QUALIFICATION HANDBOOK

Level 2 and Level 3 Refrigeration and Air Conditioning CPD Pathways (6187)

September 2019 Version 2.0

City & Guilds

Qualification at a glance

Subject area	**Refrigeration and air conditioning**
City & Guilds number	6187-21 & 6187-31
Age group approved	16-18, 19+
Entry requirements	N/A
Assessment	Assignment and portfolio
Fast track	Available
Support materials	Qualification Handbook, Candidate Logbook & Assessment Pack
Registration and certification	Consult the Walled Garden/Online Catalogue for last dates

Title and level	TQT	City & Guilds number	Accreditation number
Level 2 Award in Brazing Techniques for Refrigeration, Air Conditioning and Heat Pump Systems		6187-21	600/3030/6
Level 2 Award in Hydrocarbon Refrigeration, Air Conditioning and Heat Pump System Installation, Servicing and Maintenance	30	6187-21	600/3029/X
Level 3 Award in Hydrocarbon Refrigeration, Air Conditioning and Heat Pump System Design, Commissioning, Servicing and Maintenance	20	6187-31	600/3028/8
Level 3 Certificate in Carbon Dioxide (CO2) Air Conditioning and Heat Pump Systems Installation and Commissioning		6187-31	600/3027/6
Level 3 Certificate in Carbon Dioxide (CO2) Air Conditioning and Heat Pump Systems Service and Maintenance		6187-31	600/3025/2
Level 3 Certificate in Ammonia Refrigeration Systems Installation and Commissioning		6187-31	600/3024/0
Level 3 Certificate in Carbon Dioxide (CO2) Refrigeration		6187-31	600/3044/6

Systems Installation and Commissioning			
Level 3 Certificate in Ammonia Refrigeration Systems Service and Maintenance		6187-31	600/3043/4
Level 3 Certificate in Carbon Dioxide (CO2) Refrigeration Systems Service and Maintenance	130	6187-31	600/3026/4

Version and date	Change detail	Section
1.1 Jan 2012	Amendment to RoC	**Introduction**
2.0 September 2019	TQT added	To qualification at a glance

Contents

1 Introduction

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

Area	Description
Who are these qualifications for?	These qualifications are intended for those involved in the commissioning, installation, servicing and maintenance of refrigeration, air-conditioning and heat pump systems and support the skills necessary for employment/progression in this sector.
What do these qualifications cover?	These qualifications allow candidates to learn, develop and practise the skills required for employment and/or career progression in the refrigeration and air conditioning sector.
What opportunities for progression are there?	There are a wide variety of qualifications which learners can progress onto after completing this qualification. For further information, please visit the City and Guilds website at **www.cityandguilds.com**

Structure

To achieve the **Level 2 Award in Brazing Techniques for Refrigeration, Air Conditioning and Heat Pump Systems**, learners must achieve **3** credits from the mandatory unit.

Unit accreditation number	City & Guilds unit number	Unit title	Credit value
Y/602/4981	231	Understand and carry out brazing techniques for RAC systems	3

To achieve the **Level 2 Award in Hydrocarbon Refrigeration, Air Conditioning and Heat Pump System Installation, Servicing and Maintenance**, learners must achieve **3** credits from the mandatory unit.

Unit accreditation number	City & Guilds unit number	Unit title	Credit value
D/602/4982	232	Understand and apply hydrocarbon RAC system installation, testing, servicing and maintenance techniques	3

To achieve the **Level 3 Award in Hydrocarbon Refrigeration, Air Conditioning and Heat Pump System Design, Commissioning, Servicing and Maintenance**, learners must achieve **2** credits from the mandatory unit.

Unit accreditation number	City & Guilds unit number	Unit title	Credit value
M/502/9299	316	Understand hydrocarbon RAC system design, installation, commissioning, servicing and maintenance techniques	2

To achieve the **Level 3 Certificate in Carbon Dioxide (CO2) Air Conditioning and Heat Pump Systems Installation and Commissioning**, learners must achieve **14** credits from the mandatory units.

