



# **City & Guilds Level 2 Diploma in Refrigeration, Air-Conditioning and Heat Pump Systems (7189-02)**

**Version 1.5 (September 2024)**

**Qualification Handbook**

## Qualification at a glance

|                                       |   |
|---------------------------------------|---|
| <b>Subject area</b>                   | Building and construction   |
| <b>City &amp; Guilds number</b>       | 7189  |
| <b>Age group approved</b>             | Aged 16 and above   |
| <b>Entry requirements</b>             | City & Guilds does not set entry requirements for this qualification. |
| <b>Assessment</b>                     | Multiple choice examination, practical demonstration/assignment       |
| <b>Grading</b>                        | Pass/Fail   |
| <b>Approvals</b>                      | Full approval, Fast track   |
| <b>Support materials</b>              | Assessment pack, assignment guide, psychrometric chart                |
| <b>Registration and certification</b> | Consult the Walled Garden/Online Catalogue for last dates             |

| <b>Title and level</b>   | <b>City &amp; Guilds qualification number</b> | <b>Regulatory reference number</b> | <b>GLH</b> | <b>TQT</b> |
|--|---|------------------------------------|------------|------------|
| City & Guilds Level 2 Diploma in Refrigeration, Air-Conditioning and Heat Pump Systems | 7189-02                                       | 600/6036/0                         | 464        | 510        |

| Version and date   | Change detail  | Section                              |
|--------------------|--|--------------------------------------|
| 1.2 March 2014     | Test specification for 209/509 added                               | 4. Assessment                        |
| 1.3 September 2017 | Added TQT and GLH details  | Qualification at a Glance, Structure |
|                    | Deleted QCF  | Appendix                             |
| 1.4 August 2018    | Additional information regarding permitted materials for 202 added | Assessment                           |
| 1.5 September 2024 | Handbook reviewed and updated to new template                      | Throughout                           |

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# 1 Introduction

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

| Area  | Description   |
|---|---|
| Who is the qualification for?                 | This qualification is for learners who want to be employed as refrigeration/air conditioning engineers in the building services engineering sector.   |
| What does the qualification cover?            | This qualification allows candidates to learn, develop and practice the skills required for employment and/or career progression in the refrigeration, air conditioning and heat pumps sector.  |
| What opportunities for progression are there? | Once learners have completed this qualification they can progress onto a wide variety of other qualifications. For further information please visit the City & Guilds website at <a href="http://www.cityandguilds.com">www.cityandguilds.com</a> . |

## Structure

To achieve the City & Guilds Level 2 Diploma in Refrigeration, Air-Conditioning and Heat Pump Systems, learners must achieve:

| City & Guilds unit number | Unit accreditation number (UAN) | Unit title | Credit value | GLH |
|---------------------------|---------------------------------|------------|--------------|-----|
|---------------------------|---------------------------------|------------|--------------|-----|

### Mandatory units:

Learners must achieve all **9** mandatory units (**51 credits**).

|         |            |  |    |    |
|---------|------------|--|----|----|
| 201/501 | T/503/9669 | Health and safety in building services engineering                             | 3  | 26 |
| 202     | J/504/0745 | Scientific principles within RAC and HP Systems                                | 10 | 82 |
| 203     | R/504/0747 | Apply scientific principles to practical vapour compression systems            | 8  | 68 |
| 204     | Y/504/0748 | Functions and features of RAC and HP systems                                   | 9  | 87 |
| 205     | D/504/0749 | Service and maintain RAC and HP systems  | 5  | 48 |
| 206     | R/504/0750 | Install and commission RAC and HP systems                                      | 5  | 47 |
| 207     | Y/504/0751 | Electrical systems for RAC and HP systems                                      | 5  | 48 |
| 209/509 | D/502/0629 | Handling fluorinated gases and ozone-depleting substances category I personnel | 3  | 30 |
| 210     | J/602/2482 | Understand how to communicate with others within building services engineering | 3  | 28 |

## 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 Systems (7189-02) | 464 | 510 |



## 2 Centre requirements

### Approval

#### Full approval

To offer this qualification/these qualifications, 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.

#### Fast-track approval

If your centre is approved to offer the 6187-01 City & Guilds Level 2 NVQ Diploma in Installing, Testing and Maintaining Air Conditioning and Heat Pump Systems, or the 6187-02 City & Guilds Level 2 NVQ Diploma in Installing and Maintaining Refrigeration Systems, then you can apply for fast-track approval for the new 7189-02 City & Guilds Level 2 Diploma in Refrigeration, Air-conditioning and Heat Pump Systems using the fast-track approval form, available from the City & Guilds website.

Centres should use the fast-track form if:

- there have been no changes to the way the qualifications are delivered
- they meet all of the approval criteria in the fast-track form guidance notes.

Fast-track approval is available for 12 months from the launch of the qualification. After 12 months, centres will have to go through the standard Qualification Approval Process. The centre is responsible for checking that fast-track approval is still current at the time of application.

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 qualifications before designing a course programme.

## Resource requirements

### Physical resources and site agreements

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

### Centre staffing

Staff delivering this qualification 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.

Assessors must

- hold, or be working towards TAQA (A1/A2 – D32/33 updated) standards and continue to practice to these standards and possess CPD evidence of personally maintaining these standards, or
- have other suitable equivalent assessor qualifications endorsed by the Sector Skills Council and/or the Awarding Organisation.

### Assessor Occupational Competence

For the purposes of this qualification, occupational competence will be deemed to have been demonstrated by the verifiable evidence of one, preferably more, of the following:

- a relevant sector qualification equal to or at a level above the training and/or assessment being delivered. Where earlier forerunner qualifications are held eg City & Guilds Craft or Advanced Craft Certificated, the assessor must demonstrate through CPD evidence a thorough knowledge of the qualification standards that they meet the required criteria
- an up-to-date CPD record including relevant CPD qualifications. Assessors must either be able to demonstrate that they are registered and up-to-date with their registration with an appropriate approved industry registration body or have one or more relevant occupational qualifications to demonstrate that they can be regarded as occupationally competent in terms of assessing or verifying the qualification and the unit contained
- a verifiable CV of industry experience and current knowledge of industry practice and techniques relevant to the occupational area in which they assess. This verifiable evidence must be at or above the level being assessed
- a thorough knowledge and understanding of the qualification standards and requirements.

### 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 and 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 candidates have the potential and opportunity to gain the qualification successfully.

## Age restrictions

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 candidates 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.

Equality legislation 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 candidates will be able to access the requirements of the qualification.

Please refer to the Joint Council for Qualifications (JCQ) access arrangements and reasonable adjustments and access arrangements - when and how applications need to be made to City & Guilds. For more information documents are available on the City & Guilds website.

## 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 \(cityandguilds.com\)](https://www.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 \(cityandguilds.com\)](https://www.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 plumbing activities wherever possible.

## Support materials

The following resources are available for this qualification:

| Description         | How to access  |
|---------------------|--|
| Assessment pack     | <a href="http://www.cityandguilds.com">www.cityandguilds.com</a> |
| Assignment guide    | <a href="http://www.cityandguilds.com">www.cityandguilds.com</a> |
| Psychrometric chart | <a href="http://www.cityandguilds.com">www.cityandguilds.com</a> |

## 4 Assessment

### Assessment of the qualification

Candidates must:

- successfully complete 6 online multiple choice test papers (201, 202, 203, 204, 209, 210)
- successfully complete 1 assignment for each of units 201, 205, 206, 207 and 209.

