202	LO1 Know the standard units of measurement used in RACHP industry L02 Know the scientific relationship between heat, energy and power in vapour compression systems LO3 Know the principles of force, pressure and the relationship to fluid flow LO4 Understand how to apply the mechanical principles of the vapour compression cycle to the pressure enthalpy (Ph) diagram LO5 Understand psychrometric processes LO6 Understand the general properties of materials used in RACHP LO7 Understand the functions, features and operating principles of system components, refrigerants and lubricants (oils).	9	25%

203	LO1 Know the characteristics of line and pipe systems used in RACHP systems LO2 Understand the principles of operation of RACHP systems (single compressor/ evaporator systems), LO3 Understand the environmental impact and conditions that affect system performance.	3	9%
204	LO1 Know how to troubleshoot and repair RACHP systems using modern diagnostics technology LO2 Perform basic repairs and preventative and routine maintenance LO3 Perform practical servicing and maintenance skills	5	14%
205	LO1 Know how to plan and prepare for installation of RACHP systems.		
206	LO1 Understand the fundamental principles of electrics LO2 Understand the requirements of test instruments	8	23%
	Total	35	100%

Assessment objectives

The following assessment objectives are used within the **assessment component 351**. The weightings for how the assessment objectives are applied in the assessment are shown in the table below.

Assessment objective	Description	Weighting
AO1a Demonstrate knowledge of the content	The ability to demonstrate basic recall of relevant knowledge in response to straightforward questioning.	19 marks – 54%
AO1b Demonstrate understanding of the content	The ability to demonstrate understanding of principles and concepts beyond recall of definitions.	6 marks – 17%
AO2 Apply knowledge and understanding of the content to different situations and contexts	Applying knowledge and understanding taking the understanding of generalities and applying them to specific situations.	10 marks – 29%

The table below highlights at high level the way that the practical assessment is covered within the **251 assessment**.

Permitted materials: Permitted materials (manufacturers/installation instructions, calculator/slide rule) will be given to learners by centres.

Graded: Pass/Fail.

Learners must gain a Pass in all tasks within the assignment to achieve a pass overall for this component.

Unit	Outcome	Assessment
201	LO3 Manage workplace hazards and risks LO7 Know Personal Protective Equipment (PPE) responsibilities	1 – Install a RACHP system 2 – Service and maintain RACHP systems 3 – Install electrical systems for RACHP
202	LO7 Understand the functions, features and operating principles of system components, refrigerants and lubricants (oils).	1 – Install a RACHP system
204	LO2 Perform basic repairs and preventative and routine maintenance LO3 Perform practical servicing and maintenance skills	2 – Service and maintain RACHP systems
205	LO2 Install and test RACHP systems LO3 Commission RACHP (refrigeration circuit) systems LO4 Handover RACHP systems	1 – Install a RACHP system
206	LO1 Understand the fundamental principles of electrics LO3 Test circuits and fault find LO4 Install, test and commission an electrical control system for RACHP	3 – Install electrical systems for RACHP

5 Units

Structure of the units

These units each have the following:

- City & Guilds reference number
- title
- level
- guided learning hours (GLH)
- unit aim
- assessment type
- learning outcomes, which are comprised of a number of topics
- content elements
- supporting information
- relationship to /occupational standards inc. reference.

Unit guidance for delivery

This qualification comprises a number of **units**. A unit describes what is expected of a competent person in particular aspects of their job.

Each **unit** is divided into **learning outcomes** which describe in further detail the knowledge and skills that a learner should possess.

Each **learning outcome** has a set of **topics** (knowledge or skills) that are simple and concise statements that indicates to a learner something specific they will be learning in relation to the learning outcome. It should provide clarity to a learner at a high level on what they should be expecting to learn or be able to do about a specific area of the learning outcome.

Content (What needs to covered) the content sections define the 'depth and breadth' to which the teaching / learning must be delivered.

It is important that these sections define all the essential content that must be covered for learners to achieve the learning outcome. It is the information in this section that learners will be assessed on.

Unit 201 Principles of welfare, health and safety in RACHP environments

Unit level:	Level 2
Guided Learning Hours (GLH):	50
Unit aim:	This is a **theory** and **practical** unit. The purpose of this unit is to provide learners with the knowledge required to enable them to carry out safe working practices in Refrigeration, Air-Conditioning Heat Pumps (RACHP) environments. This unit covers RACHP sector knowledge including awareness of key health and safety legislation and regulations and through completion of the unit learners will understand the roles and responsibilities of employers and employees in maintaining safe environments. It also covers processes for hazard identification, risk assessments, accident reporting, emergency response, and welfare provision. Learners will gain knowledge on health and safety to operate safely in the RACHP sector, safe working practices relating to working at height, electrical safety, safety requirements for gas, manual handling, PPE, and fire prevention.
Assessment method:	Externally set, Multiple Choice Question (MCQ) exam, online, on-demand Practical assessment.
Links to Occupational Standards:	ST0322 Refrigeration, air conditioning and heat pump engineering technician

Learning outcomes

1. Understand health and safety regulations, roles and responsibilities in RACHP
2. Understand accident and emergency reporting procedures and documentation
3. Manage workplace hazards and risks
4. Know safe storage requirements for materials and equipment
5. Understand access requirements and equipment when working at heights
6. Understand safety considerations when working with electricity and gas
7. Know Personal Protective Equipment (PPE) responsibilities
8. Understand factors that impact on physical and mental welfare maintenance and management

Learning outcome 1

Understand health and safety regulations, roles and responsibilities in RACHP

Topics	Content elements
1.1 Legislation and the roles of employers and employees	1.1.1 Key RACHP employee considerations for health and safety legislation and where information can be found. a. Legislation, codes of practice and standards i. Health And Safety at Work Act (HASWA) • follow workplace procedures and systems • follow slips, trips and fall prevention methods • use equipment and Personal Protective Equipment (PPE) properly • report any issues or risks • employees must ensure their own safety and the safety of others. ii. Reporting Injuries Diseases and Dangerous Occurrences Regulations (RIDDOR) • report any work-related incidents • comply with reporting procedures iii. Control of Substances Hazardous to Health (COSHH) • follow instructions for safe use • implement control measures • report exposure incidents iv. Construction, Design and Management (CDM) regulations • take care of own health and safety • be aware of the safety of others who may be affected by own actions • report potential safety issues to the employer v. Provision and Use of Work Equipment Regulations (PUWER) • use equipment only if trained • report any faulty equipment • follow safety instructions provided vi. Manual Handling Operations Regulations (MHR) • follow safe lifting techniques • use aids where provided • report unsafe loads or practices vii. Personal Protective Equipment (PPE) at Work Regulations • use PPE correctly as instructed • maintain PPE correctly • report any defects or issues viii. Work at Height Regulations (WAHR) • use safety equipment provided • follow training and procedures ix. Control of Noise at Work Regulations (CNWR) • wear hearing protection when required • follow noise control procedures • report potential issues or over-exposure x. Control of Vibration at Work Regulations (CVWR) • take regular rest breaks when using vibrating tools • report potential symptoms of vibration exposure • implement control measures xi. Electricity at Work Regulations (EAWR)

Topics	Content elements
	• visually check equipment before use • report any defects immediately • follow safe systems of work xii. Lifting operations and Lifting Equipment Regulations (LOLER) • do not use equipment unless trained • follow safe lifting practices • report any defective equipment xiii. Confined Spaces Regulations • avoid entry into confined spaces whenever possible • if entry is unavoidable, put in place adequate emergency arrangements before starting work in confined spaces xiv. Building Safety Act • comply with building regulations and fire safety orders • escalate/report significant fire and structural safety concerns xv. The Control of Lead at Work Regulations • use appropriate PPE • follow safe working practices xvi. Environment Protection Act • know the hazards that arise from vapour compression • comply with environmental management systems • recycle, re-use and reduce waste xvii. DSEAR Dangerous Substance Explosive Atmosphere Regulations • Pressure Equipment (Safety) Regulations • Pressure Systems Safety Regulations xviii. BSEN378 (non-statutory regulation) • disposal requirements for refrigerating systems and heat pumps • safety and environmental requirements b. Health and safety information in RACHP environments i. where information can be found: • government website – HSE website • company handbook / induction materials • Local Authority (LA) websites ii. the purpose of on-site safety inductions • ensure employees understand site Health and Safety requirements in relation to ○ methods of accident and fire reporting ○ location of assembly points and risk assessments ○ evacuation and first aid procedures • identify specific hazards associated with the site • ensure employees understand company policies and procedures and their roles in relation to them • ensure employees understand site layout • maintain safe site access

Topics	Content elements
	iii. the purpose of toolbox talks • to provide updates on: ○ incidents and accidents ○ access routes and site layout ○ changes to company policies and procedures ○ manufacturers/suppliers' materials and plant movement 1.1.2 Employer and employee responsibilities under the Health And Safety at Work Act (HASWA) a. Employer responsibilities i. provision of safe working environment complying with legislation and codes of practice ii. provision of access to adequate staff training • CSCS card • induction • toolbox talks iii. completion of risk assessments iv. supervision v. provision of PPE for employees vi. reporting of hazards, accidents and near misses vii. comply with Construction Design Management (CDM) regulations viii. create a construction phase plans to detail sequence of activities ix. protecting/providing provision for employee welfare x. display of public liability insurance and health and safety law posters/information xi. ensure signage is present, visible, correct and up to date b. Employee responsibilities i. exercise a duty of care to themselves and to others ii. work in a safe manner, including with other trades iii. comply with employer instructions and follow organisational procedures iv. report hazards, accidents and near misses v. read and adhere to signage and escalate issues to a supervisor

Learning outcome 2

Understand accident and emergency reporting procedures and documentation

Topics	Content elements
2.1 Emergencies and major occurrences	2.1.1 Major occurrences defined as emergencies that may occur in the RACHP workplaces and their potential causes a. Fire i. fuel spillage ii. smoking on site iii. burning of waste

Topics	Content elements
	iv. hot work v. electrical circuits overheating b. Security incident i. unauthorised persons on site, terrorism, vandalism ii. inefficient security measures in place c. Gas leak i. poor storage of gas cylinders ii. unprofessional practice iii. unknown services/existing services in place d. Explosion i. gas leak ii. fuel spillage iii. mixing of chemicals iv. poor storage of hazardous materials e. Collapse of scaffolding i. adverse weather ii. missing components iii. unauthorized modifications iv. overload of weight v. insufficient safety checks vi. poor erection/quality of work f. Collapse of excavations i. adverse weather ii. poor shoring iii. lack or barriers iv. plant operation proximity g. Electric shocks i. faulty equipment ii. incorrectly isolated iii. unsecure isolation iv. incorrect equipment
2.2 Dealing with accidents and emergencies	2.2.1 The duties of authorised personnel involved in dealing with accident and emergency situations a. Fire warden i. ensure safe evacuation of personnel ii. fight fires if safe to do so b. First aider i. attend personal injury incidents ii. treat minor injuries iii. liaise with emergency service professionals c. Supervisors/managers i. oversee safety procedures are taking place ii. complete documentation to comply with legislation d. Safety officer i. initial responder ii. point of call/investigation e. Emergency services i. provide professional medical/rescue assistance f. Health and Safety Executive (HSE) i. carry out investigations into accident/emergency incidents