Unit accreditation number	City & Guilds unit number	Unit title	Credit value
T/602/4549	312	Understand CO2 air conditioning and heat pump system installation and commissioning techniques	11
Y/602/6097	314	Install and commission CO2 air conditioning and heat pump systems	3

To achieve the **Level 3 Certificate in Carbon Dioxide (CO2) Air Conditioning and Heat Pump Systems Service and Maintenance**, learners must achieve **13** credits from the mandatory units.

Unit accreditation number	City & Guilds unit number	Unit title	Credit value
Y/602/4558	313	Understand CO2 air conditioning system service and maintenance techniques	10
R/602/4591	315	Service and maintain CO2 air conditioning systems	3

To achieve the **Level 3 Certificate in Ammonia Refrigeration Systems Installation and Commissioning**, learners must achieve **14** credits from the mandatory units.

Unit accreditation number	City & Guilds unit number	Unit title	Credit value
D/502/9301	318	Understand ammonia refrigeration system installation and commissioning techniques	11
A/502/9306	322	Install and commission ammonia refrigeration systems	3

To achieve the **Level 3 Certificate in Carbon Dioxide (CO2) Refrigeration Systems Installation and Commissioning**, learners must achieve **14** credits from the mandatory unit.

Unit accreditation number	City & Guilds unit number	Unit title	Credit value
Y/602/4561	319	Understand CO2 refrigeration system installation and commissioning techniques	11
H/602/4594	323	Install and commission CO2 refrigeration systems	3

To achieve the **Level 3 Certificate in Ammonia Refrigeration Systems Service and Maintenance**, learners must achieve **13** credits from the mandatory units.

Unit accreditation number	City & Guilds unit number	Unit title	Credit value
K/502/9303	320	Understand ammonia refrigeration system service and maintenance techniques	10
J/502/9308	324	Service and maintain ammonia refrigeration systems	3

To achieve the **Level 3 Certificate in Carbon Dioxide (CO2) Refrigeration Systems Service and Maintenance**, learners must achieve **13** credits from the mandatory units.

Unit accreditation number	City & Guilds unit number	Unit title	Credit value
H/602/4563	321	Understand CO2 refrigeration system service and maintenance techniques	10
K/602/4595	325	Service and maintain CO2 refrigeration systems	3

2 Centre requirements

Approval

Centres who are currently approved to offer the following qualifications:

- 6087-02 Level 2 NVQ in Refrigeration And Air-Conditioning (Small Commercial Refrigeration and Air-Conditioning Systems)
- 6087-03 Level 3 NVQ in Refrigeration and Air Conditioning Systems (Commercial And Industrial Air Conditioning Systems)
- 6087-04 Level 3 NVQ in Refrigeration and Air Conditioning (Ammonia Refrigeration Systems)
- 6087-05 Level 3 NVQ in Refrigeration and Air Conditioning (Commercial And Industrial Refrigeration Systems – Non Ammonia)
- 6127-01 Level 2 Certificate in Small Commercial Refrigeration and Air-Conditioning Systems
- 6127-02 Level 3 Certificate in Complex Refrigeration and Air Conditioning Systems

are eligible for automatic approval for the suite of qualifications within 6187-21 and 6187-3

Centres who are not approved to offer the existing qualifications must use the standard Qualification Approval Process (refer to ***Providing City & Guilds qualifications – a guide to centre and qualification approval*** in Appendix 2). This also applies to new centres wishing to offer any of these qualifications.

City & Guilds reserves the right to insist on full qualification approval if there have been quality issues within a centre or if there have been substantial staff changes at the centre.

Resource requirements

Physical resources and site agreements

It is acceptable for centres to use specially designated areas within a centre to teach practical skills and to assess the simulated practical assignments within the knowledge units. The equipment, systems and machinery must meet current industrial standards and be capable of being used under normal working conditions, and must fully meet the requirements set in each City & Guilds practical assignment guide.

Centre staffing

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

- be technically competent in the areas for which they are delivering training and/or have experience of providing training. This knowledge must be at least to the same level as the training being delivered
- hold the appropriate qualifications detailed in this handbook
- have recent relevant experience in the specific area they will be assessing
- be occupationally knowledgeable in the area for which they are delivering training. This knowledge must be at least to the same level as the training being delivered and must include up-to-date knowledge of each industry (for which the assessment is taking place), its settings, legislative and regulatory requirements, codes of practice and guidance.
- have credible experience of providing training.