| Assessment types |   |  |  |
|------------------|---|--|--|
| Unit             | Title   | Assessment method  | Where to obtain assessment materials                             |
| 201/501          | Health and safety in building services engineering                  | Assignment <b>201</b><br><br><b>AND</b><br>Online multiple choice <b>501</b> | <a href="http://www.cityandguilds.com">www.cityandguilds.com</a> |
| 202              | Scientific principles within RAC and HP systems                     | Online multiple choice <b>202</b>  | <a href="http://www.cityandguilds.com">www.cityandguilds.com</a> |
| 203              | Apply scientific principles to practical vapour compression systems | Online multiple choice <b>203</b>  | <a href="http://www.cityandguilds.com">www.cityandguilds.com</a> |
| 204              | Functions and features of RAC and HP systems                        | Online multiple choice <b>204</b>  | <a href="http://www.cityandguilds.com">www.cityandguilds.com</a> |
| 205              | Service and maintain RAC and HP systems                             | Assignment <b>205</b>  | <a href="http://www.cityandguilds.com">www.cityandguilds.com</a> |
| 206              | Install and commission RAC and HP systems                           | Assignment <b>206</b>  | <a href="http://www.cityandguilds.com">www.cityandguilds.com</a> |
| 207              | Electrical systems for RAC and HP systems                           | Assignment <b>207</b>  | <a href="http://www.cityandguilds.com">www.cityandguilds.com</a> |

| <b>Assessment types</b> |  |  |   |
|-------------------------|--|--|---|
| <b>Unit</b>             | <b>Title</b>   | <b>Assessment method</b>   | <b>Where to obtain assessment materials</b> |
| 209/509                 | Handling fluorinated gases and ozone-depleting substances category I personnel | Assignment <b>209</b><br><b>AND</b><br>Online multiple choice <b>509</b> | <b>www.cityandguilds.com</b>                |
| 210                     | Understand how to communicate with others within building services engineering | Online multiple choice <b>210</b>  | <b>www.cityandguilds.com</b>                |

### **Assessment strategy**

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

- evolve multiple choice tests to be delivered on-screen (501, 202, 203, 204, 509, 210)
- live assignments that can be downloaded from the City & Guilds website (201, 205, 206, 207 and 209)

Evolve multiple choice tests are externally set, externally marked exams, scheduled and delivered by the centre under invigilated conditions.

Live assessments downloaded from the City & Guilds website are set by City & Guilds and administered by the centre when the candidate is ready. These assessments should be delivered by the centre under supervised conditions.

Assessments are marked by the centre using the marking guide provided in the relevant assessment materials which are available to download from [www.cityandguilds.com](http://www.cityandguilds.com). All assessment materials must be held securely by centres and not made available to candidates.



## Test specifications

The way the knowledge is covered by each test is laid out in the tables below:

| <b>Test: 7189-501</b> |  | <b>Duration: 1 hour 15 minutes</b> |                     |
|-----------------------|--|------------------------------------|---------------------|
| <b>Unit</b>           | <b>Outcome</b>   | <b>Number of questions</b>         | <b>Percentage %</b> |
| 7189-201              | 1 Know health and safety legislation   | 4                                  | 10                  |
|                       | 2 Know how to handle hazardous situations  | 14                                 | 33                  |
|                       | 3 Know electrical safety requirements when working in the building services industry                                   | 7                                  | 17                  |
|                       | 4 Know the safety requirements for working with gases and heat producing equipment                                     | 8                                  | 19                  |
|                       | 5 Know the safety requirements for using access equipment in the building services industry                            | 4                                  | 9                   |
|                       | 6 Know the safety requirements for working safely in excavations and confined spaces in the building services industry | 5                                  | 12                  |
| <b>Total</b>          |  | <b>42</b>                          | <b>100%</b>         |

**Permitted materials:** 300mm ruler, fine point pen/pencil/and A3 psychrometric chart must be provided by the centre for this test. The A3 psychrometric chart is available on the 7189 web page.

| <b>Test: 7189-202</b> |   | <b>Duration: 1 hour 30 minutes</b> |                     |
|-----------------------|---|------------------------------------|---------------------|
| <b>Unit</b>           | <b>Outcome</b>  | <b>Number of questions</b>         | <b>Percentage %</b> |
| 7189-202              | 1 Know the standard units of measurement used in the RAC sector | 2                                  | 4                   |
|                       | 2 Know fundamental thermodynamics                               | 13                                 | 28                  |
|                       | 3 Know the forms of heat as found in RAC systems                | 5                                  | 11                  |
|                       | 4 Know the principles of pressure                               | 4                                  | 9                   |
|                       | 5 Understand the pressure temperature                           | 6                                  | 13                  |
|                       | 6 Understand the vapour compression cycle                       | 4                                  | 9                   |

| <b>Test: 7189-202</b> |   | <b>Duration: 1 hour 30 minutes</b> |      |
|-----------------------|---|------------------------------------|------|
|                       | 7 Able to understand the psychrometric processes in RAC systems   | 7                                  | 15   |
|                       | 8 Know the general properties of materials used in the RAC sector | 4                                  | 11   |
| <b>Total</b>          |   | 45                                 | 100% |

| <b>Test: 7189-203</b> |   | <b>Duration: 1 hour 30 minutes</b> |                     |
|-----------------------|---|------------------------------------|---------------------|
| <b>Unit</b>           | <b>Outcome</b>  | <b>Number of questions</b>         | <b>Percentage %</b> |
| 7189-203              | 1 Know the principles of operation of the vapour compression system | 13                                 | 44                  |
|                       | 2 Know characteristics of line and pipe systems used in RAC systems | 4                                  | 13                  |
|                       | 3 Know how properties of air are controlled                         | 5                                  | 17                  |
|                       | 4 Know the principles of operation of heat pumps                    | 4                                  | 13                  |
|                       | 5 Know the impact of operating conditions on system performance     | 4                                  | 13                  |
| <b>Total</b>          |   | 30                                 | 100%                |

| <b>Test: 7189-204</b> |   | <b>Duration: 50 minutes</b> |                     |
|-----------------------|---|-----------------------------|---------------------|
| <b>Unit</b>           | <b>Outcome</b>  | <b>Number of questions</b>  | <b>Percentage %</b> |
| 7189-204              | 1 Know the function of a range of RAC and HP system components                | 6                           | 24                  |
|                       | 2 Know the operating principles for a range of RAC and HP system applications | 4                           | 16                  |
|                       | 3 Know the properties of refrigerants   | 4                           | 16                  |
|                       | 4 Know the properties of oils   | 4                           | 16                  |
|                       | 5 Know the operating principles of a range of system controls                 | 4                           | 16                  |
|                       | 6 Know the operation of a range of test instruments used in the RAC industry  | 3                           | 12                  |
| <b>Total</b>          |   | 25                          | 100%                |

**Test: 7189-509****Duration: 1 hour and 20 minutes  
(80 minutes)**

| Unit     | Test section | Outcome/Assessment Criterion  | Number of questions | Percentage % |
|----------|--------------|---|---------------------|--------------|
| 7189-209 | 01           | <p>01.01 Identify standard units of temperature, pressure, mass, density, and enthalpy</p> <hr/> <p>01.02 Describe basic theory of basic vapour compressions cycle, including key terms, and use of basic pH diagram</p> <hr/> <p>01.02 Describe the function of the four major components/processes (compressor, condenser, expansion device, evaporator)</p> <hr/> <p>01.02 Identify condition/state of refrigerant (ie superheated vapour/2 phase mix/subcooled liquid) by use of refrigerant comparator or service gauge</p> <hr/> <p>01.02 Determine reasonable operating conditions (sat. temperatures) for a condenser and evaporator, for a range of applications</p> <hr/> <p>01.02 Describe features of zeotropic blends</p> <hr/> <p>04.01 Understand the function of and role/importance of monitoring system performance for indications that leakage has occurred from:</p> <ul style="list-style-type: none"> <li>a. valves – service, pressure relief</li> <li>b. thermostats/pressure controls</li> <li>c. liquid line, receiver sight glasses and indicators</li> <li>d. defrost controls</li> <li>e. overloads</li> <li>f. service gauge manifold and thermometer</li> <li>g. oil control and separator systems</li> <li>h. high pressure receivers</li> <li>i. low pressure accumulators</li> </ul> | 13                  | 32.5         |
|          | 02           | <p>02.01, 02.02 Describe climate change and the Kyoto Protocol</p> <hr/> <p>02.03 Understand direct and indirect Global Warming Potential (GWP) of the common HFC and HC refrigerants</p> <hr/> <p>02.04 Understand importance of energy efficiency on greenhouse gas emissions to the atmosphere</p> <hr/> <p>02.05 Describe the basic regulatory requirements with regard to HCFC and HC refrigerants</p>   | 6                   | 15           |