Topics	Content elements
	ii. responsible for health and safety regulation and enforcement 2.2.2 Actions that must be taken upon discovery of an emergency or accident a. Discovery of a fire i. Step 1 – sound alarm ii. Step 2 – assess risk and tackle fire if competent/trained to use a fire extinguisher • Red (water): class A fires (paper, cloth, some plastics, never electrical, flammable liquid or gas) • Cream/off white (foam): class A and B fires (refrigerants, paper, cloth, some plastics, flammable liquids) • Black (CO_2): class B and C fires (flammable liquids, energized electrical equipment) • Blue (dry powder): class A, B and C fires (applicable to all types of fire) iii. Step 3 – evacuate to fire assembly point iv. Step 4 – call emergency services b. Accident not involving injury to persons i. Step 1 – assess seriousness of incident ii. Step 2 – ensure the area is made safe iii. Step 3 – alert other relevant persons (supervisors, employees) iv. Step 4 – assess whether emergency services are required v. Step 5 – alert the emergency services in line with workplace protocols c. Accident involving injury to persons i. Step 1 – call for help/First Aider ii. Step 2 – ensure the area is made safe iii. Step 3 – treat casualty (within limits of training and competency) iv. Step 4 – alert the emergency services if required in line with workplace procedures d. Follow up actions i. completion of records ii. contact HSE iii. review workplace safety control measures and procedures

Learning outcome 3

Manage workplace hazards and risks

Topics	Content elements
3.1 Control measures related to risk assessments	3.1.1 Control measures related to risk assessments and method statements a. Control measures i. up to date risk assessments

Topics	Content elements
	ii. good housekeeping in the workplace iii. training of employees iv. signage and safety procedures b. Potential outcome of hazards affecting individuals i. injury ii. long term illness/disability iii. loss of days worked due to injury/illness/prohibition notice iv. death
3.2 Housekeeping in RACHP environments	3.2.1 Good housekeeping in relation to health and safety in RACHP environments, its purpose, importance, and steps to maintain a. Definition 'good housekeeping' - the practice of maintaining a clean, organized, and hazard-free work environment. b. Purpose of good housekeeping i. maintain safety ii. reduce build-up of waste and keep sources of ignition and flammable substances apart iii. keep access routes clear iv. safe storage of materials, tools and equipment v. reduce workplace/site congestion vi. enhances good working relationships and reduction of stress vii. train workforce in their responsibilities of fire prevention c. Steps that can be taken to maintain good housekeeping i. cleanliness of working area ii. tidiness/robust storage systems, designated storage iii. use of skips and chutes iv. segregation of materials/waste v. segregation of stored materials to avoid congestion of work area and access vi. clear access to fire escapes and fire extinguishers vii. waste and debris management viii. storage and maintenance of tools and equipment d. Importance of good housekeeping i. protection of lives/personal safety ii. preservation of property and equipment iii. reduce site downtime, keep job on track iv. compliance with regulation v. avoid legal implications vi. protect reputation/image vii. reduce environmental impacts 3.2.2 Types of pollution and control measures (mitigations) a. Noise i. inconsiderate use of plant and machinery(drilling) ii. inconsiderate delivery times iii. inconsiderate site operational procedures b. Smell i. release of gas ii. inappropriate stored waste materials

Topics	Content elements
	iii. diesel operated machinery iv. propane fork load trucks v. sewage vi. fire vii. industrial cleaning agents c. Spill i. oils ii. condensate iii. chemicals iv. paint d. Waste i. hazardous waste ii. dry mixed recycling iii. clinical waste iv. plastic recycling v. food waste vi. Waste Electrical and Electronic Equipment (WEEE) e. Control measures i. adequate site/contracting programming ii. liaising with client iii. liaising with community iv. electronic monitoring v. segregation of waste vi. timely waste collection
3.3 Signage and notices found in RACHP environments	3.3.1 Categories of signs and safety notices used in RACHP workplaces and their key visual characteristics a. Categories of signs and safety notices i. prohibition: something must not be done • circular • red band, white background • imagery of item in black with red diagonal cross ii. mandatory: something must be done • circular • blue and white iii. warning: alerting to danger/hazard awareness • triangle • yellow and black iv. safe condition: indicates equipment is safe to use, or not and indicates what to do in the event of an emergency • rectangular • green and white b. Environmental signs and notices i. hazardous waste disposal sign ii. hazardous waste storage sign iii. dangerous chemical sign iv. biohazard sign v. corrosive substance sign vi. radiation hazard sign vii. toxic substance sign viii. acidic sign

Learning outcome 4

Know safe storage requirements for materials and equipment

Topics	Content elements
4.1 Safe storage of materials and equipment	4.1.1 Methods for the safe storage of materials and equipment a. Safe storage of materials and equipment i. stored securely and safely ii. following workplace systems/protocols iii. ease of access and availability iv. kept clean (using a soft brush where required) and dry where relevant and possible v. location and designated area of storage b. Safe storage of electrical equipment i. components present including any safety guards ii. equipment is cleaned iii. check for damage regularly and before and after use, report where relevant iv. store in a clean, dry and secure location v. electrical equipment is PAT tested c. Safe storge of gas equipment i. components present including any safety guards ii. equipment cleaned iii. check for damage regularly/before and after use and report where relevant iv. stored in a clean, dry and secure location v. gas cylinders stored in secure and ventilated area d. Importance of safe storage i. maintain safety of self and others ii. promote efficiency and safe working iii. prevent damage and maintain working order iv. prevent loss/theft v. restrict/limit access where appropriate vi. prevention of fire/explosion

Learning outcome 5

Understand access requirements and equipment when working at heights

Topics	Content elements
5.1 Health and safety consideration when working at height	5.1.1 Responsibilities of employers and employees under Working at Height Regulations a. Responsibilities of employers i. undertake risk assessments ii. employ competent people for working at height iii. provide appropriate access equipment iv. ensure sufficient inspection and recording of condition of access equipment as appropriate b. Responsibilities of employees i. carry out visual inspection before using any access equipment ii. do not alter or remove any parts of access equipment provided

	iii. use identified access to working height iv. report any safety issues to employer v. use equipment and PPE provided as instructed 5.1.2 Types of access equipment used in RACHP workplace environments and safety considerations for their use a. Access equipment i. stepladders ii. ladders: pole, extension, combination, multi-purpose, telescopic iii. trestles iv. hop-ups v. scaffolding: mobile, static vi. podiums vii. stilts viii. MEWPs (Mobile Elevating Working Platforms) b. Safety considerations for their use i. erection by competent persons (where applicable) ii. use equipment only if properly trained iii. maintain three points of contact (where applicable) iv. do not overreach (sideways) v. check ground condition before setting up: level, firm, stable vi. do not work in adverse weather conditions if unsafe vii. comply with method statement

Learning outcome 6

Understand safety considerations when working with electricity and gas

Topics	Content elements
6.1 Dangers of working with electrical and gas equipment	6.1.1 Potential hazards and risks when using electrical and gas equipment in RACHP workplace environments a. Potential hazards i. faulty equipment ii. weather and the environment iii. lack of training/incorrect use iv. hidden services v. dust inhalation vi. specific to electrical equipment • incorrect voltage • overhead powerlines • not carrying out safe isolation of equipment • charged capacitors vii. specific to gas equipment • different gas types (CO2, ammonia, LPG, refrigerant, oxygen, acetylene, nitrogen, MAPP gas) • Lower Explosion Limit (LEL), Upper Explosion Limit (UEL) b. Potential risks i. death

Topics	Content elements
	ii. fire iii. specific to electrical equipment • burns • electrocution iv. specific to gas equipment • burns (hot and cold) • spillage • asphyxiation • explosions (flammable/non-flammable gases) • cardiac sensitisation • Central Nervous System (CNS) • thermal decomposition 6.1.2 Precautions that should be taken to avoid risks to self and others when working with equipment and why this is important a. Precautions i. checking tools and equipment before use ii. checking leads for sign of wear and damage iii. checking plugs for labelling and signs of wear and damage iv. escalating issues or concerns to a supervisor v. ensuring training has been given before use vi. use of dust suppression measures and use of Respiratory Protective Equipment (RPE) vii. use of safety control equipment and PPE viii. specific to electrical equipment • using cable hangers where possible • ensuring there is a current PAT certificate ix. specific to pressurised gasses and flame brazing equipment • ensuring there is a current calibration certificate • follow standards for testing x. awareness of elements essential to the creation of fire and how they interact with each other: oxygen, fuel, heat/ignition source • the elements must all be present, they are interdependent (removal of one will extinguish the fire) b. Importance of taking precautions i. keep self and other safe ii. reduce risk of injury or death iii. comply with legislation and workplace conduct
6.2 Power sources and voltages for electrical equipment	6.2.1 Power sources, voltages and voltage colour coding that are used for electrical equipment in construction workplace environments a. Power sources i. battery powered ii. mains powered iii. portable generator iv. renewable energy sources – solar/wind b. Voltages and associated colours of plug and sockets

Topics	Content elements
	i. no standard colour: 12/18/24 volts (extra low voltage below 50 volts) – battery power for cordless tools ii. yellow: 110/115 volts – common workplace voltage for power tools and equipment iii. blue: 230/240 volts – standard domestic voltage for power tools and equipment iv. red: 415 volts – commercial/industrial machinery

Learning outcome 7

Know Personal Protective Equipment (PPE) responsibilities

Topics	Content elements
7.1 Responsibilities in relation to PPE	7.1.1 Responsibilities of employers and employees relating to standard PPE under current regulations a. Standard PPE i. Polyurethane (PU) coated gloves ii. safety glasses/goggles iii. safety boots iv. overalls and work wear v. respirators vi. masks vii. helmets viii. ear defenders ix. knee protectors b. Responsibilities of employers i. ensure suitable PPE is provided free of charge to employees who may be exposed to a risk to their health or safety while at work ii. the maintenance, storage and replacement of any PPE they provide iii. provide training and instruction on safe and correct use of PPE for relevant tasks c. Responsibilities of employees i. use PPE correctly following training and instruction from employer ii. if PPE is lost or becomes damaged/defective, report to employer and do not use iii. check and ensure PPE to be used is within date before use, and report to employer and do not use where out of date

Learning outcome 8

Understand factors that impact on physical and mental welfare maintenance and management

Topics	Content elements
8.1 Considerations in relation to RACHP workplace welfare	8.1.1 Duty of care and mental health considerations in the workplace and why they are important

Topics	Content elements
	a. Definition 'duty of care' – all employers are under a statutory duty to ensure the health, safety and welfare of their staff b. Definition "mental health" – an individual's emotional, psychological and social wellbeing c. Considerations i. physical wellbeing • taking regular breaks • staying hydrated and making healthy food choices • maintaining good personal hygiene ii. psychological wellbeing • positive work/life balance • recognition of achievement/success • attendance to social events d. Importance i. safety of employees is maintained • protection from harm, abuse, injury • remain fit for work/tasks and day-to-day life ii. satisfaction and happiness of employees iii. legal requirement e. Sources of support i. peers and colleagues ii. management or employer iii. human resources and mental health first aider iv. trade union representative v. medical professional or doctor vi. mental health charities/organisations vii. online support networks 8.1.2 Facilities for welfare that must be provided and their importance a. Welfare facilities i. toilets ii. washing facilities with hot and cold running water iii. secure storage for personal items iv. canteen v. drinking water vi. drying room vii. heat rested facilities viii. multi-faith room ix. first aid facilities b. Importance/reasons for provision i. legal requirement ii. employee comfort and duty of care iii. attraction and retention of employees iv. company reputation 8.1.3 Potential causes and effects of excessive noise and employer/employee responsibilities in relation to minimising the impact a. Definition 'excessive noise' – can be gradual from exposure to loud noise over time or that caused by sudden, extreme loud noise. b. Potential causes of excessive noise