Centre staff may undertake more than one role, e.g. a tutor and assessor or internal verifier, but they must never internally verify their own assessments.

Assessors and internal verifiers

Assessors must:

- be working towards or have achieved A1 or A2 Standards and continue to practice to those standards or;
- have achieved D32 or D33 or TQFE/TQSE and possess CPD evidence of practicing to A1 or A2 Standards or;
- have other suitable 'equivalent assessor qualifications' endorsed by SummitSkills, which apply the principles of the A1/A2 Standards.

Assessor occupational competence

Have verifiable relevant industry experience and current knowledge of industry working practices and techniques relevant to the occupational working area. This verifiable evidence must be **at or above the level being assessed** and include one or more of the following:

- a relevant qualification. 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 of a relevant occupational qualification to ensure that they can be regarded as occupationally competent in terms of assessing or verifying the relevant qualifications and units therein.
- NVQs/SVQs at the appropriate level or their equivalents in the Qualifications and Credit Framework.

For particular units/qualifications the verifiable evidence may need to be above the level of the unit/qualification being assessed. This requirement will be detailed in the "Additional Information" pertaining to specific units/qualifications.

Assessment of competence-based units/qualifications for mechanical services occupations will require assessors **to have the relevant qualification** that certifies their competence in key technical areas pertinent to the completion of the unit/qualification.

This occupational competence must include up-to-date knowledge of each industry (for which the assessment is taking place), its settings, legislative and regulatory requirements, codes of practice and guidance.

Assessor continuing professional development

The occupational competence of assessors must be updated on a regular basis and be periodically reconfirmed via continuing professional development (CPD) via the assessment centres and quality assured by City & Guilds.

It is the responsibility of each assessor to identify and make use of opportunities for CPD, such as industry conferences, access to trade journals, and SSC and Professional Body/Trade Association events, at least on an annual basis to enhance and upgrade their professional development and technical knowledge. It is imperative that records are kept of all such CPD opportunities/occasions and that they provide evidence of cascading such technical knowledge and industry intelligence to all relevant colleagues.

Internal Verifiers

Role and responsibilities

The Sector Skills Council, SummitSkills considers the main focus of IVs to be the quality assurance of assessment procedures. The IV is also required to have a minimum of occupational experience evidenced by having a Building Services Engineering sector related qualification or proven sector competence/experience plus access to relevant 'occupational expertise' to enable them to conduct their role as internal verifier appropriately. This evidence and access to 'occupational expertise' is quality assured by City & Guilds.

Internal verifiers must:

- be working towards or have achieved the V1 Standard and continue to practice to that standard or;
- have achieved D34 and possess CPD evidence of practicing to the V1 Standard and;
- demonstrate an understanding of the assessment process.

Internal verifiers continuing professional development

The occupational experience of IVs must be updated on a regular basis and be periodically reconfirmed via continuing professional development (CPD) via the assessment centres and quality assured by City & Guilds.

It is the responsibility of each IV to identify and make use of opportunities for CPD, such as industry conferences, access to trade journals, and SSC and Professional Body/Trade Association events, at least on an annual basis to enhance and upgrade their professional development and technical knowledge. It is imperative that records are kept of all such CPD opportunities/occasions.

Expert witnesses

Where expert witnesses are used in the assessment process identified above they must be sector competent individuals who can attest to the learner's performance in the workplace. It is not necessary for expert witnesses to hold an assessor qualification, as a qualified assessor must assess the performance evidence provided by an expert witness. Evidence from expert witnesses must meet the tests of validity, reliability, authenticity and sufficiency.

Expert witnesses will need to demonstrate:

- they have relevant current knowledge of industry working practices and techniques
- that they have no conflict of interest in the outcome of their evidence.

Candidate entry requirements

Candidates should be F-Gas certified before embarking on these CPD qualifications. Copies of their F-Gas certification should be made available to the external verifier on request.

Candidates should not be entered for a qualification of the same type, content and level as that of a qualification they already hold.

Age restrictions

These qualifications are not approved for use by candidates under the age of 16, and City & Guilds cannot accept any registrations for candidates in this age group.