**Test: 7189-509****Duration: 1 hour and 20 minutes  
(80 minutes)**

| Unit | Test section | Outcome/Assessment Criterion   | Number of questions | Percentage % |
|------|--------------|--|---------------------|--------------|
|      | 03           | 02.06 Describe the equipment records/commissioning data requirements to be recorded in such records  | 2                   | 5            |
|      | 04           | 04.01, 04.02, 04.06 Identify potential leakage points of refrigeration/air conditioning and heat pump equipment  | 2                   | 5            |
|      | 05           | 04.03 State requirements and procedures for handling, storage, transportation and disposal of contaminated refrigerant and oil   | 2                   | 5            |
|      | 06           | 04.04, 04.06 Describe the function of a compressor and the risks of refrigerant leakage or release associated with it  | 2                   | 5            |
|      |              | 04.05 Identify the state/condition of a compressor that could lead to refrigerant release  |                     |              |
|      | 07           | 04.04, 04.06 Describe the function of a condenser and the risks of refrigerant leakage or release associated with it   | 2                   | 5            |
|      |              | 04.05 Identify the state/condition of a condenser that could lead to refrigerant release   |                     |              |
|      | 08           | 04.04, 04.06 Describe the function of an evaporator and the risks of refrigerant leakage or release associated with it   | 2                   | 5            |
|      |              | 04.05 Identify the state/condition of an evaporator that could lead to refrigerant release   |                     |              |
|      | 09           | 04.04, 04.06 Describe the function of a thermostatic expansion valve and a capillary tube restrictor, and the risk of refrigerant release associated with them                                 | 2                   | 5            |
|      |              | 04.05 Identify the state/condition of a thermostatic expansion valve and capillary tube restrictor that could lead to refrigerant release  |                     |              |
|      | 10           | 03.01, 03.02 Demonstrate knowledge of the potential of HCFC refrigerants to deplete ozone, and the effect of chlorine on ozone depletion. Identify the ODP of various HCFC refrigerants in use | 2                   | 5            |
|      |              | 03.03, 03.04 Describe the basic requirements of Regulation (EC) 2037/2000 and the impact of the Montreal Protocol  |                     |              |

**Test: 7189-509****Duration: 1 hour and 20 minutes  
(80 minutes)**

| Unit         | Test section | Outcome/Assessment Criterion  | Number of questions | Percentage % |
|--------------|--------------|---|---------------------|--------------|
|              | 11           | 05.02 Describe the hazards associated with refrigerant release, including: <ul style="list-style-type: none"> <li>a cold burns</li> <li>b asphyxiation</li> <li>c thermal decomposition</li> <li>d CNS effect</li> <li>e cardiac sensitisation</li> </ul> | 5                   | 12.5         |
|              |              | 05.03 Describe the hazards associated with flame brazing  |                     |              |
|              |              | 05.01 Describe the hazards associated with pressure testing with nitrogen   |                     |              |
| <b>Total</b> |              |   | 40                  | 100%         |

**Test: 7189-210****Duration: 40 minutes**

| Unit         | Outcome  | Number of questions | Percentage % |
|--------------|--|---------------------|--------------|
| 7189-210     | 1 Know the members of the construction team and their role within the building services industry | 5                   | 25           |
|              | 2 Know how to apply information sources in the building services industry                        | 9                   | 45           |
|              | 3 Know how to communicate with others in the building services industry                          | 6                   | 30           |
| <b>Total</b> |  | 20                  | 100%         |

## 5 Units

### Structure of the units

These units each have the following:

- City & Guilds reference number
- unit accreditation number
- title
- level
- credit value
- guided learning hours (GLH)
- unit aim
- health and safety requirements
- learning outcomes, which comprise a number of assessment criteria
- range statements
- supporting information.

### Guidance for delivery of the units

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 skills and knowledge that a candidate should possess.

Each **learning outcome** has a set of **assessment criteria** (performance and knowledge and understanding) which specify the desired criteria that must be satisfied before an individual can be said to have performed to the agreed standard.

**Range** statements define the breadth or scope of a learning outcome and its assessment criteria by setting out the various circumstances in which they are to be applied.

**Supporting information** provides guidance of the evidence requirement for the unit and specific guidance on delivery and range statements. Centres are advised to review this information carefully before delivering the unit.

|                          |   |
|--------------------------|---|
| <b>Level:</b>            | 2   |
| <b>GLH:</b>              | 26  |
| <b>Credit value</b>      | 3   |
| <b>Assessment type:</b>  | Practical assignment and multiple choice online test  |
| <b>Aim:</b>              | This combination unit provides learners with the essential health & safety knowledge and skills to demonstrate best practice in a business services engineering environment or sector. The unit provides learners with an awareness of relevant legislation and should underpin all business services engineering activities learners take part in. |
| <b>Health and safety</b> | Health and safety behaviour learned in this mandatory unit should be displayed in all arenas.   |

### Learning outcome

The learner will:

LO1 Know health and safety legislation.

### Assessment criteria

The learner can:

AC1.1 state the aims of **health and safety legislation**

AC1.2 identify the responsibilities of **individuals** under health and safety legislation

AC1.3 identify statutory and non-statutory **health and safety materials**

AC1.4 identify the different **roles** of Health and Safety Executive in enforcing health and safety legislation.

### Range

#### Health and safety legislation

The Health & Safety at Work Act, The Electricity at Work Regulations, Control of Substances Hazardous to Health (COSHH) Regulations, Working at Heights Regulations, Personal Protective Equipment at Work Regulations (PPE), Lifting and Manual Handling Operations Regulations, Provision and Use of Work Equipment Regulations, Control of Asbestos at Work

Regulations, Health, Safety and Welfare Regulations, Health and Safety (First Aid) Regulations, Confined Spaces Regulations.

### **Individuals**

Employers, employees and contractors, visitors to site.

### **Health and safety materials**

Acts of Parliament, regulations, approved codes of practice, HSE Guidance notes.

### **Roles**

Improvement notice, prohibition notice, powers of prosecution, providing advice and guidance.

---

## **Learning outcome**

The learner will:

LO2 Know how to handle hazardous situations.

## **Assessment criteria**

The learner can:

- AC2.1 identify common **hazardous situations** found on site
- AC2.2 describe **safe systems at work**
- AC2.3 identify the **categories** of safety signs
- AC2.4 identify **symbols** for hazardous substances
- AC2.5 list common **hazardous substances** used in the building services industry
- AC2.6 list **precautions** to be taken when working with hazardous substances
- AC2.7 identify the **types of asbestos** that may be encountered in the workplace
- AC2.8 identify the **actions** to be taken if the presence of asbestos is suspected
- AC2.9 describe the **implications** of being exposed to asbestos
- AC2.10 state the application of different types of **personal protective equipment**
- AC2.11 identify the **procedures for manually handling** heavy and bulky items
- AC2.12 identify the **actions** that should be taken when an accident or emergency is discovered
- AC2.13 state **procedures for handling injuries** sustained on-site
- AC2.14 state the **procedures for recording accidents** and near misses at work.

---

## **Range**

### **Hazardous situations**

Trailing leads, slippery or uneven surfaces, presence of dust and fumes, handling and transporting equipment or materials, contaminants and irritants, fire, working at heights, malfunctioning equipment, improper use and storage of tools and equipment, potential presence of asbestos.

### **Safe systems at work**

Method statements, permit to work systems, risk assessments, safety signs and notices.

### **Categories**



Mandatory, prohibition, information, warning.

### **Symbols**

Toxic, harmful, corrosive, irritant, oxidising, extremely flammable.

### **Hazardous substances**

Lead - solid and fume, solvents and lubricants, fluxes, jointing compounds, sealants, gases – LPG, oxy-acetylene and carbon dioxide, cleaning agents.

### **Precautions**

PPE, ventilation, risk assessment, method statements, safe systems of work.

### **Types of asbestos**

White asbestos (Chrysotile), brown or grey asbestos (Amosite), blue asbestos (Crocidolite), asbestos cement materials.

### **Actions**

Stop working immediately, report to supervisor.

### **Implications**

Long-term health implications (mesothelioma, asbestosis).

### **Personal protective equipment**

Clothing protection including high visibility, Eye protection, Hand protection, Head protection, Foot protection, Hearing protection, Respiratory protection.

### **Procedures for manually handling**

Single, two-person lift, mechanical lift.

### **Actions**

Raising the alarm, contact emergency services, follow typical emergency evacuation procedures, inform supervisor.

### **Procedures for handling injuries**

Make self safe, make area safe, administer first aid where appropriate, contact emergency services, contact nominated first aid person, contact supervisor.