Topics	Content elements
	i. machinery and equipment ii. power tools iii. demolition activity iv. construction activity v. deliveries and transport of materials with machines vi. Communication and radio systems c. Potential effects of exposure to excessive noise i. deafness/hearing loss ii. tinnitus/ringing in the ears iii. disturbed sleep iv. stress v. communication issues on site/within workplace vi. loss or reduction of working hours d. Employee responsibilities i. wearing PPE: ear defenders ii. adhering to workplace/site rules/training iii. being aware of own safety and that of others on site/in the workplace e. Employer responsibilities i. providing PPE and ensuring employees know how/when to use it ii. adherence with legislation iii. regular monitoring of sound levels iv. taking action when excess levels are evident v. ensuring risk assessments are in place and followed

Unit 202 Scientific principles in RACHP systems

Unit level:	2
Guided Learning Hours (GLH):	100
Unit aim:	This is a **theory** and **practical** unit. The purpose of this unit is to provide learners with the knowledge required to enable them to carry out mathematical calculations and measurements working in Refrigeration, Air-Conditioning Heat Pumps (RACHP) environments, including temperature, pressure and heat. This unit covers RACHP sector knowledge including SI units, gas laws, force, pressure, temperature, heat loads and psychrometric properties of air. The unit also covers properties of refrigerants, lubricants and materials used in RACHP industry.
Assessment method:	Externally set, Multiple Choice Question (MCQ) exam, online, on-demand Practical assessment.
Links to Apprenticeship Standard:	ST0322 Refrigeration, air conditioning and heat pump engineering technician

Learning outcomes

1. Know the standard units of measurement used in RACHP industry
2. Know the scientific relationship between heat, energy and power in vapour compression systems
3. Know the principles of force, pressure and the relationship to fluid flow
4. Understand how to apply the mechanical principles of the vapour compression cycle to the pressure enthalpy (Ph) diagram
5. Understand psychrometric processes
6. Understand the general properties of materials used in RACHP
7. Understand the functions, features and operating principles of system components, refrigerants and lubricants (oils).

Learning outcome 1

Know the standard units of measurement used in RACHP industry

Topics	**Content elements** What needs to be covered
1.1 System International (SI) units and their application in the RACHP industry	1.1.1 Base and derived System International (SI) Units and their application in the RACHP industry. a. Base SI units i. metre (m): length ii. kilogram (kg): mass iii. second (s): time

	iv. Kelvin (K): temperature v. Ampere (A): electrical current b. Derived SI units i. area: m^2 ii. volume: m^3 iii. litres: L iv. density: kg/m^3 v. velocity: m/s vi. acceleration: m/s^2 vii. pressure: Pascal viii. energy: Joules ix. power: watts x. enthalpy: kJ/kg xi. entropy: kJ/kg xii. specific volume: m^3/kg

Learning outcome 2

Know the scientific relationship between heat, energy and power in vapour compression systems

Topics	Content elements
2.1 Relationship between temperature scales and conversion method	2.1.1 Differences between temperature scales and conversion method a. Temperature scales: i. Celsius: °C ii. Kelvin: K iii. Fahrenheit: °F iv. Rankine: °R b. Conversion method: i. from Celsius to Fahrenheit: K = °C + 273 ii. from Kelvin to Fahrenheit: °C = K – 273 iii. from Fahrenheit to Celsius: °C = 5 / 9 (°F – 32) iv. from Fahrenheit to Rankine: °R = °F + 459.67
2.2 Types associated with changes of state of matter	2.2.1 Types associated with changes of state and matter a. States of matter i. solid ii. liquid iii. gas b. Changes of state i. melting ii. freezing iii. boiling iv. evaporating (evaporation/vaporisation) v. condensing (condensation) vi. two-phase mixture c. Changing pressure on saturation temperature for a range of substances (water, primary refrigerants) i. boiling point: temperature at which state change occurs ii. freezing point: temperature at which state change occurs

Topics	Content elements
	iii. absolute zero: the lowest temperature that is theoretically possible iv. pressure at which saturation temperature occurs v. sensible cooling processes: super-heat, sub-cooling d. Laws of thermodynamics i. first law: energy can neither be created nor destroyed, only altered in form. ii. second law: the temperature difference when heat moves from a warm area to a cold area e. Mollier diagram i. work done by compressor ii. heat rejected by condenser iii. refrigeration effect in evaporator iv. useful superheat v. non-useful superheat vi. capacity calculations vii. superheat viii. subcooling ix. dew x. bubble xi. specific volume
2.3 Types of heat applicable to three states of matter	2.3.1 Types of heat, methods of heat transfer and their calculations: a. Types of heat i. sensible heat: heat that changes temperature of a substance without changing its state – specific heat capacity (J/kgK) ii. latent heat of vaporisation: heat that changes the state of a substance without changing its temperature (kJ/kg) iii. latent heat of fusion (kJ/kg): heat that is released or absorbed during a constant-temperature process b. Calculations to determine the heat required to raise/lower the temperature of a substance i. sensible heat (Joules) = mass (kg) x specific heat capacity (J/kgK) x temperature difference (K) Q = mcTD ii. latent heat (Kilojoules) = mass (kg) x latent heat capacity (KJ/kg) Q = mL iii. power (watts) = energy (Joules)/time (seconds) Q = J/s c. Methods of heat transfer i. conduction: heat transfer in solids ii. convection: heat transfer in fluids iii. radiation: emission/transmission of energy in the form of waves/particles through space or a material medium

Learning outcome 3

Know the principles of force, pressure and the relationship to fluid flow

Topics	Content elements
3.1 Units of force, pressure and fluid/vapour flow rate	3.1.1 Units of force, pressure and fluid/vapour flow rate a. Force and pressure calculations using SI units i. force (newtons) (N) = ma ii. gravitation force (N) = mg iii. acceleration due to gravity = g ($9.8 m/s^2$) iv. static Pressure (P) = force/area (F/A) (N/m^2) v. dynamic Pressure (P) = ½ pv^2 b. Units of pressure: i. Pascal (Pa) ii. kPa iii. Bar iv. torr/micron v. PSI vi. Inches of mercury vii. mmHg (millimetres mercury) c. Atmospheric pressure (ATM) and its units. i. ATM = 101325 Pa at sea level d. Units of flow rate and calculations of conversions i. velocity (m/s) ii. Volume Flow Rate (m^3/s, L/s) VFR = Velocity x area iii. Mass Flow Rate (kg/s) MFR = VFR x Density e. The main gas laws and calculations of flow rate i. Boyles: PV = constant ii. Charles: VT = constant iii. Gay-Lussac: PT = constant iv. combined: PV/T = constant v. Daltons: Pt = P1 + P2+ P3+....

Learning outcome 4

Understand how to apply the mechanical principles of the vapour compression cycle to the pressure enthalpy (Ph) diagram

Topics	Content elements
4.1 Plotting of the mechanical vapour compression cycle onto Ph diagram	4.1.1 Plotting of the mechanical vapour compression cycle onto Ph diagram a. Pressure b. Enthalpy c. Entropy d. Liquid/vapour/two-phase mixture zones e. Latent and sensible heat processes f. Refrigeration effect (heat gained in the evaporator) g. Compressor work done h. Total heat rejection i. Discharge temperature j. Sub-cooling k. Suction superheat l. Dryness fraction / quality m. Coefficient of Performance (CoP)

4.2 Using variables to maximise system performance and balance and the impact of superheat and subcooling on the vapour compression cycle	4.2.1 Using variables to maximise system performance and balance and the impact of changing suction superheat and subcooling on the compression cycle a. Variables to maximise performance: i. work done ii. refrigeration effect iii. total heat rejection iv. co-efficient of performance v. mass flow rate vi. compression ratio vii. component selection and system balance b. Impact of changing suction superheat: i. refrigeration effect ii. compressor work done iii. total heat rejection iv. discharge temperature v. coefficient of performance c. Impact of changing subcooling: i. refrigeration effect ii. quality / dryness fraction iii. coefficient of performance

Learning outcome 5

Understand psychrometric processes

Topics	Content elements
5.1 Psychometric processes	5.1.1 Properties of air and dry and wet bulb temperatures, their characteristics and measuring instruments a. Properties of air i. elements ii. percentages iii. temperature iv. moisture content b. Temperatures i. dry bulb temperature ii. wet bulb temperature c. Characteristics i. temperature ii. moisture content iii. air flow d. Measuring instruments i. dry-bulb thermometer ii. sling psychrometer iii. hygrometer 5.1.2 Plotting on a psychrometric chart given two variables a. Dry bulb b. Wet bulb c. Moisture content d. Humidity (% saturation)

Topics	Content elements
	e. Enthalpy f. Specific volume g. Dew point

Learning outcome 6

Understand the general properties of materials used in RACHP

Topics	Content elements
6.1. Properties of materials used in RACHP	6.1.1 Materials used in RACHP and their properties a. Materials i. pure metals: • copper • iron • tin • aluminium • zinc ii. alloys • brass • bronze • mild steel • stainless steel iii. brazing alloys • copper-phosphorous • silver solder iv. plastics (thermoplastic, thermoset) • polystyrene • polyurethane • PVA • neoprene • PTFE v. insulation materials • expanded polyurethane • expanded polystyrene • fibreglass b. Properties i. tensile strength ii. compressive stress iii. torsion iv. shear stress v. ductility vi. malleability vii. hardness viii. brittleness ix. work-hardening x. annealing xi. temper c. Properties of insulation material: i. low conductivity ii. non-toxic iii. non-flammable

Topics	Content elements
	iv. vermin-proof v. cost vi. self-supporting d. Corrosion: i. types of corrosion: oxidisation, chemical, electrolytic, erosion ii. preventing corrosion: painting, cathodic protection, inhibitors, drying agents, anodising e. K and U insulation factors: i. K-Value represents the thermal conductivity of a material, and it measures its ability to conduct the heat. The lower the K-value, the better the insulation is. ii. U-Value measures the thermal transmittance of materials as the rate of transfer of heat through matter. The lower the U-value, the better the insulation is. f. Calculations to determine heat flow through a wall i. Q (watts) = A U td (Area x U factor x temperature difference) ii. Q (watts) = A K td / t) (Area x K factor x temperature difference/wall thickness(m)

Learning outcome 7

Understand the functions and operating principles of system components, refrigerants and lubricant (oils)

Topics	Content elements
7.1 Functions and operating principles components used in RACHP systems	7.1.1 Types of system components and their functions: a. Compressors: used to develop and maintain the flow of refrigerant through the system i. hermetic ii. semi-hermetic iii. open type iv. reciprocating v. scroll vi. rotary (screw, vane, lobe) vii. centrifugal b. Condensers: heat transfer devices that allow heat to be conducted to a space or a fluid i. natural convection ii. forced draft iii. plate iv. evaporative v. liquid cooled vi. air cooled c. Expansion/metering devices: used to vary or maintain the flow of refrigerant into the evaporator and control superheat i. capillary tube ii. short tube restrictor iii. thermostatic expansion valve