Other legal considerations

All legal requirements related to the subject matter must be met by candidates and centres.

3 Delivering the qualification

Initial assessment and induction

Centres will need to make an initial assessment of each candidate prior to the start of their programme to ensure they are entered for an appropriate type and level of qualification.

The initial assessment should identify:

- any specific training needs the candidate has, and the support and guidance they may require when working towards their qualifications. This is sometimes referred to as diagnostic testing.
- any units the candidate has already completed, or credit they have accumulated which is relevant to the qualifications they are about to begin.

City & Guilds recommends that centres provide an induction programme to ensure the candidate fully understands the requirements of the qualifications they will work towards, their responsibilities as a candidate, and the responsibilities of the centre. It may be helpful to record the information on a learning contract.

Recommended delivery strategies

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

SummitSkills expect knowledge units to be completed before performance units are undertaken by the candidate.

Centres may design course programmes of study in any way which

- best meets the needs and capabilities of their candidates
- satisfies the requirements of the qualifications.

When designing and delivering the course programme, centres might wish to incorporate other teaching and learning that is not assessed as part of the qualifications. This might include the following:

- literacy, language and/or numeracy
- personal learning and thinking
- personal and social development
- employability.

Where applicable, this could involve enabling the candidate to access relevant qualifications covering these skills.

Support materials

The following resources are available for these qualifications:

Description	How to access
Assignment guide for centres	Go to the **www.cityandguilds.com** and navigate to the 6187 web pages.
Leaner Logbook	Go to the **www.cityandguilds.com** and navigate to the 6187 web pages.

4 Assessment

Assessment of the qualification

Unit	Title	Assessment method	Where to obtain assessment materials
231/ 531	Understand and carry out brazing techniques for RAC systems	Multiple choice question paper (6187-231). Externally set, internally marked and externally verified Assignment (6187-531) Externally set assignment, locally marked and externally verified.	Go to **www.cityandguilds.com** and navigate to the 6187 webpage. Password available on Walled Garden
232/ 532	Understand and apply hydrocarbon RAC system installation, testing, servicing and maintenance techniques	Multiple choice question paper (6187-232). Externally set, internally marked and externally verified Assignment (6187-532) Externally set assignment, locally marked and externally verified.	Go to **www.cityandguilds.com** and navigate to the 6187 webpage. Password available on Walled Garden
312	Understand CO_2 air conditioning and heat pump system installation and commissioning techniques	Multiple choice question paper (6187-312). Externally set, internally marked and externally verified	Go to **www.cityandguilds.com** and navigate to the 6187 webpage. Password available on Walled Garden.
313	Understand CO_2 air conditioning and heat pump system service and maintenance techniques	Multiple choice question paper (6187-313). Externally set, internally marked and externally verified	Go to **www.cityandguilds.com** and navigate to the 6187 webpage. Password available on Walled Garden

Unit	Title	Assessment method	Where to obtain assessment materials
314	Install and commission CO_2 air conditioning and heat pump systems	Portfolio (6187-314) This unit will be assessed via observation and the development of a portfolio in a working environment and will be assessed to the assessment criteria set out in the unit.	The City & Guilds 6187 logbook can be downloaded from the City & Guilds website. Go to **www.cityandguilds.com** and navigate to the 6187 webpage. Alternatively centres may wish to use approved e-portfolios, with more details available at **www.cityandguilds.com/eportfolio**
315	Service and maintain CO_2 air conditioning and heat pump systems	Portfolio (6187-315) This unit will be assessed via observation and the development of a portfolio in a working environment and will be assessed to the assessment criteria set out in the unit.	The City & Guilds 6187 logbook can be downloaded from the City & Guilds website. Go to **www.cityandguilds.com** and navigate to the 6187 webpage. Alternatively centres may wish to use approved e-portfolios, with more details available at **www.cityandguilds.com/eportfolio**
316	Understand hydrocarbon RAC system design, installation, commissioning, servicing and maintenance techniques	Multiple choice question paper (6187-316). Externally set, internally marked and externally verified	Go to **www.cityandguilds.com** and navigate to the 6187 webpage. Password available on Walled Garden
318	Understand ammonia refrigeration system installation and commissioning techniques	Multiple choice question paper (6187-318). Externally set, internally marked and externally verified	Go to **www.cityandguilds.com** and navigate to the 6187 webpage. Password available on Walled Garden