### **Procedures for recording accidents**

RIDDOR, the use of company accident books, details to be recorded.

---

## **Learning outcome**

The learner will:

LO3 know electrical safety requirements when working in the building services industry.

## **Assessment criteria**

The learner can:

AC3.1 identify the common **electrical dangers** to be aware of on site

AC3.2 list different **sources** of electrical supply for tools and equipment

- AC3.3 describe **reasons** for using reduced low voltage electrical supplies for tool and equipment on site
- AC3.4 identify how to conduct a **visual inspection** of portable electrical equipment for safe condition before use
- AC3.5 state **actions** to take when portable electrical equipment fails visual inspection
- AC3.6 outline the Safe Isolation Procedure
- AC3.7 state the **procedures** for dealing with electric shocks.
- 

## Range

### Electrical dangers

Faulty electrical equipment, damaged electrical equipment, exposed conductors, damaged insulation, worn electrical cables and cords, trailing cables, proximity of cables, buried/hidden cables.

### Sources

Battery powered supplies, 110 volt supplies, 230 volt supplies, generating sets.

### Reasons

Increased likelihood for damage to equipment, operative in better contact with earth, protect from electric shock, reduces trailing leads.

### Visual inspection

Checking for a valid PAT test, Inspection for general condition.

### Actions

Remove from use, report to supervisor.

### Procedures

Removal from supply, CPR method, contact emergency services, report to supervisors, treatment of minor burns.

---

## Learning outcome

The learner will:

LO4 Know the safety requirements for working with gases and heat producing equipment.

## Assessment criteria

The learner can:

AC4.1 identify different **types of gases** used on site

AC4.2 describe how bottled gases and equipment should be safely transported and stored

AC4.3 describe how to conduct a **visual inspection** on heat producing equipment for safe condition

AC4.4 describe how **combustion** takes place

AC4.5 state the **dangers** of working with heat producing equipment

AC4.6 state the **procedures** to follow on discovery of fires on site

AC4.7 identify different **classifications of fires**

AC4.8 identify types of **fire extinguisher** for different classifications of fires.

---

---

## Range

### Types of gases

Propane, butane, oxy-acetylene, nitrogen.

### Visual inspection

Inspection for general condition.

### Combustion

Three elements of the fire triangle.

### Dangers

Fires, burns, fumes, equipment damage, explosions.

### Procedures

Raise the alarm, follow safety evacuation procedures, fight fire if trained to do so.

### Classifications of fires

Class A, B, C, D, electrical fires.

### Fire extinguisher

Carbon dioxide, water, powder, foam.

---

## Learning outcome

The learner will:

LO5 Know the safety requirements for using access equipment in the building services industry.

## Assessment criteria

The learner can:

AC5.1 identify different **types of access equipment**

AC5.2 select suitable equipment for carrying out work at heights based on the **work being carried out**

AC5.3 describe the **safety checks** to be carried out on access equipment

AC5.4 describe safe erection methods for **access equipment**.

---

## Range

### Types of access equipment

Step ladders, ladders, roof ladders and crawling boards, mobile tower scaffolds, podiums fixed scaffolds and edge protection, mobile elevated work platforms including scissor lifts and cherry pickers, telescopic ladders.

### Work being carried out

Duration at work, action points for heights.

### Safety checks

Visual, tagging, fit for purpose, secure level ground.

## Access equipment

Step ladders, ladders, roof ladders, mobile tower scaffolds, podiums, telescopic ladders.

---

## Learning outcome

The learner will:

LO6 Know the safety requirements for working safely in excavations and confined spaces in the building services industry.

## Assessment criteria

The learner can:

AC6.1 identify the situations in which it may be necessary to work in excavations

AC6.2 describe how excavations should be **prepared** for safe working

AC6.3 state **precautions** to be taken to make excavations safe

AC6.4 identify areas where working in **confined space** may be a consideration

AC6.5 state **safety considerations** when working in confined spaces.

---

## Range

### Prepared

Safe access into the excavation, trench support systems.

### Precautions

Use of warning signs, use of barriers, vehicle proximity to excavation edges.

### Confined space

Drainage systems, Plant rooms, Main service duct-rooms, In tanks, cylinders, boilers or cisterns, Under suspended timber floors, In roof spaces.

### Safety considerations

Ventilation, lighting, PPE, evacuation procedures, medical conditions, lone working.

---

## Learning outcome

The learner will:

LO7 Be able to apply safe working practice.

## Assessment criteria

The learner can:

AC7.1 perform **manual handling** techniques

AC7.2 manually handle loads using mechanical lifting aids

AC7.3 demonstrate the safe method of assembly of **access equipment**

AC7.4 use access equipment safely.

---

---

## **Range**

### **Manual handling**

Single, two-person lift.

### **Access equipment**

Step ladders, ladders, mobile tower scaffolds.

## **Unit 201/501**

## **Health and safety in building services engineering**

### **Supporting information**

#### **Guidance**

##### **Electrical equipment**

Includes power tools, lights etc

##### **Safe Isolation Procedure**

Recommend referring to JIB Safe Isolation Procedure

#### **On Site**

Where reference to 'on site' is made in this unit, the intention is that this covers building sites and domestic sites.

It is recommended that assessors cover employee rights in relation to Health & Safety.

This First Aid element of this unit is not intended to replicate a full First Aid course but to give learners the underpinning knowledge to understand the types of injuries they may come across in a work place.

## Unit 202

## Scientific Principles within RAC and HP Systems

|                          |  |
|--------------------------|--|
| <b>Level:</b>            | 2  |
| <b>GLH:</b>              | 82   |
| <b>Credit value</b>      | 10   |
| <b>Assessment type:</b>  | Multiple choice online test  |
| <b>Aim:</b>              | This unit provides learners with the underpinning knowledge of scientific principles refrigeration, air conditioning and heat pumps systems. It is structured by first introducing the units of measurement followed by their application to the principles of vapour compression systems. |
| <b>Health and safety</b> | Health and safety behaviour learned in mandatory unit 201/501 should be displayed in all arenas.   |

---

### Learning outcome

The learner will:

LO1 Know the standard units of measurement used in the RAC sector.

### Assessment criteria

The learner can:

AC1.1 define the **System International (SI) units of measurement**.

---

### Range

#### SI units of measurement

##### **Standard**

Metre (length) m, kilogram (mass) kg, second (time) s, Kelvin (temperature) K.

##### **Derived**

Area (m<sup>2</sup>), volume (m<sup>3</sup>), litres (L), density (kg/m<sup>3</sup>), velocity (m/s), acceleration (m/s<sup>2</sup>), pressure (Pascal).

---

## Learning outcome

The learner will:

LO2 Know fundamental thermodynamics.

## Assessment criteria

The learner can:

- AC2.1 describe the concept of temperature
- AC2.2 describe **temperature scales**
- AC2.3 define absolute zero
- AC2.4 convert values between **temperature scales**
- AC2.5 define the **laws of thermodynamics**
- AC2.6 describe the concept of heat as energy in transition
- AC2.7 describe how **heat is transferred**
- AC2.8 state the unit of heat
- AC2.9 state the unit used to describe the rate of heat transfer
- AC2.10 describe how power is derived from energy and time values
- AC2.11 define the units of power
- AC2.12 **calculate** compressor input power.

---

## Range

### Temperature scales

Celsius, Kelvin.

### Laws of thermodynamics

First law, second law.

### Heat is transferred

Conduction, convection, radiation.

### Calculate

Mass flow rate x enthalpy change.

---

## Learning outcome

The learner will:

LO3 Know the forms of heat as found in RAC and HP systems.

## Assessment criteria

The learner can:

- AC3.1 describe **latent heat processes**
- AC3.2 describe **sensible heat processes**
- AC3.3 define specific heat capacity
- AC3.4 define latent heat capacity
- AC3.5 use **formulae** to calculate quantity of heat.



---

## Range

### Latent heat processes

Melting (Fusion), freezing, sublimation, condensation, evaporation, boiling.

### Sensible heat processes

Super heating, sub-cooling, cooling, heating.

### Formulae

$Q=mC\Delta t$ ,  $Q=mL$ .

---

## Learning outcome

The learner will:

LO4 Know the principles of pressure.

## Assessment criteria

The learner can:

AC4.1 define pressure

AC4.2 describe how **units of pressure** are derived

AC4.3 convert **units of pressure**

AC4.4 describe **pressure scales**.