Topics	Content elements
	iv. electronic linear expansion valve v. liquid level control vi. low side float valve vii. Stepper valve viii. Constant pressure d. Evaporators: heat transfer devices allowing heat to be conducted from a space or fluid i. natural convection ii. forced draft iii. liquid cooling iv. plate v. direct expansion vi. flooded e. Ancillary components: added to a basic system to enhance its operation or protect system components i. liquid and suction filter-driers ii. pressure relief valves iii. strainers iv. oil separators v. moisture indicating sight glass vi. service valves f. Storage vessels: used to accommodate variations in load in none critically charged systems i. high pressure liquid receivers ii. suction line accumulators g. Control valves: added to a basic system to enhance its operation or protect system components i. solenoid ii. four-way reversing iii. evaporator pressure regulator iv. suction pressure regulator v. crankcase vi. oil differential vii. hot gas h. Fans: used to provide airflow to spaces and components i. propeller ii. axial iii. centrifugal (forward curve, backward curve) iv. tangential 7.1.2 Operating principles of components and their interaction in vapour compression systems a. Compressor: i. increases the pressure and temperature of the refrigerant, making it possible for heat to be rejected in the condenser ii. receives low pressure superheated vapour from the evaporator and raises its pressure and temperature. b. Condenser:

Topics	Content elements
	i. reject mainly latent heat, the refrigerant enters the condenser as high pressure and temperature vapour. ii. as it passes through the condenser it releases heat to the surroundings causing it to change to high pressure liquid iii. receives the high pressure and temperature refrigerant from the compressor to cool it down changing into liquid. c. Expansion/metering devices: i. restrict the flow of refrigerant from the high-pressure side to the low-pressure side causing a pressure drop. ii. this allows the refrigerant to expand and cool rapidly as it enters the evaporator iii. drops the pressure of the liquid arriving from the condenser cooling it down rapidly d. Evaporator: i. absorb latent heat mainly, the refrigerant enters the evaporator as low-pressure liquid-vapour mixture. ii. by absorbing the latent heat from its surroundings, it evaporates changing from liquid to vapour iii. low pressure and temperature mixture enters the evaporator is now able to absorb the heat of product/space changing into superheated vapour e. Ancillary components: i. components, vessels and valves are added to enable the system to operate efficiently and safely
7.2 Properties of refrigerant fluids and lubricants	7.2.1 Types of refrigerants, fluids and lubricants and their properties: a. Types of refrigerants: i. CFC ii. HCFC iii. HFC iv. Hydrofluoroolefin (HFO) v. Hydrocarbons (HC) vi. ammonia (NH_3) vii. carbon dioxide (CO_2) b. Types of secondary fluids: i. water ii. glycols iii. brine iv. pure fluids v. zeotropes vi. azeotropes c. Types of lubricants: i. mineral ii. synthetic

Topics	Content elements
	d. Properties of primary refrigerants: i. saturation ii. temperatures iii. pressures iv. ODP v. GWP vi. hazard class (flammability, toxicity) vii. cost viii. availability ix. phase outs x. bans e. Properties of secondary fluids: i. viscosity ii. sensible heat capacity iii. eutectic point iv. freezing point v. use of inhibitors vi. additives f. Properties of lubricants: i. viscosity ii. miscibility iii. flammability iv. dielectric strength v. pour point vi. wax (FLOC) point vii. hydroscopic

Unit 203 Vapour compression systems (single compressor/single evaporator) in RACHP

Unit level:	2
Guided Learning Hours (GLH):	50
Unit aim:	This is a **theory only** unit. This unit provides the learner with the knowledge of a range of RACHP and to understand the operating principles of the systems and how the components interact. The purpose of this unit is to provide learners with the knowledge required to enable them to understand the operation and function of a vapour compression system. This unit covers RACHP sector knowledge including pipe and line systems, pressure-enthalpy diagrams, The unit also covers properties of refrigerants, lubricants and materials used in RACHP industry.
Assessment method:	Externally set, Multiple Choice Question (MCQ) exam, online, on-demand
Links to Apprenticeship Standard:	ST0322 Refrigeration, air conditioning and heat pump engineering technician

Learning outcomes

1. Know the characteristics of line and pipe systems used in RACHP systems
2. Understand the principles of operation of RACHP systems (single compressor/ evaporator systems),
3. Understand the environmental impact and conditions that affect system performance.

Learning outcome 1

Know the characteristics of line and pipe systems used in RACHP systems

Topics	Content elements
1.1 Pipe characteristics, refrigerant velocity and the impacts	1.1.1 Pipe characteristics, refrigerant velocity and the impacts a. Pipe characteristics: i. diameter ii. length iii. bends iv. fittings v. friction vi. orientation vii. strength

	b. Impact of pipe characteristics on refrigerant and oil flow i. gas velocity ii. oil entrainment iii. equipment location c. Impact of pipe sizing and pressure drop on system performance: i. gas velocity ii. oil return iii. operating temperatures and pressures iv. saturation temperatures v. mass flow rate vi. flash gas d. Impact of refrigerant velocity changes on oil return, system performance and pressure drop: i. gas velocity ii. oil return iii. operating temperatures and pressures iv. saturation temperatures v. mass flow rate vi. flash gas

Learning outcome 2

Understand the principles of operation of RACHP systems (single compressor/evaporator systems)

Topics	Content elements
2.1 Functions of a vapour compression system in relation to a pressure-enthalpy chart.	2.1.1 Functions of a vapour compression system when plotted on a pressure-enthalpy chart: a. Main system components i. compression ii. condensing iii. expansion iv. evaporation b. Changes in refrigerant state around the system i. refrigerant fluids and lubricants properties ii. superheated vapour iii. saturated two-phase mixture iv. subcooled liquid v. saturated vapour vi. saturated liquid vii. dryness fraction/quality
2.2 Operating conditions of RACHP systems and applications	2.2.1 Operating conditions of RACHP systems and applications and their impact/considerations a. Types of defrost methods i. off-cycle ii. electric iii. reverse cycle iv. hot gas v. saturated (cool) gas b. Impact of defrost on system performance

	i. operating pressure and temperature ii. air flow reduction iii. system efficiency reduction iv. design (controlled) temperatures v. components damage vi. energy efficiencies reduction c. Types of RACHP applications i. blast freezing ii. cold storage (rooms and display cases) iii. cellar cooling iv. air conditioning v. dehumidification vi. heat pumps (air, water) vii. manufacturing viii. transport ix. process cooling (food production and data warehouse) x. domestic d. Operating considerations of RACHP applications i. temperature (storage, control) ii. humidity (storage, control) iii. air flow (storage, control) iv. time (product cooling time, shelf life) v. secondary refrigerants e. Operation of a four-way reversing valve i. reverse cycle operation ii. pilot operated valve f. Operating principles of heat-pumps i. air source ii. water source iii. reverse cycle iv. ground source v. heat recovery vi. humidity

Learning outcome 3

Understand the environmental impact and conditions that affect system performance

Topics	Content elements
3.1 Changing environmental conditions and impact on system performance	3.1.1 Types of environmental changes that impact system performance. a. Internal environmental changes: i. ambient temperature ii. design temperature iii. air flow iv. coil cleaning v. energy efficiencies (indirect emissions) vi. system performance vii. humidity viii. hazards ix. leak rates (direct emissions) x. damage b. External environmental changes:

	i. leakage ii. air flow iii. defrost iv. temperature set-point v. water quality

Unit 204 Service, maintenance and repair of RACHP systems

Unit level:	Level 2
Guided Learning Hours (GLH):	80
Unit aim:	This is a **theory and practical** unit. The purpose of this unit is to provide learners with the knowledge required to efficiently perform servicing and maintenance on refrigeration, air-conditioning, and heat pump (RACHP) systems, as well as to develop the practical skills necessary to execute these tasks effectively.
Assessment method:	Externally set, Multiple Choice Question (MCQ) exam, online, on-demand Practical assessment.
Links to Apprenticeship Standard:	ST0322 Refrigeration, air conditioning, and heat pump engineering technician

Learning outcomes

1. Know how to troubleshoot and repair RACHP systems using modern diagnostics technology
2. Perform basic repairs and preventative and routine maintenance
3. Perform practical servicing and maintenance skills

Learning outcome 1

Know how to troubleshoot and repair RACHP systems using modern diagnostics technology

Topics	Content elements
1.1 Common faults and symptoms on RACHP systems	1.1.1 Faults and related symptoms in RACHP system components a. Refrigerant leaks i. reduced cooling or heating efficiency ii. hissing sounds iii. oil traces near leak iv. lower running amps v. partial or no refrigeration vi. erratic running on Low Pressure (LP) switch vii. lower suction and discharge pressure viii. may cycle on thermal overload protector ix. compressor hotter than normal x. compressor runs continuously on thermostat xi. condenser cooler than normal xii. higher superheats than normal xiii. lower subcooling than normal

Topics	Content elements
	b. Faulty compressor i. refrigeration system will not run ii. unusual noises iii. tripped circuit breakers iv. acid present in system v. low insulation resistance (down to earth) vi. high suction pressure and low discharge pressure vii. system unable to pump down fully due to suction valve passing viii. compressor runs continuously on incorrectly calibrated thermostat ix. condenser cooler than normal x. lower running amps xi. compressor hotter than normal xii. discharge pressure lower than expected xiii. suction pressure higher than expected c. Tripped circuit breaker i. low component insulation resistance (down to earth) ii. incorrect rated breaker fitted iii. power surge iv. faulty control boards v. poor discrimination d. Shortage of refrigerant at commissioning (service and maintenance) i. low suction pressure ii. higher superheat than normal iii. lower subcooling than normal iv. unit operating in a vacuum v. low level in liquid receiver vi. bubbles in sight glass (undercharged system?) vii. unit not refrigerating viii. unit not defrosting ix. condenser cooler than normal x. compressor noisy xi. compressor hotter than normal xii. cycling on Low Pressure (LP) switch xiii. discharge pressure lower than normal xiv. suction pressure lower than normal xv. lower running amps xvi. frozen evaporator e. Excess refrigerant i. high discharge pressure ii. excessive frost on suction line iii. condenser hotter than normal iv. suction pressure higher than normal v. compressor hotter than normal vi. higher running amps vii. cycling on High Pressure (HP) switch f. Blocked air cooled evaporator i. low suction pressure. ii. reduced cooling/ heating capacity iii. compressor runs continuously on thermostat iv. may cycle on thermal overload protector v. compressor hotter than normal

Topics	Content elements
	vi. ice Formation vii. decreased airflow viii. higher than normal energy consumption ix. unusual noise local to evaporator x. uneven temperature distribution across the coil xi. excess condensation g. Blocked chilled water/glycol evaporator i. ineffective cooling of the water being circulated ii. longer than normal period to achieve desired water temperature iii. significant pressure drop across the evaporator iv. increased energy consumption v. unusual noise local to evaporator vi. inconsistent temperatures of the water leaving the evaporator vii. overheating water pump viii. low flow alarm activated ix. water quality issues (corrosion/debris) h. Blocked condenser i. high discharge pressure and high suction pressure. ii. compressor hotter than normal iii. higher running current iv. cycling on High Pressure (HP) switch v. cut out on High Pressure (HP) switch vi. not cycling on thermostat vii. may cycle on overload protector i. Blocked liquid line drier i. reduced cooling or heating efficiency ii. ice formation iii. abnormal pressures iv. high discharge pressure v. temperature differential across the drier vi. compressor overheating vii. unusual noise local to drier viii. refrigerant flow issues ix. system cycling on Low Pressure (LP) switch x. moisture present in system xi. oil formation and degradation in the system j. Non-condensable in system i. erratic supply of refrigerant to the evaporator ii. compressor and condenser extremely hot iii. may cycle on thermal overload protector iv. suction pressure higher than expected v. discharge pressure higher than expected vi. running amps higher than expected vii. cycle on High Pressure (HP) switch k. Not switching modes or defrosting i. faulty reverse cycle valve ii. faulty hot gas valve iii. faulty control board
1.2 Diagnostic and repair tools and modern technology to troubleshoot and identify	1.2.1 Diagnostic and repair tools, troubleshooting methods and causes of system malfunctions.