Unit	Title	Assessment method	Where to obtain assessment materials
319	Understand CO_2 refrigeration system installation and commissioning techniques	Multiple choice question paper (6187-319). Externally set, internally marked and externally verified	Go to **www.cityandguilds.com** and navigate to the 6187 webpage. Password available on Walled Garden
320	Understand ammonia refrigeration system service and maintenance techniques	Multiple choice question paper (6187-320). Externally set, internally marked and externally verified	Go to **www.cityandguilds.com** and navigate to the 6187 webpage. Password available on Walled Garden
321	Understand CO_2 refrigeration system service and maintenance techniques	Multiple choice question paper (6187-321). Externally set, internally marked and externally verified	Go to **www.cityandguilds.com** and navigate to the 6187 webpage. Password available on Walled Garden
322	Install and commission ammonia refrigeration systems	Portfolio (6187-322) This unit will be assessed via observation and the development of a portfolio in a working environment and will be assessed to the assessment criteria set out in the unit.	The City & Guilds 6187 logbook can be downloaded from the City & Guilds website. Go to **www.cityandguilds.com** and navigate to the 6187 webpage. Alternatively centres may wish to use approved e-portfolios, with more details available at **www.cityandguilds.com/eportfolio**
323	Install and commission CO_2 refrigeration systems	Assignment (6187-323) Externally set assignment, locally marked and externally verified or portfolio	Go to **www.cityandguilds.com** and navigate to the 6187 webpage. Password available on Walled Garden

Unit	Title	Assessment method	Where to obtain assessment materials
324	Service and maintain ammonia refrigeration systems	Portfolio (6187-324) This unit will be assessed via observation and the development of a portfolio in a working environment and will be assessed to the assessment criteria set out in the unit.	The City & Guilds 6187 logbook can be downloaded from the City & Guilds website. Go to **www.cityandguilds.com** and navigate to the 6187 webpage. Alternatively centres may wish to use approved e-portfolios, with more details available at **www.cityandguilds.com/eportfolio**
325	Service and maintain CO_2 refrigeration systems	Assignment (6187-325) Externally set assignment, locally marked and externally verified or portfolio	Go to **www.cityandguilds.com** and navigate to the 6187 webpage. Password available on Walled Garden

Evidence requirements

The evidence requirements and City & Guilds assessment strategy for these qualifications has been designed within the confines of the SSC SummitSkills 'Consolidated Assessment Strategy for Units and Qualifications of 'Occupational Competence' in the Qualifications and Credit Framework (England, Northern Ireland and Wales) for the Building Services Engineering Sector' (April 2010 v2.1a 06.10)'.

There are three types of units within these qualifications:

Knowledge unit	A unit that gives the learner the opportunity to demonstrate their knowledge and understanding of identified topics and subject areas.
Performance unit	A unit that gives the learner the opportunity to demonstrate they have the practical skills that are in keeping with the relevant National Occupational Standards for identified activities.
Combination unit	A unit that gives the learner the opportunity to demonstrate their understanding and application of specific knowledge, and is assessed in simulated conditions using particularly identified 'relevant practical activities'.

'Knowledge' units must be undertaken in line with the City & Guilds assessment strategy for each unit as detailed in this handbook. All knowledge only units for the award are assessed by paper-based multiple choice tests.

The environment in which the evidence and the quantity of evidence for **performance units** must be assessed, ie sourced from the real working environment, is detailed in the 'Additional requirements' for each Performance Unit. This could be applicable to all the Learning Outcomes in the unit or particular Learning Outcomes.

Evidence that is sourced from the real working environment for **performance units** must be naturally occurring and can be generated by:

- direct observation of performance in the workplace by a qualified assessor and/or testimony from an expert witness subject to the activity being assessed. **This will be the primary source of evidence.**
- candidate's reflective account of performance.
- work plans and work based products e.g. diagrams, drawings, specifications, customer testimony, authorised & authenticated photographs / images and audio-visual records of work completed.
- evidence from prior achievements that demonstrably match the requirements of the Performance Unit.
- witness testimony.