---

## Range

### Units of pressure

Pascal, Bar, Millimetres of Hg.

### Pressure scales

Atmospheric, absolute, vacuum, gauge.

---

## Learning outcome

The learner will:

LO5 Understand the pressure temperature relationship.

## Assessment criteria

The learner can:

AC5.1 describe the impact of changing pressures on saturation temperatures for a **range of substances**

AC5.2 describe two phase mixes

AC5.3 describe sensible heating processes in terms of superheat and sub-cooling

AC5.4 describe the **ideal gas laws**

AC5.5 describe Dalton's Law of partial pressures

---

AC5.6 calculate a variable using the Combined Gas Law.

---

### Range

#### Range of substances

Water, refrigerants.

#### Ideal gas laws

Boyle's law, Charles' law, combined gas law.

---

### Learning outcome

The learner will:

LO6 Understand the vapour compression cycle.

### Assessment criteria

The learner can:

AC6.1 describe the vapour compression cycle

AC6.2 describe the **pressure enthalpy chart**

AC6.3 plot the vapour compression cycle using a **pressure enthalpy chart**

AC6.4 calculate using a pressure enthalpy chart a **range of variables**.

---

### Range

#### Pressure enthalpy chart

Pressure, temperature, constant quality, enthalpy, specific volume, latent, superheat and sub-cooled zones.

#### Range of variables

Work done, refrigeration effect, total heat rejected, Coefficient of Performance, mass flow rate, compression ratio.

---

### Learning outcome

The learner will:

LO7 Understand the psychrometric processes in RAC and HP systems.

### Assessment criteria

The learner can:

AC7.1 describe the **properties of air**

AC7.2 define the relationship between specific volume and specific density

AC7.3 differentiate between wet and dry bulb temperatures

AC7.4 describe **devices** used for measuring wet and dry bulb temperatures

AC7.5 describe the **psychrometric chart**

---

AC7.6 plot a point on the **psychrometric chart** using any two given variables

AC7.7 define from a given point on the **psychrometric chart** the values of remaining variables.

---

## **Range**

### **Properties of air**

Physical make-up, moisture content, temperature.

### **Devices**

Sling psychrometer, hygrometer.

### **Psychrometric chart**

Wet bulb temperature, dry bulb temperature, percentage saturation, moisture content, specific volume.

---

## **Learning outcome**

The learner will:

LO8 Know the general properties of materials used in the RAC and HP sector.

## **Assessment criteria**

The learner can:

AC8.1 identify the **properties** of a **range of materials**

AC8.2 describe the common use of a **range of materials**.

---

## **Range**

### **Range of materials**

Steels (common varieties), copper and cuprous based alloys, aluminium and its alloys, silver and its alloys, lead and its alloys, natural and synthetic rubbers, plastics including PTFE, heavy metals.

### **Properties**

Compatibility with oils and refrigerants, suitability for use in a food processing environment, thermal expansion & contraction, brittleness, elasticity, malleability, conductivity, ductility, corrosiveness.

---

## Unit 203

# Apply scientific principles to practical vapour compression systems

|                          |  |
|--------------------------|--|
| <b>Level:</b>            | 2  |
| <b>GLH:</b>              | 68   |
| <b>Credit value</b>      | 8  |
| <b>Assessment type:</b>  | Multiple choice online test  |
| <b>Aim:</b>              | This unit enables learners to apply scientific principles to practical refrigeration systems. The unit commences with the theory of vapour compression systems in a practical environment discussing the important components and their operation. At its completion learners will have studied from basic systems through to system performance evaluation. |
| <b>Health and safety</b> | Health and safety behaviour learned in mandatory unit 201/501 should be displayed in all arenas.   |

---

### Learning outcome

The learner will:

LO1 Know the principles of operation of the vapour compression system.

### Assessment criteria

The learner can:

AC1.1 describe the function of an evaporator as defined by the pressure enthalpy chart

AC1.2 distinguish on a typical DX evaporator the importance of the areas of latent and sensible heat using the pressure enthalpy chart as a reference

AC1.3 describe the function of a condenser as defined by the pressure enthalpy chart

AC1.4 distinguish on an air-cooled condenser the importance of the areas of latent and sensible heat using the pressure enthalpy chart as a reference

AC1.5 describe the function of a compressor as defined by the pressure enthalpy chart

AC1.6 describe the impact of superheat at the compressor inlet

AC1.7 describe the function of a metering device as defined by the pressure enthalpy chart

AC1.8 identify the condition of the refrigerant entering the metering device and its impact

AC1.9 describe the impact of **refrigerant states** entering the metering device.

---

## Range

### Refrigerant states

Sub-cooled liquid, saturated liquid, saturated mixture.

---

## Learning outcome

The learner will:

LO2 Know characteristics of line and pipe systems used in RAC systems.

## Assessment criteria

The learner can:

AC2.1 describe how **pipe characteristics** affect refrigerant and oil flow

AC2.2 describe the impact of pressure drop on **system performance**

AC2.3 describe the importance of pipe sizing for **specific system conditions**

AC2.4 describe how oil can be returned to the compressor using refrigerant vapour velocity.

---

## Range

### Pipe characteristics

Diameter, length, bends, fittings, orientation, equation of continuity.

### System performance

Flash gas, oil return, velocity, saturation temperature.

### Specific system conditions

Refrigerants, operating temperatures, system design.

---

## Learning outcome

The learner will:

LO3 Know how properties of air are controlled.

## Assessment criteria

The learner can:

AC3.1 describe how **vapour compression systems** control the properties of air using a psychrometric chart

AC3.2 describe the range of **air conditioning systems** in common use

AC3.3 describe ideal storage conditions for a **range of products**.

---

## Range

### Vapour compression systems

Split system for a single room cooling application, fruit and vegetable chill store system.

---

## **Air conditioning systems**

Comfort cooling/heating, close control, de-humidification specific.

### **Range of products**

Unpackaged fresh fruit and vegetables, unpackaged meat, flowers.

---

### **Learning outcome**

The learner will:

LO4 Know the principles of operation of heat pumps.

### **Assessment criteria**

The learner can:

AC4.1 describe the operation of a ground source heat pump using a pressure enthalpy chart

AC4.2 compare heat pump efficiency against **traditional heating methods**

AC4.3 describe the **range of heat pumps** available.

---

### **Range**

#### **Traditional heating methods**

Oil boiler, gas boiler, electric heating.

#### **Range of heat pumps**

Domestic and commercial ground source, air source, swimming pool heat reclaim, district heating systems.

---

### **Learning outcome**

The learner will:

LO5 Know the impact of operating conditions on system performance

### **Assessment criteria**

The learner can:

AC5.1 describe how system performance is affected when **environmental conditions** change using a pressure enthalpy chart

AC5.2 describe how system performance is affected by **common system faults** using a pressure enthalpy chart.

---

### **Range**

#### **Environmental conditions**

Higher than design ambient temperatures, lower than design ambient temperatures.

#### **Common system faults**

Blocked condenser, blocked evaporator, shortage of refrigerant, large load variations.

---

## Unit 204

## Functions and features of RAC and HP systems

|                          |  |
|--------------------------|--|
| <b>Level:</b>            | 2  |
| <b>GLH:</b>              | 87   |
| <b>Credit value</b>      | 9  |
| <b>Assessment type:</b>  | Multiple choice online test  |
| <b>Aim:</b>              | The purpose of this unit is to provide learners with the knowledge of a range of RAC and HP systems and their components. Learners will be able to use their knowledge of material properties, systems and their components in order to relate to well-defined systems related problems. |
| <b>Health and safety</b> | Health and safety behaviour learned in mandatory unit 201/501 should be displayed in all arenas.   |

---

### Learning outcome

The learner will:

LO1 Know the function of a range of RAC and HP system components.

### Assessment criteria

The learner can:

AC1.1 describe the construction of **system components** used in the RAC and HP industry

AC1.2 describe the function of **system components** used in the RAC and HP industry

AC1.3 describe the operating principles of **system components** used in the RAC and HP industry.

---

### Range

#### System components compressors

Reciprocating, rotary, scroll.

#### Condensers

Air, liquid cooled.

#### Evaporators

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

### **Expansion devices**

Capillary, thermostatic expansion valves (internally and externally equalised), orifice plates and tubes, electronic expansion valves (stepper and pulse).