Topics	Content elements
the causes of system malfunctions.	a. Diagnostic and repair tools i. refrigerant leak detectors ii. manifold gauge iii. vacuum gauge iv. multi meters v. thermometer vi. insulation tester vii. anemometer viii. clamp meter ix. refrigerant scales x. diagnostic software and apps xi. vacuum pump xii. recovery machine xiii. recovery cylinder xiv. inspection mirror xv. flashlight b. Troubleshooting methods i. listen, touch, visual inspection ii. 6-point technique (collect, analyse, diagnose, repair, test, report) iii. refrigerant charge levels check iv. system pressure check v. temperature checks vi. airflow checks vii. mechanical components checks viii. defrost system and settings checks ix. system settings and operation checks x. documentation and manufacturer guidelines check xi. sight glass (moisture indicator) xii. electrical troubleshooting methods xiii. measuring amperage xiv. measuring voltage: measuring Ohms (including insulation resistance) c. Causes of system malfunctions i. refrigerant issues: • leakage • acid problems • undercharged • non-condensable • wrong refrigerant ii. electrical problems: • power supply issues • compressor electrical problems • thermostat and control issues • relay and contactor problems • defrost system failures • fan motor problems • wiring issues • capacitor problems • overload protector problems • switch problems • circuit board issues • sensor failures

Topics	Content elements
	• earthing issues • auxiliary component problems • rodent damaging cables iii. mechanical failures • compressor problems • evaporator problems • condenser issues • expansion valve problems • refrigerant leaks • pipework/tubing issues • defrost system failures • lubrication problems • airflow problems • thermostat problems • condensate drain problems • fan issues, vibration/noise problems • reversing valve issues • heat exchanger issues • wear and tear • corrosion • system contamination iv. environmental factors • extreme high/low ambient temperatures • humidity levels • air quality/ pollution • water quality • corrosive environments • pest and insect infestation • vegetation and debris • solar radiation • wind and weather conditions • ground conditions • building and site conditions • human activity • power supply issues v. maintenance neglect • clogged air/water/glycol filters • dirty evaporator/condenser coils • loose connections • neglected electrical inspections • dirty/misaligned fans • worn out belts • clogged condensate drains • dirty drain pans • mis-calibrated thermostats • lack of lubrication • neglected drier replacements • general dirt and debris • neglected water treatment • airflow obstructions • improper sized system

Topics	Content elements
	• improper handling and charging of refrigerant • ignoring manufacturer recommendations
1.3 Interpret data from diagnostics technology to perform accurate and efficient repairs.	1.3.1 Interpret data provided by diagnostic tools to perform accurate and efficient repairs. a. Temperature data i. evaporator temperature • low temperatures may indicate proper operation or potential overcooling • high temperatures can signal insufficient cooling or issues with refrigerant flow ii. condenser temperature • high temperatures suggest the condenser is not rejecting heat effectively, due to dirty coils or inadequate airflow • low temperatures might indicate underloading or low ambient temperatures iii. suction line temperature • high temperatures can indicate insufficient refrigerant, while low temperatures might mean overcharging or a potential blockage iv. discharge line temperature • excessively high temperatures can signal issues like compressor overheating or discharge line restrictions v. ambient temperature • helps in determining if external conditions are affecting system performance. High ambient temperatures can lead to increased load on the system b. Pressure data i. suction pressure: low suction pressure may indicate refrigerant undercharge, blockage, or restricted airflow over the evaporator. High suction pressure could be due to overcharging, load issues or damaged compressor valves ii. discharge pressure: high discharge pressure can result from overcharging, poor condenser airflow, or high ambient temperatures. Low discharge pressure might indicate undercharging, system leaks or damaged compressor valves c. Flow rate data i. airflow across evaporator and condenser: low airflow can reduce heat exchange efficiency, causing lower temperature and pressure in the evaporator and higher temperature and pressure in the condenser. This might result from dirty filters/ coils, blocked ducts, or failing fans ii. refrigerant flow rate: abnormal flow rates can indicate blockages, leaks, or issues with the expansion valve d. Humidity data i. relative humidity of the ambient air ii. humidity within the refrigerated space

Topics	Content elements
	• high relative humidity in the refrigerated space can indicate poor door seals, frequent door openings, or insufficient dehumidification • low humidity levels might lead to the product drying out e. Electrical data i. voltage: voltage deviations from the norm can affect compressor and motor performance. Low voltage can cause motors to overheat, while high voltage can damage electrical components ii. current (amperage): higher than normal current draw can signal motor overloading or electrical issues. Low current might indicate underloading or a malfunctioning component iii. power consumption: excessive power consumption suggests inefficiencies in the system, due to overworking components or poor maintenance iv. electrical frequency: deviations from the standard frequency can affect the performance and longevity of motors and other components f. Refrigerant data i. type of refrigerant: ensures compatibility with the system design and environmental regulations g. Operational data i. compressor running hours: tracks the total operating time of the compressor. High running hours can indicate high cooling demand or inefficiencies, while sudden increases might point to system problems such as leaks or poor insulation ii. compressor on/off cycles: frequent cycling can indicate improper sizing, refrigerant charge issues, or control problems. Long cycles might mean a high load or inefficiency iii. fan speed and operation: fan performance affects heat exchange. Slow or non-operational fans can lead to overheating and inefficient cooling iv. expansion valve operation: proper operation is crucial for maintaining correct refrigerant flow and system pressure. Malfunctions can cause imbalances in cooling h. System performance data i. cooling capacity: measures the system's ability to remove heat. Reduced capacity can signal inefficiencies or malfunctions ii. Energy Efficiency Ratio (EER): lower EER indicates higher energy consumption for the same cooling output, suggesting potential inefficiencies iii. Coefficient Of Performance (COP): similar to EER, a lower COP means the system is less efficient, possibly due to poor maintenance or component wear i. Error codes and alerts i. fault codes: specific codes indicate particular problems or failures within the system, guiding targeted troubleshooting

Topics	Content elements
	ii. alerts: provide warnings for conditions that could lead to system failure or inefficiency, such as high pressure, low refrigerant, or sensor malfunction j. Historical data i. historical trends: analysing trends over time helps identify gradual performance declines, recurring issues, and the effectiveness of maintenance practices ii. maintenance records: ensure that regular maintenance is being performed and can highlight recurring issues needing attention

Learning outcome 2

Perform basic repairs and preventative and routine maintenance

Topics	Content elements
2.1 Perform basic repairs and adjustments to restore system performance	2.1.1 Perform basic repairs and adjustments to restore system functionality. a. Adjust refrigerant levels: i. recharging refrigerant: adding refrigerant to correct undercharging ii. recovering excess refrigerant: removing excess refrigerant to prevent overcharging. iii. fixing leaks: sealing leaks in refrigerant lines and coils. b. Cleaning and replacing filters: i. cleaning air filters: removing dust and debris from air filters. ii. replacing air filters: installing new filters if old ones are damaged or clogged. c. Coil cleaning: i. evaporator coil: cleaning the evaporator coil to improve heat absorption. ii. condenser coil: cleaning the condenser coil to enhance heat rejection d. Defrost system repairs: i. defrost timer replacement: replacing a faulty defrost timer. ii. heater and thermostat repairs: fixing or replacing defrost heaters and thermostats. e. Fan motor repairs and replacements: i. lubricating motor bearings: ensuring smooth operation of fan motors. ii. replacing faulty motors: installing new motors if the old ones fail. f. Sealing air leaks: i. door seal replacement: replacing worn or damaged door seals to ensure proper closure. ii. insulating panels: fixing or replacing insulating panels to maintain internal temperatures. g. Drain line maintenance:

	i. clearing blockages: removing obstructions in the condensate drain line. ii. replacing damaged lines: installing new drain lines if the old ones are cracked or leaking. h. Electrical component repairs: i. replacing capacitors: installing new capacitors to ensure proper motor function. ii. repairing wiring: fixing loose or damaged wiring connections. i. Reversing valve repairs: i. fixing stuck valves: ensuring the reversing valve can switch between heating and cooling modes. ii. replacing faulty valves: installing a new reversing valve if the old one is malfunctioning. j. Ductwork repairs: i. sealing leaks: ensuring all ductwork is properly sealed to prevent air leaks. ii. insulating ducts: adding insulation to ducts to improve efficiency.
2.2 Perform preventative and routine maintenance	2.1.1 Preventative and routine maintenance a. Preventative maintenance: i. cleaning components: routine cleaning of filters, coils, and fans to ensure efficient operation ii. lubrication: periodic lubrication of moving parts like motors and bearings to reduce wear and tear iii. refrigerant level checks: ensuring refrigerant levels are within the optimal range to prevent system inefficiencies b. Routine maintenance: i. filter replacement: regularly replacing air filters to maintain air quality and system efficiency ii. coil cleaning: periodic cleaning of evaporator and condenser coils to enhance heat exchange efficiency iii. drain line maintenance: ensuring condensate drain lines are clear to prevent water damage and mould growth iv. pre-season preparation: inspecting and servicing systems before peak usage seasons v. post-season shutdown: performing maintenance after the peak season to prepare the system for a period of low usage vi. upgrading components: replacing older components with more efficient or advanced ones to improve system performance vii. system optimisation: making adjustments and upgrades to enhance overall system efficiency and reliability

Learning outcome 3

Perform practical servicing and maintenance skills

Topics	Content elements
3.1 Selecting general hand tools	3.1.1 Selecting general hand tools a. Measuring tools i. tape measure: for measuring lengths and distances. ii. thermometers: for measuring temperature in different parts of the system iii. manifold gauge set: for measuring refrigerant pressure in the system iv. digital multi meter: for measuring voltage, current, and resistance in electrical components b. Cutting tools i. tube cutter: for cutting refrigerant tubing cleanly ii. hacksaw: for cutting metal pipes and other materials iii. utility knife: for cutting insulation and other materials. iv. wire strippers: for stripping the insulation off electrical wires c. Pliers and wrenches i. adjustable wrench (crescent wrench): for tightening and loosening nuts and bolts ii. pipe wrench: for gripping and turning pipes iii. slip-joint pliers: for gripping and holding objects of various sizes iv. needle-nose pliers: for reaching into tight spaces and bending wires. v. channel lock pliers: for gripping larger objects with adjustable jaws vi. locking pliers: for holding objects securely vii. flare nut wrench: for tightening flare nut connections on refrigerant lines. d. Screwdrivers and nut drivers i. flathead screwdriver: for driving flathead screws. ii. Phillips screwdriver: for driving Phillips head screws iii. nut drivers: for tightening nuts and bolts, available in various sizes e. Hammers and mallets i. ball peen hammer: for striking and shaping metal components ii. rubber mallet: for gently tapping parts without damaging them f. Soldering and brazing tools i. soldering torch: for soldering and brazing refrigerant lines ii. soldering iron: for electrical soldering tasks iii. flux and solder: for making soldered connection iv. brazing rods: for brazing connections g. Miscellaneous tools i. Allen wrenches (hex keys): for tightening and loosening hexagonal screws and bolts ii. deburring tool: for smoothing the edges of cut pipes iii. hand reamer: for cleaning and enlarging holes in metal iv. inspection mirror: for viewing hard-to-reach areas