The notes for guidance attached to each of the performance units identifies the types of evidence that will be suitable to support assessment in each of the learning outcomes. These notes also detail the minimum requirements for direct observation of performance by a qualified assessor that must be provided for specific learning outcomes.

Meeting the assessment requirements of **performance Units** will need initial discussions and assessment planning between the learner and assessor, as an essential activity to identify opportunities to assess real working environment evidence, gaps that need to be filled or opportunities to recognise the prior achievement of the learner.

Competence must be demonstrated **consistently over a period of time and on more than one occasion.** Unless specifically stated otherwise within the unit, there is no stipulation what that period of time might be as this is a decision for the assessor. Based on their own professional judgement assessors must be capable of identifying when competence has been demonstrated by the learner.

For the performance units the majority of evidence must be generated from an environment in which real work activities take place, under real working conditions, in keeping with real commercial situations.

Simulation can take place in those rare circumstances where the opportunities to collect naturally occurring evidence are limited or absent and the learner lacks evidence for completion of the unit. However, this scenario is anticipated to be rare in relation to the qualifications and the units to which this strategy applies given the inherent flexibility of the evidence-gathering process. Where simulation does take place it must be in a realistic working environment.

A simulated environment must replicate a real working environment. The criteria for which must be to supply fit-for-purpose tools, equipment, full-size components, realistic deadlines and other commercial requirements.

Simulation **must** take place for industry identified key-safety critical aspects of the qualification. A key safety-critical aspect is defined by SummitSkills as any 'technical' activity with the potential to harm/damage personnel/property if carried out incorrectly The activities that will be undertaken to demonstrate competence in these areas are contained within each industry's 'Assessment of Occupational Competence' arrangement and this must **not** be undertaken until they are deemed ready to be assessed as competent. This underpins the assumption that the learner has sufficient technical expertise, knowledge, skill and maturity.

Key safety-critical aspects are listed below:

- activities relating to F Gas installations/service and maintenance
- pressure testing
- handling of refrigerants (ODS, Ammonia, HC and CO_2)
- thermal pipe joining methods – welding; brazing; soldering activities
- limited scope electrical work
- as relevant, the installation, connection and servicing/maintenance of fuel systems and equipment – gas; oil; solid fuel
- as relevant, the installation, connection and servicing/maintenance of hot/cold water systems and equipment – unvented water; backflow prevention.

Recording documents

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

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

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

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

Recognition of prior learning (RPL)

Recognition of Prior Learning (RPL) recognises the contribution a person's previous experience could contribute to a qualification.

City & Guilds will recognise achievement of unit/qualifications through other awarding organisations which have the same content and assessment.

5 Units

Availability of units

The learning outcomes and assessment criteria are also viewable on the Register of Regulated Qualifications **http://register.ofqual.gov.uk/unit**

Structure of units

These units each have the following:

- City & Guilds reference number
- unit accreditation number (UAN)
- title
- level
- credit value
- unit aim
- relationship to NOS, other qualifications and frameworks
- endorsement by a sector or other appropriate body
- information on assessment
- learning outcomes which are comprised of a number of assessment criteria

Unit 231 Understand and carry out brazing techniques for RAC systems

UAN:	**Y/602/4981**
Level:	2
Credit value:	3
GLH:	24
Endorsement by a sector or regulatory body:	This unit is endorsed by SummitSkills.

Learning outcome
The learner will: 1 Understand the working principles of RAC compressed gas brazing processes
Assessment criteria
The learner can: 1.1 identify the working principles of all the following items of compressed gas brazing equipment: • compressed gas cylinders • two stage regulators • blowback arresters • non-return valves • high pressure welding torches • welding nozzles • high pressure hoses.

Learning outcome
The learner will: 2 Understand the legislative and organisational procedures related to RAC compressed gas brazing processes
Assessment criteria
The learner can: 2.1 interpret and apply appropriate sources of health and safety information as it relates to: • compressed gases • welding equipment • brazing processes • materials handling

2.2 interpret and apply regulations, codes of practice, industry recommendations and brazing specifications appropriate to:
- compressed gases
- welding equipment
- brazing processes

2.3 state appropriate persons whom it may be necessary to advise before undertaking brazing processes

2.4 define the actions that should be taken upon completion of brazing processes in terms of:
- quality control
- documentation procedures

2.5 explain how to prevent the inadvertent operation of brazing equipment after completion of work operations.