### **Ancillary components**

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

### **Storage vessels**

Suction line accumulator, high pressure receivers.

### **Control valves**

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

### **Fans**

Axial, centrifugal.

---

## **Learning outcome**

The learner will:

LO2 Know the operating principles for a range of RAC and HP system applications.

## **Assessment criteria**

The learner can:

AC2.1 describe the **operating principles** of RAC and HP systems

AC2.2 describe how operating principles differ in a range of **system applications**.

---

## **Range**

### **Operating principles**

Temperature difference (TD), airflow, defrost methods, system controls.

### **System applications**

Chill store, cold store, liquid chilling, heat pumps, air conditioning, dehumidifiers.

---

## **Learning outcome**

The learner will:

LO3 Know the properties of refrigerants.

## **Assessment criteria**

The learner can:

AC3.1 assess how well **primary refrigerants** meet **ideal properties**

AC3.2 assess how well **secondary refrigerants** meet **ideal properties**



AC3.3 select **refrigerants** for a **range of applications**

AC3.4 explain the differences between pure fluids, azeotropic and zeotropic refrigerants

AC3.5 explain how the refrigerant numbering system categorises the **refrigerants**.

---

## Range

### Primary refrigerant ideal properties

Has an odour, non-flammable, non-explosive, non-toxic, miscible with oil, high latent heat value, low cost, easily leak detectable, manageable pressure range, suitable saturation temperatures, non-ozone depleting, non-global warming potential, high dielectric strength, high density, low specific volume.

### Primary refrigerants

HFC, HCFC, HC, natural refrigerants.

### Secondary refrigerant ideal properties

Low viscosity, non-toxic, non-flammable, non-explosive, high specific heat value, low cost, non-corrosive, low freezing point.

### Secondary refrigerants

Water, propylene glycol, ethylene glycol.

### Range of applications

Air conditioning, cold storage, chill storage, heat pumps, blast freezing.

---

## Learning outcome

The learner will:

LO4 Know the properties of oils.

## Assessment criteria

The learner can:

AC4.1 describe the **properties** of an ideal oil

AC4.2 explain why oils must be matched with the system refrigerant

AC4.3 explain the differences between synthetic and mineral oils.

---

## Range

### Properties

Low floc point, low pour point, low viscosity, high dielectric strength, low foaming tendency, high flashpoint, low hygroscopic effect, low acidity, low moisture content, low toxicity, high miscibility with refrigerant.

---

## Learning outcome

The learner will:

LO5 Know the operating principles of a range of system controls.

---

## Assessment criteria

The learner can:

AC5.1 describe the **operating principles of system controls**

AC5.2 describe the **operating principles for defrost systems.**

---

## Range

### System controls

Pressure controls, temperature controls (for cooling, for heating), time controls, sequence controllers, flow switches.

### System control operating principles

High pressure, low pressure, dead band, differential, proportional.

### Defrost operating principles

Initiation, termination, defrost sequence.

### Defrost systems

Off cycle, electric, hot gas, saturated gas.

---

## Learning outcome

The learner will:

LO6 Know the operation of a range of test instruments used in the RAC industry.

## Assessment criteria

The learner can:

AC6.1 identify the function of **test instruments**

AC6.2 describe how **test instruments** operate

AC6.3 describe how **test instruments** are used.

---

## Range

### Test instruments

Pressure gauges, service manifolds, thermometers, anemometers, sling psychrometers, hydrometers, scales.

---

## **Unit 204**

# **Functions and features of RAC and HP systems**

## **Supporting information**

### **Guidance**

Information sources could be any of the following: DOSSAT, ASHRAE, CIBSE, insulation and equipment manufacturers. Learners can be introduced to Smartphone applications but these should not be used in any assessment activities

## Unit 205

## Service and maintain RAC and HP systems

|                          |  |
|--------------------------|--|
| <b>Level:</b>            | 2  |
| <b>GLH:</b>              | 48   |
| <b>Credit value</b>      | 5  |
| <b>Assessment type:</b>  | Practical assignment   |
| <b>Aim:</b>              | The purpose of this unit is for learners to gain knowledge of the principles of servicing and maintaining RAC and HP systems and develop the skills needed to apply those principles. The skills developed will enable them to carry out service and maintenance tasks on a variety of systems. This unit refers to mechanical fault finding. Fault finding on electrical circuits is addressed in Service and Maintain RAC and HP systems |
| <b>Health and safety</b> | Health and safety behaviour learned in mandatory unit 201/501 should be displayed in all arenas.   |

---

### Learning outcome

The learner will:

LO1 Know service and maintenance principles for RAC and HP systems.

### Assessment criteria

The learner can:

AC1.1 identify faults on **RAC and HP system components**

AC1.2 describe symptoms of **component** faults in RAC and HP systems

AC1.3 describe **maintenance requirements** for RAC and HP systems

AC1.4 identify effects of **component** failure on other RAC and HP system **components**

AC1.5 describe **fault finding techniques** used in RAC and HP systems

AC1.6 identify **sources of information** which aid service and maintenance of RAC and HP systems

AC1.7 identify information included in **documentation** when completing service and maintenance activities on RAC and HP systems.

---

## Range

### RAC and HP system

Small commercial.

### Components

Compressors, condensers, evaporators, capillary line, thermostatic expansion valves (internally and externally equalised), orifice plates and tubes, electronic expansion valves (stepper and pulse), liquid and suction line driers, pressure relief valves, strainers, oil separators, service valves, suction line accumulator, liquid receivers, four way reversing, solenoid, evaporator, crankcase, differential pressure regulators, non return valves, axial fans, centrifugal fans.

### Maintenance

Planned preventative maintenance.

### Requirements

Cleaning, component replacement, leak testing, visual inspection.

### Fault finding techniques

Six point, half split, algorithmic.

### Sources of information

Previous service reports, operations manuals, customer, senses.

### Documentation

Log books, job sheets, certificates, site logs, permits to work, maintenance sheets, parts requisition sheets.

---

## Learning outcome

The learner will:

LO2 Know requirements of RAC and HP service and maintenance tools and equipment.

## Assessment criteria

The learner can:

AC2.1 describe purpose of service and maintenance **tools** and **equipment**

AC2.2 describe maintenance requirements of **tools** and **equipment**

AC2.3 identify inspection requirements of service and maintenance **tools**

AC2.4 describe safe storage of **tools** and **equipment**.

---

## Range

### Equipment

Vacuum pump, recovery rig, recovery cylinders, scales, oil pump, leak indicators, flame brazing equipment, regulators.

### Tools

Torque wrench, valve keys, flare block, hexagonal wrench, Torx wrench, tube cutters, reamer, tube expander, Schrader key, flare spanners, vernier calliper, inspection mirror, tube benders, tape measure.

---

### **Learning outcome**

The learner will:

LO3 Be able to service and maintain RAC and HP system.

### **Assessment criteria**

The learner can:

- 3.1 identify faults on RAC and HP systems
  - 3.2 prepare RAC and HP systems for service and maintenance
  - 3.3 **rectify** RAC and HP systems faults
  - 3.4 restore original state of RAC and HP systems following service and maintenance
  - 3.5 assess fitness for purpose of tools and equipment
  - 3.6 record service and maintenance activities.
- 

### **Range**

#### **Rectify**

Replace components, cleaning components, calibrate, adjust, align.

## Unit 206

## Install and commission RAC and HP systems

|                          |  |
|--------------------------|--|
| <b>Level:</b>            | 2  |
| <b>GLH:</b>              | 47   |
| <b>Credit value</b>      | 5  |
| <b>Assessment type:</b>  | Practical assignment   |
| <b>Aim:</b>              | This unit aims to develop in learners the ability to apply a range of skills related to installation and commissioning of small commercial RAC and HP systems. |
| <b>Health and safety</b> | Health and safety behaviour learned in mandatory unit 201/501 should be displayed in all arenas.   |

---

### Learning outcome

The learner will:

LO1 Be able to prepare for installation of RAC and HP systems.

### Assessment criteria

The learner can:

AC1.1 collate **information** available prior to planning the installation activities

AC1.2 list **resources** required for installation activities

AC1.3 identify roles and responsibilities of **persons involved**

AC1.4 conduct risk assessment for installation activities

AC1.5 **complete** permit to work

AC1.6 identify variations to original planned work

AC1.7 identify safe storage for all resources prior to commencement of the installation

AC1.8 identify **services** required for the installation.