Topics	Content elements
	v. flashlight or headlamp: for illuminating dark areas while working vi. service valve wrench: for opening and closing service valves on refrigeration systems vii. refrigerant scale: for weighing refrigerant during charging and recovery viii. pipe bender: for bending refrigerant lines to the desired shape ix. flaring tool: for flaring the ends of refrigerant lines x. swaging tool: for expanding the ends of tubes to fit them together h. Personal Protective Equipment (PPE) i. safety glasses: to protect eyes from debris and refrigerant ii. gloves: to protect hands from cuts, burns, and chemicals iii. ear protection: to protect hearing in noisy environment iv. safety footwear: to protect feet and toes from impact v. hard hat: to protect head from falling objects
3.2 Safe handling of refrigerants	3.2.1 Safe handling of refrigerants and risk mitigation a. Identification and preparation i. identification of refrigerant type: verify the specific type of refrigerant in the system using labels, documentation, or testing kits ii. appropriate equipment: use appropriate tools such as refrigerant recovery machines, cylinders, manifolds, hoses, and PPE iii. safety precautions: work in well-ventilated areas iv. appropriate PPE, including gloves, goggles, and protective clothing v. emergency procedures in case of refrigerant exposure b. Refrigerant recovery i. turn off the system: shut down the refrigeration or air conditioning system before starting the recovery process. ii. connect recovery machine: attach the recovery machine to the system’s service ports using proper hoses and fittings. iii. recover the refrigerant: operate the recovery machine to remove refrigerant from the system and transfer it into a recovery cylinder. ensure the cylinder is rated for the type and amount of refrigerant being recovered iv. weigh the recovered refrigerant: measure the amount of refrigerant recovered to verify complete removal and for record-keeping purposes c. Refrigerant recycling and reclamation i. recycle refrigerant (on-site cleaning): use on-site recycling equipment to clean the recovered refrigerant by removing oil, moisture, and other contaminants. ii. reintroduce the cleaned refrigerant into the system if it meets purity standards

Topics	Content elements
	iii. send for reclamation: if the refrigerant is contaminated beyond on-site cleaning capabilities, send it to an authorized reclamation facility. The facility will process and purify the refrigerant to meet industry standards d. Refrigerant charging i. check system for leaks: before recharging, use leak detection methods to ensure the system is leak-free ii. evacuate the system: use a vacuum pump to evacuate the system, removing air and moisture to create a vacuum iii. charge the refrigerant: connect a refrigerant cylinder to the system's service port using a charging hose and manifold gauges. Slowly add the refrigerant into the system, monitoring pressure and weight to ensure the correct amount is added iv. verify proper charge: use system specifications and performance data to confirm the system is charged with the correct amount of refrigerant e. Leak detection and repair i. perform leak detection: use electronic leak detectors, UV dye, or soap bubbles to identify leaks in the system ii. repair leaks: fix identified leaks by tightening fittings, replacing gaskets, or repairing damaged components iii. verify leak repair: recheck of system to ensure all leaks are repaired before recharging f. Documentation and compliance i. record keeping: detailed records of refrigerant recovery, recycling, reclamation, and recharging activities. Information such as refrigerant type, quantity, date, and technician details ii. compliance with regulations: regulations regarding refrigerant handling g. Disposal of refrigerant i. identify non-recyclable refrigerant: determine if the refrigerant is non-recyclable due to contamination or regulations h. Complete waste transfer documentation: i. end of life management to minimise environmental impact ii. record and keep records of the disposal process, including quantities, dates, and the disposal facility used iii. segregation of resources: prevention, re-use, recycling, recovery, disposal
3.3 Installation skills	3.3.1 Installation skills a. System components: i. familiarity with components: function and placement of key components such as compressors, condensers, evaporators, expansion valves, and thermostats ii. component identification: purpose of various system parts

Topics	Content elements
	b. Basic mechanical skills: i. pipe cutting and bending: cutting and shaping refrigerant pipes to fit the installation layout ii. basic soldering and brazing: joining copper pipes using basic soldering techniques to ensure leak-free connections. iii. mounting and securing components: mounting compressors, condensers, evaporators, and other components to their designated locations c. Electrical skills: i. basic wiring: connecting electrical components according to wiring diagrams ii. using a multi meter: testing and verifying electrical circuits and connections for continuity and proper voltage d. Refrigerant handling: i. refrigerant charging: adding the correct type and amount of refrigerant to the system ii. refrigerant recovery: safely recovering refrigerant from systems for reuse or disposal iii. leak detection: identifying and repairing refrigerant leaks using basic leak detection methods such leak detection spray, electronic leak detector e. System evacuation: i. using a vacuum pump: evacuating the system to remove air and moisture ii. pressure testing: testing the system for leaks and pressure integrity to BS EN378 standard f. Basic insulation and sealing: i. pipe insulation: installing insulation on refrigerant lines to prevent condensation and energy IoS ii. sealing joints: ensuring all joints and connections are properly sealed to prevent leaks g. Component installation and adjustment: i. thermostats and controllers: installing and setting basic thermostats and control systems for temperature regulation ii. expansion valves: installing and making basic adjustments to expansion valves to ensure proper refrigerant flow h. System commissioning: i. initial start-up: performing initial start-up procedures to ensure all components are operating correctly ii. basic performance testing: checking system performance parameters such as temperature and pressure to ensure they are within acceptable ranges i. Safety and compliance: i. following safety protocols: safety guidelines to prevent accidents and injuries ii. regulatory compliance: complying with regulations regarding refrigerant handling and system installation j. Requirements of documentation and communication:

Topics	Content elements
	i. record keeping: maintaining basic records of the installation process, including refrigerant quantities and system settings ii. customer communication: explaining basic system operation and maintenance requirements to customers k. Tools and equipment proficiency i. basic tools: hand tools such as wrenches, pliers, screwdrivers, and basic power tools like drills and saws required for installation ii. specialised tools: familiarity with using manifold gauges, vacuum pumps, and refrigerant recovery machines
3.4 Brazing skills	3.4.1 Brazing Skills a. General brazing skills i. brazing fundamentals • the brazing process, including differences between brazing, soldering, and welding. • capillary action and how it facilitates the flow of filler metal into the joint ii. safety practices • personal protective equipment (PPE) such as gloves, goggles, and protective clothing. • hazard awareness related to brazing, such as burns, fumes, and fire risks, and knowledge of prevention measures • proper ventilation and handling of gases. iii. material preparation • cleaning surfaces to be brazed to remove grease, dirt, and oxidation using appropriate cleaning agents and tools • correctly cutting, deburring, and fitting pipes and components to ensure proper alignment and gap spacing b. Specific skills for brazing copper to copper i. flux application • when using copper-phosphorus brazing rods (Phoson) flux may not be necessary, often self-fluxing when used on copper to copper. Apply correct flux to the joint to prevent oxidation and ensure good flow of the filler metal ii. filler material • select type of Phoson brazing rod (a phosphorus-copper-silver alloy) for copper to copper joints • feed filler material into the joint to achieve full penetration and a strong bond c. Specific skills for brazing copper to brass i. flux and filler material selection • fluxes compatible with both copper and brass since brass does not contain phosphorus • select suitable Phoson brazing rod or other brazing alloy for copper to brass joints

Topics	Content elements
	ii. heat control • adjust flame to avoid overheating brass, which has a lower melting point than copper • apply heat evenly to ensure both metals reach the brazing temperature without causing damage d. Using Phoson brazing rod i. filler material handling • composition and characteristics of Phoson brazing rods • ensuring proper storage and handling of brazing rods to maintain their effectiveness ii. application techniques • heating the joint area and applying the Phoson brazing rod to ensure adequate flow and bonding • correct temperature to avoid burning the phosphorus content in the brazing rod e. Setting a neutral flame i. torch setup • set up and maintaining of brazing torch, including checking for leaks and ensuring correct gas pressures ii. lighting the torch • lighting torch and adjusting the flame to achieve a neutral flame, which has a balanced mix of oxygen and acetylene iii. adjusting the flame • characteristics of a neutral flame: a distinct inner cone and outer envelope with no excessive noise • ensure the flame is not oxidizing (excess oxygen) or carburizing (excess acetylene), which can affect the quality of the brazed joint f. Inspection and testing i. visual inspection • inspecting the brazed joint for proper wetting, smoothness, and absence of voids or cracks • ensuring complete coverage of the joint area by the filler material ii. pressure testing • performing pressure tests to ensure the integrity and leak-free nature of the brazed joints. • Identification and correction of any leaks or weak joints g. Troubleshooting i. identifying issues • common brazing problems such as insufficient heat, improper flux application, or incorrect filler material • correct issues like leaks, weak joints, or poor flow of filler material
3.5 Component replacement	3.5.1 Component replacement a. Compressor replacement

Topics	Content elements
	i. disconnect electrical connections, refrigerant lines, and mounting hardware ii. install the new compressor, ensuring it is securely mounted and connected iii. check oil levels and ensure proper lubrication b. Condenser and evaporator coils i. remove and replace condenser and evaporator coils, ensuring proper alignment and secure connections ii. clean coils and ensure no debris enters the system c. Expansion devices i. replace Thermostatic Expansion Valves (TXVs), capillary tubes, or other expansion devices, ensuring correct orientation and calibration ii. check for proper superheat settings after replacement d. Filters and driers i. replace filter driers to maintain system cleanliness and prevent moisture and contaminants from circulating ii. install sight glasses to monitor refrigerant flow and condition e. Electrical components i. replace electrical components such as capacitors, contactors, relays, and sensors, ensuring proper wiring and secure connections ii. test electrical circuits for continuity and proper operation f. Fans and motors i. replace fan motors and blades, ensuring correct orientation and balance for optimal airflow. ii. lubricate bearings and check for proper operation g. Reversing valves i. replace reversing valves to ensure proper switching between heating and cooling modes ii. verify correct operation and refrigerant flow direction after installation h. Defrost controls i. replace defrost control boards or sensors to ensure efficient defrost cycles. ii. test defrost cycle functionality to confirm proper operation.

Unit 205 Install and commission RACHP (refrigeration circuit) systems

Unit level:	Level 2
Guided Learning Hours (GLH):	80
Unit aim:	This is a **theory** and **practical** unit This unit aims to develop the learners' ability to apply a range of skills related to installation and commissioning of single stage vapour compression RACHP systems. This unit covers RACHP sector knowledge including jointing methods, system components, fixing pipework and insulation methods. The unit also covers key handover requirements post installation and commission in the RACHP industry.
Assessment method:	Externally set, Multiple Choice Question (MCQ) exam, online, on-demand Practical assessment
Links to Apprenticeship Standard:	ST0322 Refrigeration, air conditioning and heat pump engineering technician

Learning outcomes

1. Know how to plan and prepare for installation of RACHP systems.
2. Install and test RACHP systems
3. Commission RACHP (refrigeration circuit) systems
4. Handover RACHP systems

Learning outcome 1

Know how to plan and prepare for installation of RACHP systems

Topics	Content elements
1.1 Information and services required for preparation of RACHP installation	1.1.1 Types of information and services required for preparation of RACHP installation a. Types of information required for the preparation of RACHP installation i. regulatory documents (see Unit 201 1.1.1) ii. industry codes of practice • BSEN 378