Learning outcome
The learner will: 3 Understand how to complete preparation work for compressed gas brazing activities
Assessment criteria
The learner can: 3.1 explain how to complete a basic risk assessment for the completion of brazing in the work location 3.2 specify the content of a method statement for the completion of brazing processes 3.3 identify the personal protective equipment appropriate to the work activity being carried out 3.4 state the preparation requirements for: • joining pipework by brazing • testing brazed pipework sections • commissioning brazed pipework sections • decommissioning brazed pipework sections • identifying faults on brazed pipework sections 3.5 identify pipework materials and fittings required to complete brazing processes and check them for defects 3.6 identify suitable tools and equipment required to carry out brazing processes 3.7 state the procedures for maintaining brazing tools and equipment.

Learning outcome
The learner will: 4 Be able to complete preparation work for RAC compressed gas brazing activities
Assessment criteria
The learner can: 4.1 carry out a basic risk assessment for the completion of brazing processes in the work location

4.2 interpret method statements for brazing to ascertain requirements for:
- storage of materials and finished products
- availability of service supplies
- informing appropriate people at key stages in the brazing process
- reporting problems
- joining procedures
- job instructions

4.3 select personal protective equipment appropriate to the work activity being carried out

4.4 select pipe and materials for brazing processes and confirm that they are appropriate for the work activity

4.5 select equipment for the completion of brazing processes and confirm that is appropriate for the work activity

4.6 confirm that preparations have been completed in line with organisational procedures.

Learning outcome
The learner will: 5 Understand how to connect pipework by compressed gas brazing
Assessment criteria
the learner can: 5.1 identify and interpret engineering drawings and brazing specifications for the completion of brazing procedures 5.2 state the methods for setting up and using brazing equipment, including: • compressed gas cylinders • two stage regulators • blowback arresters • non return valves • high pressure welding torches • welding nozzles • high pressure hoses 5.3 describe the basic principles for inspecting, testing and maintaining gas brazing equipment 5.4 identify procedures for brazing the following materials in accordance with industry standards • copper pipe • end feed bends and elbows • end feed tees • end feed couplings • integral ring capillary fittings • manually formed sockets • manually formed branches 5.5 define the procedures for: • checking brazed joints for compliance • testing for defects.

Learning outcome
The learner will: 6 Be able to connect pipework by RAC compressed gas brazing
Assessment criteria
The learner can: 6.1 complete checks to establish that: • joint preparation • brazing equipment • consumables comply with specifications and are fit for purpose 6.2 select tools and equipment required to carry out compressed gas brazing of pipework and confirm they are fit for purpose 6.3 set up brazing equipment in accordance with industry standards and regulations 6.4 braze the following pipework materials to conform with job specifications: • copper pipe • end feed bends and elbows • end feed tees • end feed couplings • integral ring capillary fittings • manually formed sockets • manually formed branches 6.5 confirm that equipment has been safely isolated completion of brazing activities 6.6 conduct industry approved checks and tests on brazed joints to: • confirm compliance with specification • identify any defects • identify any corrective actions 6.7 complete relevant documentation including brazed joint test reports.

Unit 232 Understand and apply hydrocarbon RAC system installation, testing, servicing and maintenance techniques

UAN:	**D/602/4982**
Level:	2
Credit value:	3
GLH:	24
Endorsement by a sector or regulatory body:	This unit is endorsed by SummitSkills.

Learning outcome
The learner will: 1 Understand the specific health and safety requirements which apply to the installation, servicing and maintaining and de-commissioning of hydrocarbon RAC systems
Assessment criteria
The learner can: 1.1 identify the hazards associated with hydrocarbon refrigerants: • flammability • low boiling point • asphyxiation (heavier than air) • LFL • UFL • sources if ignition • practical limits • density 1.2 state and identify the commonly used refrigerant designations 1.3 state the requirements of hydrocarbon specific risk assessments 1.4 identify the appropriate fire extinguishers for work on hydrocarbon RAC systems.