---

### Range

#### Information

Regulatory documents, industry codes of practice, manufacturers' instructions, installation specifications.

#### Resources

Tools, equipment and materials, documentation.

### **Persons involved**

Self, colleagues, supervisor, client, general public, health and safety officer.

### **Complete**

Prior to installation, on completion.

### **Services**

Electricity, water, drainage, ventilation, gas.

---

## **Learning outcome**

The learner will:

LO2 Be able to install RAC and HP systems.

## **Assessment criteria**

The learner can:

- AC2.1 **form** pipework
- AC2.2 position **system components**
- AC2.3 assemble interconnecting pipework
- AC2.4 **fix** pipework
- AC2.5 use oxygen free nitrogen for purging during flame brazing operations
- AC2.6 use **protective measures** when flame brazing **temperature sensitive system components**
- AC2.7 **apply** insulation to pipework systems
- AC2.8 fix **cabling**
- AC2.9 **terminate cabling**
- AC2.10 compare installed system with system drawings.

---

## **Range**

### **Form**

Braze (oxy-acetylene), flare, bend, swage, other mechanical joints.

### **System components**

Condensing units, evaporators, condensate drains, valves, electrical cabling, drier, pressure switches, pumps, sight glass, vessels.

### **Fix**

Vibration damping clamps, pipe saddles, blackboard clips, insulated clamps.

### **Protective measures**

Wet rag, non-conductive foam, temporary removal of low melting point items.

### **Temperature sensitive system components**

Thermostatic expansion valves, solenoid valves, vibration eliminators, schrader valves, pressure transducers.

### **Apply**



Pre-insulated, cut and glue, continuous, mitred, insulated tape.

### **Cabling**

Multi-core flex, steel wire armoured, single conductor, twin and earth, braided sheath cable, screened.

### **Terminate**

Insulated crimps, non-insulated crimps.

---

### **Learning outcome**

The learner will:

LO3 Be able to commission RAC and HP systems.

### **Assessment criteria**

The learner can:

AC3.1 record **commissioning activities**.

---

### **Range**

#### **Commissioning activities**

Visual checks, strength test, tightness test, evacuation, charging, system running, measure (Superheat, Subcooling, Evaporator air on and off temperature, Running currents, Refrigerant type and quantity, condenser air on and off).

---

### **Learning outcome**

The learner will:

LO4 Be able to handover RAC and HP systems.

### **Assessment criteria**

The learner can:

AC4.1 demonstrate **system operation**

AC4.2 explain maintenance requirements for the system

AC4.3 **document** installation activities.

---

### **Range**

#### **System operation**

Heating, cooling, defrost, time clocks, auto/manual operation, system controls

#### **Document**

Job sheet/card

---

## Unit 207

## Electrical systems for RAC and HP systems

|                          |   |
|--------------------------|---|
| <b>Level:</b>            | 2   |
| <b>GLH:</b>              | 48  |
| <b>Credit value</b>      | 5   |
| <b>Assessment type:</b>  | Practical assignment  |
| <b>Aim:</b>              | <p>This unit applies knowledge and related practical skills required to undertake safe testing and fault finding on small RAC and HP systems under direction.</p> <p>This unit refers to fault finding on electrical circuits. Mechanical fault finding is addressed in Service and maintain RAC and HP systems</p> |
| <b>Health and safety</b> | Health and safety behaviour learned in mandatory unit 201/501 should be displayed in all arenas.  |

---

### Learning outcome

The learner will:

LO1 Know the fundamental principles of electrical systems used in RAC and HP systems.

### Assessment criteria

The learner can:

AC1.1 identify the fundamental **principles of electricity**

AC1.2 identify the fundamental **principles of electrical circuits** used INRAC and HP circuits

AC1.3 identify the fundamental working principles of **electrical controls**

AC1.4 identify the working principles of **electrical components**

AC1.5 identify the **starting arrangements** for single phase compressor motors.

---

### Range

#### Principles of electricity

Ohm's Law, direct current and alternating current, potential difference, resistance, capacitance, frequency, impedance, current, power, electrical shock potential and its consequences.

### **Principles of circuits**

Single phase, earthing and bonding, series, parallel.

### **Electrical controls**

Pressure switches, thermostats, flow switches, over current/over temperature (bimetal, PTC, NTC), relays (current, potential, solid state).

### **Electrical components**

Single phase motors, coils, transformers, heaters, lights.

### **Starting arrangements**

Resistance start induction run (RSIR), capacitor start induction run (CSIR), capacitor start and run (CSR).

---

## **Learning outcome**

The learner will:

LO2 Know the requirements of electrical test instruments.

## **Assessment criteria**

The learner can:

AC2.1 identify the test instruments used to measure **electrical circuits**

AC2.2 identify scales used to measure **electrical circuits**

AC2.3 state when it is appropriate to carry out an insulation resistance test using a megaohm meter

AC2.4 describe importance of Guidance Note GS38 for use of electrical test instruments.

---

## **Range**

### **Electrical circuits**

Continuity, short circuit, open circuit, insulation resistance, polarity, current, voltage, capacitance.

---

## **Learning outcome**

The learner will:

LO3 Be able to test electrical circuits.

## **Assessment criteria**

The learner can:

AC3.1 select **testing instruments**

AC3.2 check **testing instruments** are calibrated

AC3.3 **use** testing instruments on **electrical circuits**

AC3.4 record measurements.

---

## Range

### Testing instruments

Multimeter, ammeter, voltmeter, megaohm meter, capacitance tester.

### Electrical circuits

Continuity, short circuit, open circuit, insulation resistance, polarity, current, voltage (a.c, d.c), capacitance.

### Use

Use appropriate scales, operate safely.

---

## Learning outcome

The learner will:

LO4 Be able to fault find in electrical circuits for RAC and HP systems.

## Assessment criteria

The learner can:

AC4.1 identify electrical faults on RAC and HP systems **components**

AC4.2 replace faulty **components**

AC4.3 record recommissioning activities.

---

## Range

### Components

Motors, switches, heaters, relays, conductors, thermistors, transformers, coils.

## **Unit 207**

# **Electrical systems for RAC and HP systems**

## **Supporting information**

### **Guidance**

If learners can use a multimeter that covers resistance, voltage and capacitance they do not need to use separate testing instruments

## Unit 209/509

## Handling fluorinated gases and ozone-depleting substances category I personnel

|                          |   |
|--------------------------|---|
| <b>Level:</b>            | 2   |
| <b>GLH:</b>              | 30  |
| <b>Credit value</b>      | 3   |
| <b>Assessment type:</b>  | Practical assignment and multiple choice online test  |
| <b>Aim:</b>              | Through this unit learners will gain knowledge of the theory and thermodynamics of vapour compression cycles and refrigerants. They will learn to identify causes and effects of global warming. Learners will develop skills to fabricate and examine pipework and pressure testing, taking account of health and safety considerations. |
| <b>Health and safety</b> | Health and safety behaviour learned in mandatory unit 201/501 should be displayed in all arenas.  |

---

### Learning outcome

The learner will:

LO1 Identify basic systems, terms, principles, units and how these relate to theory and thermodynamics of vapour compression cycles and refrigerants.

### Assessment criteria

The learner can:

AC1.1 identify the standard units relating to Category I Systems

AC1.2 identify the terms and principles of basic theory/thermodynamics that relate to Category I Systems.

---

### Learning outcome

The learner will:

LO2 Identify the causes and effects of global warming and climate change.

## Assessment criteria

The learner can:

- AC2.1 identify the stated causes of climate change
  - AC2.2 identify how the Kyoto Protocol aims to reduce the effect of effects of greenhouse gas emissions
  - AC2.3 identify direct and indirect global warming potential (GWP) of the common hydrofluorocarbon (HFC) and hydrocarbon (HC) refrigerants
  - AC2.4 identify the importance of energy efficiency on greenhouse gas emissions to atmosphere
  - AC2.5 identify the basic requirements of relevant regulations
  - AC2.6 identify the equipment records/commissioning data regulatory requirements and all appropriate regulations and standards
- 

## Learning outcome

The learner will:

- LO3 Identify causes and effects of ozone depletion.