	• 18th Edition 7161 • IoR (Institute of Refrigeration) Guidance Notes • BRA testing ACOP • BRA brazing ACOP iii. manufacturers' instructions • helplines • websites • apps iv. installation specifications • mechanical and electrical drawings • as-fitted drawings (accurately records changes to original design) • operation and maintenance manuals b. Types of services required for installation i. electricity: to provide motive power and control ii. water: for steam humidification and use for fluid condensing mediums and secondary refrigeration systems iii. gas: a heat source in some ducted air handling units iv. drainage: to facilitate removal of condensate from RACHP systems v. ventilation: required to performing brazing, glueing and recovery/reclaim operations
1.2 Personnel involved with RACHP installation	1.2.1 Responsibilities related to RACHP installation a. RACHP Engineering Technician i. position and secure fixing of RACHP components and equipment ii. carry out jointing of pipework iii. carry out termination of control cables b. Colleagues i. support and assist with lifting operations ii. designate tasks to support installation activities iii. support with erection of access equipment c. Supervisors i. interpret installation requirements as per specifications and drawings ii. facilitate installation through clear and concise instructions iii. maintain health and safety iv. provide a link between design team and site operatives/client d. Client i. comply with CDM regulations and contracts ii. appoint main contractors iii. organise funding of project e. General public i. follow health and safety displays and warnings f. Health And Safety Officer i. ensure compliance with health and safety legislation ii. complete risk assessments iii. assess sub-contractor risk assessments

1.3 Resources required for RACHP installation activities	1.3.1 Resources required for RACHP installation activities a. Tools i. torque wrenches ii. service keys/spanners iii. flaring tools iv. spanners, adjustable and sized v. pipe cutters, tube expanders, de-burers, hacksaw. vi. insulated screwdrivers, side cutters, plyers cable strippers. multi meter, GS38 voltage tester and proving unit. vii. battery drills, Slotted Drive Shaft (SDS) and impact. viii. clamp meter ix. pipe benders, multiple sizes. x. capacitance tester. xi. thermometer xii. air temperature probes xiii. tape measure xiv. spirit level b. Equipment iii. nitrogen pressure testing equipment iv. tubes and gauges relating to brazing operations v. recovery/reclaim units vi. vacuum pump vii. weighing scales viii. manifold gauges ix. cylinders recovery and refrigerant x. electronic leak detector xi. leak detection fluid c. Materials i. copper pipe and fittings ii. cable tray iii. pipe brackets iv. insulation v. refrigerant gasses vi. plastic pipe and fittings for condensate removal vii. slotted channel and channel nuts viii. threaded rod complete with nuts and washers ix. screws and fixings x. brazing rods xi. flux d. Documents i. equipment manufacturers' instructions ii. tools instructions for use iii. Control of Substances Hazardous to Heath (COSHH) data for fluxes and gasses iv. risk assessment and method statements (consulted prior to site work) v. hot work permit

Learning outcome 2

Install and test RACHP systems

Topics	Content elements
2.1 System components for positioning and pipework installation/fixing methods	2.1.1 System components for positioning: a. Condensing units b. Evaporators c. Condensate drains d. Valves e. Electrical cabling f. Drier (flow direction) g. Pressure switches h. Pumps i. Sight glass j. Vessels 2.1.2 Pipework installation/fixing methods: a. Vibration damping clamps b. Pipe saddles c. Pipe clips d. Insulated clamps e. Pipe fittings
2.2 Form pipework and jointing methods	2.2.1 Ways of forming pipework a. Flare b. Bend c. Swage d. Braze (oxyfuel) i. ensure equipment is set to the correct pressure ii. choose correct size nozzle iii. set the torch to the correct flame 2.2.2 Types of jointing methods a. Similar and dissimilar metals with hot and cold joints – mechanical and brazed b. Copper to copper joints c. Dissimilar metal joints using silver solder
2.3 Protective measures used when flame brazing temperature sensitive system components	2.3.1 Protective measures used when flame brazing temperature sensitive system components a. Wet rag i. prevents overheating of a component ii. non-conductive foam (cooling gel) iii. prevents conduction of heat to the component b. Temporary removal of low melting point items i. prevents radiated heat damage c. Heat resistant barriers i. prevent conducted and radiated heat transmission 2.3.2 Temperature sensitive system components

	a. Thermostatic expansion valves b. Solenoid valves c. Vibration eliminators d. Schrader valves e. Pressure transducers f. Insulation
2.4 Types of insulation for pipework systems and their purpose	2.4.1 Types of insulation for pipework systems a. Pre-insulated b. Cut and glue c. Continuous d. Mitred e. Insulated tape 2.4.2 Purpose of insulation for pipework systems a. Reduce thermal losses b. Reduces thermal gains c. Prevents ice formation d. Prevents sweating on secondary refrigerant systems (CHWS) e. Prevent freezing of the water side of air source heat pumps

Learning outcome 3

Commission RACHP (refrigeration circuit) systems

Topics	Content elements
3.1 RACHP commissioning activities	3.1.1 The stages of testing and commissioning activities for vapour compression systems, their importance and recording requirements a. Stages of testing and commissioning activities i. stage 1 – visual inspection of system incorporating earthing systems, wiring connections, pipework, insulation and unit fixing and positioning, ensuring that all necessary services are ready for safe operation ii. stage 2 – ensure pressure tested to BSEN378 • use OFN (Oxygen Free Nitrogen) • set the pressure to the equivalent of 55 degrees C(high side) and 32 degrees C(low side) • strength test(for new systems only) • recommend leave the pressure test for 24 hours iii. stage 3 – ensure correct dehydration of system to BSEN378

	iv. stage 4 – charge system to manufactures instructions/ correct super heat and sub cooling as per industry standards v. stage 5 – perform functional testing checking phase rotation where necessary, running currents, air on air off temperatures and specific manufacturer's instructions vi. stage 6 – decommission system in accordance with BS EN 378 and the F-Gas regulations, and remove all pipework, brackets, fixings and valves b. Importance of commissioning activities i. ensures compliance with manufacturer's warranty conditions ii. confirms sustainable system operation iii. safeguards electrical safety of systems iv. ensures system performs to the design parameters c. Methods of recording commissioning activities i. manufacturers' warranty documentation ii. test certificates iii. company generated commissioning documents iv. company generated operation and maintenance manuals v. apps and online recording
3.2 Requirements for component warranty, legislation or regulation related to installation or other protections.	3.2.1 Requirements for component warranty, legislation or regulation related to installation or other protections. a. Component warranty requirements i. evidence of installation in accordance with manufacturer's instructions ii. record of all system commissioning operational conditions. iii. details of compliance with manufactures pre-commissioning check lists iv. documentation detailing system design parameters against actual performance. b. Legislation/regulation requirements i. British standards ii. F Gas regulations iii. European pressure systems directive iv. Construction Design and Management (CDM) Regulations

Learning outcome 4
Handover RACHP systems

Topics	Content elements
4.1 Handover activities related to install and commission activities	4.1.1 Handover system operation to the client a. Verbal

	i. engineering terms to responsible person ii. non-technical jargon to users b. Written handover using manufacturer's instructions c. Simple quick start instructions d. Service intervals and advice to client 4.1.2 Communicate maintenance requirements for the system a. Operation and maintenance manuals b. Propose maintenance contract and aftercare c. Instruct client on simple routine maintenance of system
4.2 Handover documents related to install and commission activities	4.2.1 Types of documents required for handover: a. System documentation: i. as-fitted drawings ii. equipment manuals iii. commissioning reports b. Manuals: i. maintenance manuals ii. operational manuals iii. manufacturers' instructions c. Compliance documentation i. relevant planning permissions ii. electrical test certificates iii. pressure test certificates 4.2.2 Handover activities related to documentation: a. Personal delivery to client on handover b. Provision of physical and digital copies for client c. Physical and digital copies to be retained by the installer

Unit 206 Electrical systems (single phase) for RACHP

Unit level:	Level 2
Guided Learning Hours (GLH):	90
Unit aim:	This is a **theory** and **practical** unit. The purpose of this unit is to enable learners to understand the basic principles of single-phase electrical circuits and perform basic calculations involving voltage, current, resistance and power. They will learn about different types of circuit protective devices, motor starting techniques, electrical components and wiring systems. They will also learn how to install electrical systems, select and use test instruments, fault find and repair, test and commission electrical systems.
Assessment method:	]Externally set, Multiple Choice Question (MCQ) exam, online, on-demand Practical Assignment
Link to Occupational Standard:	ST0322 Refrigeration, air conditioning and heat pump engineering technician

Learning outcomes

1. Understand the fundamental principles of electrics
2. Understand the requirements of test instruments
3. Test circuits and fault find
4. Install, test and commission an electrical control system for RACHP

Learning outcome 1

Understand the fundamental principles of electrics

Topics	Content elements
1.1 Principles of electricity	1.1.1 Fundamental principles of electricity a. Ohms law: V=I x R b. Potential difference c. Voltage d. Current: Alternating Current (AC) and Direct Current (DC) e. Resistance Ohms (Ω) f. Series and parallel circuits g. Capacitance: Farads (F) h. Frequency: Hertz (Hz) i. Impedance: Ohms (Ω)

Topics	Content elements
	j. Power: P= V x I k. Earthing and earth bonding l. Basic symbols: IETA regulations m. Circuit diagrams: schematic, network, as-installed, physical wiring, pictorial, block
1.2 Purpose and components of consumer units and distribution boards	1.2.1 Key purpose of consumer units and distribution boards a. Circuit protection device i. protects people and properties if an electrical fault occurs ii. reduces the risk of a fire caused by an electrical fault iii. protects a circuit from either overcurrent or overvoltage conditions iv. automatically disconnects the supply of electricity to the part of the circuit where the fault has occurred b. Main switch i. main connecting link between external supply and wiring within the RACHP environment ii. allows for the electricity supply to be turned on and off to the fuse box iii. there may be more than one mains switch linked to different fuse boxes c. Circuit isolation i. disconnects the circuit from the live supply ii. ensures a circuit is safe for an operative to work on iii. has two clear stages – switching off the supply and proving it is dead 1.2.2 Types of circuit protection devices for electrical systems and their uses: a. Miniature Circuit Breakers (MCB) b. Residual Current Devices (RCCB/RCD) c. Cartridge fuses d. Rewirable fuses e. Residual Current Breaker Overload (RCBO)
1.3 Isolation of electrical system circuits	1.3.1 Test equipment required to carry out safe isolation of electrical supplies and their locations. a. Test equipment: i. proving devices ii. voltage indicator iii. label informing that work is in progress iv. store removable fuses in secure location/on person v. locking off devices vi. plug in testing device b. Locations for isolating system circuits: i. consumer unit or fuse box ii. fuse spurs iii. electrical isolators iv. emergency power stop button (EPO)

Topics	Content elements
	1.3.2 Safe isolation procedure a. Identify the source of supply and suitable point(s) for isolation b. Test voltage indicator using the proving device to make sure it is working properly c. Carry out the safe isolation process, disconnecting the circuit from the mains d. Secure or “lock off” the point of isolation e. Use voltage indicator to determine that the system is dead f. Prove that voltage indicator using reproving device is functioning correctly as in step 2 g. Put up visible warning signs to indicate to end users that the circuit has been isolated h. Re-prove that the system is dead before beginning work
1.4 Working with electrical systems	1.4.1 Working with electrical systems; regulations, risks and mitigations a. Regulations i. Electricity at Work Act Regulations (EAWR) ii. IET wiring regulations iii. GS38 b. Risks i. shock ii. heat iii. fire iv. explosions c. Mitigations i. safe isolation procedures ii. earthing iii. insulated tools iv. correctly fitted fuse v. preventative maintenance vi. voltage reduction vii. protection from water ingress viii. flammable refrigerants (separation) d. Main features of electrical circuits in buildings: i. ring mains ii. radial iii. spur and fused outlets iv. bus bars
1.5 Operating principles of electrical controls and components used in the RACHP industry.	1.5.1 Operating principles of controls and components a. Controls and components: i. thermal overload protectors (bimetal. NTC, PTC) ii. solenoid coils iii. relays iv. contactors v. overloads vi. electric motors (compressor, fan, pump) vii. compressor motor starting relays (current coil, potential, solid state) viii. start / run capacitors