## Assessment criteria

The learner can:

- AC3.1 identify ozone depletion potential (ODP) of hydrochlorofluorocarbon (HCFC) refrigerants
  - AC3.2 identify the effect of chlorine on ozone depletion
  - AC3.3 identify the basic requirements of Regulation (EC) 2037/2000
  - AC3.4 identify the aims and impact of the Montreal Protocol.
- 

## Learning outcome

The learner will:

- LO4 identify stationary refrigerant, air conditioning and heat-pump system components, functions and leakage risk.

## Assessment criteria

The learner can:

- AC4.1 identify the function of and the role/importance of monitoring system performance for indications that leakage has occurred from equipment (control and line components) relating to category I systems
  - AC4.2 identify potential leakage points of refrigeration/air conditioning and heat pump equipment
  - AC4.3 identify the requirements and procedures for handling, storage, transportation and disposal of contaminated refrigerant and oil
  - AC4.4 identify the function of stationary refrigeration, air conditioning and heat-pump system equipment (major components)
  - AC4.5 identify how the state/condition of equipment (major components) can lead to refrigerant release
-

AC4.6 identify the risks of refrigerant release associated with equipment (major, control and line components).

---

### **Learning outcome**

The learner will:

LO5 Identify the hazards and safe working practices for the installation, commissioning and handling of refrigerants.

### **Assessment criteria**

The learner can:

AC5.1 identify the hazards and safe working practices associated with flame brazing

AC5.2 identify the hazards and safe working practices associated with nitrogen pressure testing

AC5.3 identify the hazards and safe working practices associated with refrigerant release.

---

### **Learning outcome**

The learner will:

LO6 Fabricate and examine pipework.

### **Assessment criteria**

The learner can:

AC6.1 fabricate pipework test piece by completing brazed and mechanical joints to industry standards

AC6.2 install pipework test piece to testing station

AC6.3 visually examine pipework on testing station for signs of leakage

AC6.4 remove fabricated test piece from the system and inspect for penetration by a cut and peel test, upon completion of refrigerant recovery.

---

### **Learning outcome**

The learner will:

LO7 Undertake pressure testing, evacuation and record completion.

### **Assessment criteria**

The learner can:

AC7.1 determine appropriate test pressures to BS EN378 standards

AC7.2 conduct strength tests to BS EN378 standards

AC7.3 undertake leak / tightness pressure tests to BS EN378 standards

AC7.4 evacuate the system to below 2 Torr/2000 microns/m bar/270 Pa

AC7.5 complete pressure testing and evacuation records.

---



---

## Learning outcome

The learner will:

LO8 Undertake refrigerant charging, leak checking and record keeping.

## Assessment criteria

The learner can:

- AC8.1 charge zeotropic blend into a system
- AC8.2 record the weight of refrigerant charged (3 kg or more)
- AC8.3 run a charged system
- AC8.4 identify state of refrigerant in cylinder prior to charging
- AC8.5 identify state of refrigerant in system while running
- AC8.6 visually inspect the system for leaks
- AC8.7 use equipment to accurately determine that the charge is correct
- AC8.8 undertake an indirect leakage check
- AC8.9 use an electronic leak detector to carry out a direct leak check to EU commission standard leak checking requirements
- AC8.10 complete a leak check record
- AC8.11 connect and disconnect gauges to/from running system with minimal refrigerant loss (by reducing gauge pressure to safe minimum) using a valve.

---

## Learning outcome

The learner will:

LO9 Undertake recovery of refrigerant and oil and prepare for disposal.

## Assessment criteria

The learner can:

- AC9.1 recover refrigerant from system into recovery cylinder
- AC9.2 record weight of refrigerant recovered
- AC9.3 drain oil out of a compressor to meet health & safety requirements.

## Unit 210

# Understand how to communicate with others within building services engineering

|                         |  |
|-------------------------|--|
| <b>Level:</b>           | 2  |
| <b>GLH:</b>             | 28   |
| <b>Credit value</b>     | 3  |
| <b>Assessment type:</b> | Multiple choice online test  |
| <b>Aim:</b>             | This knowledge unit provides learning in the development and continued maintenance of effective working relationships in the building services industry associated with work in dwellings, industrial and commercial premises and for private and contract type clients. |

---

### Learning outcome

The learner will:

LO1 Know the members of the construction team and their role within the building services industry.

### Assessment criteria

The learner can:

AC1.1 identify the key roles of the site management team:

- architect
- project manager/clerk of works
- structural engineer
- surveyor
- building services engineer
- quantity surveyor
- buyer
- estimator
- contracts manager
- construction manager

AC1.2 identify the key roles of the individuals that report to the site management team:

- sub contractors
- site supervisor
- trade supervisor
- trades:

- bricklayer
- joiner
- plasterer
- tiler
- electrician
- H&V fitter
- gas fitter
- decorator
- groundworkers

AC1.3 identify the key roles of site visitors:

- building control inspector
- water inspector
- HSE inspector
- Electrical services inspector.

## Learning outcome

The learner will:

LO2 Know how to apply information sources in the building services industry.

## Assessment criteria

The learner can:

AC2.1 identify the types of statutory legislation and guidance information that applies to working in the industry:

- legislation:
  - data protection
  - equal opportunities
  - health and safety
  - employment
- regulations
- british standards
- codes of practice
- manufacturer guidance:
  - installation instructions
  - service and maintenance instructions
  - user instructions

AC2.2 identify the purpose of information that is used in the workplace:

- job specifications
- plans/drawings
- work programmes
- delivery notes
- time sheets
- policy documentation – health and safety, environmental, customer service

AC2.3 identify the purpose of information given to customers:

- quotations
- estimates
- invoices/statements

- statutory cancellation rights
- handover information

AC2.4 state the importance of company policies and procedures that affect working relationships:

- company working policies/procedures:
    - behaviour
    - timekeeping
    - dress code
    - contract of employment
  - limits to personal authority:
    - apprentices
    - level 2 qualified staff
    - level 3 qualified staff
  - supervisor and management responsibilities.
- 

## **Learning outcome**

The learner will:

LO3 Know how to communicate with others in the building services industry.

## **Assessment criteria**

The learner can:

AC3.1 identify suitable communication methods for use in work situations:

- oral communication
- written communication:
  - e-mail
  - fax
  - letter

AC3.2 define methods of effective communication for people with:

- physical disabilities
- learning difficulties
- language differences:
  - dialects
  - accents
  - foreign and second language issues

AC3.3 state the actions to take to deal with conflicts between:

- customers and operatives
- co-workers
- supervisors and operatives

AC3.4 state the effects that poor communication may have on an organisation:

- between operatives
- between operatives and management
- company to customer.

# Appendix 1 Relationships to other qualifications

## Links to other qualifications

This qualification has connections to the:

- Level 3 Diploma in Refrigeration, Air Conditioning and Heat Pump Systems (7189)
- Level 2 Diploma in Heating and Ventilating (7188)
- Level 3 Diploma in Heating and Ventilating (7188)
- Level 2 Diploma in Plumbing Studies (6035)
- Level 3 Diploma in Plumbing Studies (6035)
- Level 2 NVQ in Plumbing and Heating (6189)
- Level 3 NVQ in Plumbing and Heating (6189)
- Level 3 NVQ in Electrotechnical Services (2357)
- Level 2 NVQ in Heating and Ventilating (6188)
- Level 3 NVQ in Heating and Ventilating (6188)
- Level 2 NVQ in Refrigeration and Air Conditioning (6187)
- Level 3 NVQ in Refrigeration and Air Conditioning (6187)
- Level 2 Diploma in Electrical Installations (Buildings and Structures) (2365)
- Level 3 Diploma in Electrical Installations (Buildings and Structures) (2365)

## Literacy, language, numeracy and ICT skills development

These qualifications can develop skills that can be used in the following qualifications:

- Functional Skills (England) – see [cityandguilds.com](http://cityandguilds.com)
- Essential Skills (Northern Ireland) – see [cityandguilds.com](http://cityandguilds.com)
- Essential Skills Wales – [cityandguilds.com](http://cityandguilds.com)

## Appendix 2 Sources of general information

The following documents contain essential information for centres delivering City & Guilds qualifications. They should be referred to in conjunction with this handbook. To download the documents and to find other useful documents, go to the [Centre document library](#) on [www.cityandguilds.com](http://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 Assessment: 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 candidates 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.

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