Topics	Content elements
	ix. pressure switches x. thermostats xi. transformers xii. heater elements xiii. light bulbs xiv. on-off switches xv. fuses (cartridge, High Breaking Current (HBC)) xvi. Miniature Circuit Breaker (MCB) - BSEN60898 type A, B, C and D – protects against overcurrent xvii. Residual Current Circuit Breaker (RCCB) - BSEN61008 - protects against earth leakage xviii. Residual Current Breaker Overload (RCBO) - BSEN61009 protects against overcurrent and earth leakage xix. Variable Speed Drives (VSD) b. Squirrel-cage induction motors: i. brushless motor ii. rotor iii. stator (start and run windings) iv. rotating magnetic field c. Electric motor starting arrangements: i. Resistance Start-Induction Run (RSIR) ii. Capacitor Start-Induction Run (CSIR) iii. Capacitor Start-Capacitor Run (CSCR)

Learning outcome 2

Understand the requirements of test instruments

Topics	Content elements
2.1 Electrical and appliance testing	2.1.1 Tests, checks and types of electrical appliances: a. Types of testing and their purpose: i. Ensures that electrical appliances are safe to use ii. Supports companies in complying with the regulatory requirements for the inspection of electrical appliances and equipment iii. Functional testing iv. Ensures the safety, reliability and performance of the electrical system or device v. Validates the compliance with the relevant standards and regulations vi. Tests system against functional requirements and specifications vii. Tests circuits, such as lights and sockets, to ensure that they perform as expected b. Legislation for the safety of electrical equipment within domestic and commercial settings i. Provision and use of work equipment regulations (PUWER) ii. Requirements of the organisational policy requirements iii. User checks

Topics	Content elements
	iv. Visual inspections (damaged sheathing, cracked plug, cracked casing, exposed conductor) v. Portable Appliance Testing (PAT) vi. Effective testing intervals c. Actions to take when equipment fails PAT testing i. Remove from use ii. Mark as failed using recognised process iii. Report to supervisor
2.2 Test instruments used to measure electric circuits	2.2.1 Test instruments used to measure electric circuits and the stages of their use a. Test instruments i. Voltage meter ii. Ammeter iii. Ohmmeter iv. Multi meter v. Insulation resistance tester vi. Capacitance tester vii. Earth loop impedance tester viii. GS38 compliance b. Stages of using test instruments i. Choose appropriate test instrument scale ii. Check instrument calibration expiry date
2.3 Circuit or component testing and IET wiring regulations	2.3.1 Circuit or component testing in accordance with IET wiring regulations a. Circuit or component testing i. Earth continuity ii. Line / neutral continuity iii. Polarity b. Circuit testing using an insulation resistance meter i. IET wiring regulations stipulate the minimum voltage to be applied dependent upon the circuit

Learning outcome 3

Test circuits and fault find

Topics	Content elements
3.1 Testing circuits and fault finding	3.1.1 Testing circuits and fault finding, appropriate instruments and safety measures a. Visual inspections prior to electrical testing i. loose connections ii. heat marks iii. mis-wires iv. heat damage v. physical damage b. The use of test instruments to determine: i. continuity ii. insulation resistance

Topics	Content elements
	iii. polarity iv. functional testing v. current vi. voltage c. Common electric faults i. short circuit ii. open circuit iii. poor wire termination iv. component failure d. Circuit testing i. dead testing ii. live testing (RCCB/RCD device) iii. Electricity at Work Act Regulations (EAWR) e. Appropriate safety measures for live testing a circuit i. PPE ii. warning notices iii. barriers iv. GS38 instruments

Learning outcome 4

Install, test and commission an electrical control system for RACHP.

Topics	Content elements
4.1 Installation and connection requirements in accordance with IET regulations	4.1.1 Installation and connection requirements in accordance with IET regulations a. Suitability of existing circuit or power supply for proposed system to be installed. b. Cable sizing procedure for wires and cables i. single core ii. multicore iii. SWA c. Circuit protection sizing procedure i. fuses ii. MCBs iii. RCCBs iv. RCBOs d. Protection of cables i. embedding ii. trunking iii. conduit iv. timber stud walls v. timber floors e. Cable termination methods i. crimps ii. screw terminals iii. strip connectors

4.2 Install, test and commission an electrical control system for a RACHP system	4.2.1 Install, test and commission an electrical control system for a RACHP system
	
	a. Electrical control system installation from an existing power supply
	    i. main fuse
	    ii. meter
	    iii. consumer unit
	    iv. main earth terminal
	b. Install control system testing
	    i. Visual
	    ii. Earthing
	        • requirements: TT, TN-S, protective equipotential bonding, supplementary earth bonding, temporary bonding
	    iii. Dead tests
	    iv. Functional testing
	c. Impact of earth-fault loop impedance regarding the automatic disconnection of supply during fault conditions: disconnection time
	d. Record test data and hand over to client

Qualification guidance for delivery

Opportunities for efficiencies in delivery across/between units:	Providers should consider the learner cohort and their relevant chosen construction specialism(s) when preparing to deliver to identify where contextualisation can be added to enhance relevance. Standardised templates: develop templates for units to ensure delivery is consistent across unit where applicable. Health and safety and planning of work are common themes across all units; there are also common tools and equipment within units.
Suggestions for formative assessment opportunities, both for knowledge and practical outcomes:	Short formative assessments at the end of sessions/aligned to outcome. Peer assessment to encourage students to assess each other's work developing critical thinking and communication skills. Knowledge checks: integrate short quizzes or online learning checks after key theoretical concepts to ensure understanding before moving on. Sample test exam prep session to prepare for assessment. Practical skills: implement short, practical assessments throughout the program where students create small models or components using specific RACHP methods. A reflective approach by learners is encouraged throughout the units when completing practical tasks to support their improvement and ability to recognise whether the completion of holistic tasks is to the required standard.
Opportunities for visits/engagement with local industry and employers:	Employer engagement opportunities for this qualification should be incorporated in order to allow the learner to understand application of knowledge learnt in context. This could include site visits linked to specific trade area or having guest lectures or speakers from local employers explaining elements of theoretical knowledge and how they are addressed on site. Examples of employer engagement opportunities: research, work placements, demonstrations by industry professionals, careers and job role information provided by local employers.
Considerations for innovative methods of delivery:	Providers should make the best use of available resources to provide learners with the opportunity to use a wide range of activities that could include lectures, discussions and self-study. A blended learning approach, with online learning opportunities, could be adopted for content delivery. Learner's research and investigation of local/national health and safety incidents that have made recent news, related to their chosen/specific trade area and explore their impacts (eg changes in legislation/practice, implications for employees, fines etc).

	The use of Artificial Intelligence (AI) to help produce and guide lecturers on certain topics; Virtual Reality (VR) simulations to practice complex RACHP techniques in a safe, controlled environment before working with refrigerants.
Ways of ensuring content is delivered in line with current, up to date industry practice:	Providers should be up to date with current legislation/guidance and industry best practice and new methods of work. Staff CPD should be in line with current practices (eg CSCS card). Employer guest lectures or real site visits should be encouraged to allow students to gain insight and or practical application of knowledge and skills in a real environment. Providers should ensure adherence to current relevant regulations.
EDI or accessibility considerations:	Teaching may need adaptation, for example, electrical power colour cords, fire extinguisher colours, PPE considerations based on religious grounds (eg headwear), and formats (eg, dyslexia-friendly fonts, audio recordings) to cater to diverse learning styles. Adapt assessments to accommodate different learning abilities, offering alternative ways for students to demonstrate their understanding. Consider offering flexible learning options to cater to students with different needs. Digitisation of resources with correct formatting for screen readers and content in multiple formats. Ensure that course materials are available in accessible formats for students with visual or learning differences/disabilities. Use inclusive language and explain technical terms and concepts clearly. Be aware of cultural differences and ensure that examples are culturally sensitive and inclusive, including gender-balanced representation and avoiding reinforcing stereotypes. Providers must deliver the unit in line with their EDI policy and organisational procedures.
Digital initiative considerations:	Online VR tools to explore risks and hazards in workshop. Develop online learning materials with detailed video tutorials showcasing complex RACHP techniques and tool usage. Implement the use of online classrooms and digital formats for work. The use of digital games and quizzes to enhance learning. Use of video streaming channels to provide multi technical content relevant to the expectations of the RACHP role.

Sustainability considerations:	Encourage paperless working practices, printing materials only where necessary. Use of digital techniques to reduce use of materials. Use of digital VLE and electronic assessment to reduce paper outputs. Consider approaches to sustainability throughout the RACHP processes in order to minimise environmental impact; these could include recycling of materials where possible, minimising waste, and reusing materials for practical tasks where possible.
Books:	Hundy. Modern refrigeration and air conditioning, F-Gas reference manual 2nd edition, Refrigeration & Air Conditioning. HSE pamphlets available from HSE website
Websites:	Air Conditioning and Refrigeration Industry Board (ACRIB) member organisations: **https://acrib.org.uk/acrib-skillcard** American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE): **https://www.ashrae.org/** British Standards Institution (BIS) group: **https://www.bsigroup.com/en-GB/** Health and Safety Executive: **www.hse.gov.uk** Institute of Occupational Safety and Health (ISOH) magazine: **https://www.ioshmagazine.com/** Institute of Refrigeration (IoR): **https://ior.org.uk/** National Examination Board in Occupational Safety and Health (NEBOSH): **https://www.nebosh.org.uk/home/** Refrigeration Equipment Certification (REFCOM): **https://www.refcom.org.uk/f-gas**

Appendix 1 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 **Centre document library** on **www.cityandguilds.com** or click on the links below:

Centre Handbook: Quality Assurance Standards

This document is for all approved centres and provides guidance to support their delivery of our qualifications. It includes information on:

- centre quality assurance criteria and monitoring activities
- administration and assessment systems
- centre-facing support teams at City & Guilds/ILM
- centre quality assurance roles and responsibilities.

The Centre Handbook should be used to ensure compliance with the terms and conditions of the centre contract.

Centre Handbook: Quality Assurance Standards

This document sets out the minimum common quality assurance requirements for our regulated and non-regulated qualifications that feature centre-assessed components. Specific guidance will also be included in relevant qualification handbooks and/or assessment documentation.

It incorporates our expectations for centre internal quality assurance and the external quality assurance methods we use to ensure that assessment standards are met and upheld. It also details the range of sanctions that may be put in place when centres do not comply with our requirements or actions that will be taken to align centre marking/assessment to required standards. Additionally, it provides detailed guidance on the secure and valid administration of centre assessments.

Access arrangements: When and how applications need to be made to City & Guilds provides full details of the arrangements that may be made to facilitate access to assessments and qualifications for learners who are eligible for adjustments in assessment.

The **Centre document library** also contains useful information on such things as:

- conducting examinations
- registering learners
- appeals and malpractice.

Useful contacts

Please visit the **Contact us** section of the City & Guilds website.

City & Guilds

For almost 150 years, we have worked with people, organisations and economies to help them identify and develop the skills they need to thrive. We understand the life-changing link between skills development, social mobility, prosperity and success. Everything we do is focused on developing and delivering high-quality training, qualifications, assessments and credentials that lead to jobs and meet the changing needs of industry.

We partner with our customers to deliver work-based learning programmes that build competency to support better prospects for people, organisations and wider society. We create flexible learning pathways that support lifelong employability because we believe that people deserve the opportunity to (re)train and (re)learn again and again – gaining new skills at every stage of life, regardless of where they start.

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City & Guilds
Giltspur House
5–6 Giltspur Street
London
EC1A 9DE

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