Learning outcome
The learner will: 2 Understand the legislative and organisational procedures for installation, servicing and maintaining and de-commissioning of hydrocarbon RAC systems
Assessment criteria
The learner can: 2.1 state the appropriate sources of health and safety information when installing, servicing and maintaining and de-commissioning of RAC systems 2.2 state the regulations, codes of practice, and industry recommendations appropriate to the installation, servicing and maintaining and de-commissioning of RAC systems, including working with refrigerants 2.3 state the occupancy classifications and charge size limitations for refrigeration systems 2.4 state charge size limitations for human comfort cooling and heating for air conditioning systems.

Learning outcome
The learner will: 3 Understand the differences between halocarbon and hydrocarbon RAC systems
Assessment criteria
The learner can: 3.1 identify the specific system features and components which apply to hydrocarbon systems: • electrical devices • electrical enclosures • associated electrical devices (including halocarbon systems) • compressors (including starter and associated electrics) 3.2 identify the features and characteristics of: • critical charge systems • oil compatibility 3.3 state the properties, advantages and disadvantages of hydrocarbon refrigerants including: • leakage implications (direct and indirect) • thermodynamic properties • cooling capacity and energy efficiency • density • not stenched 3.4 explain why hydrocarbons are not suitable for retro-filling into halocarbon systems 3.5 identify typical applications of hydrocarbon RAC systems: • integral (plug in systems) • fluid chillers • high stage CO2 cascade systems • split AC systems • domestic fridge freezers (ISO butane).

Learning outcome
The learner will: 4 Understand the procedures for planning and preparing for work on hydrocarbon RAC systems
Assessment criteria
The learner can: 4.1 state the requirements for completing a risk assessment for work on hydrocarbon RAC systems 4.2 state the requirements for creating and maintaining a safe working area, including requirements for temporary zoning 4.3 identify appropriate tools and equipment for work on hydrocarbon RAC systems.

earning outcome
The learner will: 5 Be able to plan and prepare for work on hydrocarbon RAC systems
Assessment criteria
The learner can: 5.1 complete a location specific risk assessment (using a dynamic risk assessment template) 5.2 establish and maintain a safe working area 5.3 select appropriate tools, equipment and PPE for work on hydrocarbon RAC systems.

Learning outcome
The learner will: 6 Understand the specific requirements for installing and testing hydrocarbon RAC systems
Assessment criteria
The learner can: 6.1 identify occupancy class 6.2 identify the maximum refrigerant charge based on occupancy class 6.3 calculate the maximum charge based on the practical limit 6.4 determine from calculations the system specific maximum charge 6.5 state the methods and procedures for: • strength integrity testing • tightness testing • leak testing • evacuation and dehydration 6.6 state the procedures for charging hydrocarbon refrigerants into systems 6.7 state the procedures for determining when charge is correct 6.8 state the records to be completed prior to handover 6.9 state the requirements for safely labelling hydrocarbon RAC systems

6.10 specify the information that should be provided to customers, including:
- operation of system and controls
- using only appropriately trained servicing personnel
- restrictions on the relocation of equipment.

Learning outcome

The learner will:

7 Understand the differences between halocarbon and hydrocarbon service and maintenance procedures

Assessment criteria

The learner can:

7.1 identify appropriate 'like for like' replacement components for the following:
- electrical devices
- electrical enclosures
- associated electrical devices (including halocarbon systems)
- Compressors (including starter and associated electrics)

7.2 state the importance of maintaining the integrity of sealed electrical enclosures

7.3 state appropriate methods for accessing and sealing hydrocarbon systems

7.4 specify the requirements for recovering hydrocarbon refrigerants, including situations when it may be safe to vent refrigeration to atmosphere

7.5 state the requirements for the safe use of vacuum pumps evacuating hydrocarbon systems.

Learning outcome

The learner will:

8 Be able to service and maintain hydrocarbon RAC systems

Assessment criteria

The learner can:

8.1 calculate the safe fill weight for the recovery cylinder (density difference between HFCs and HCs)

8.2 connect equipment in preparation for recovery

8.3 recover hydrocarbon refrigerant to a prescribed pressure

8.4 fill the system with Nitrogen to a prescribed pressure and release to atmosphere

8.5 un-braze specified component

8.6 re-braze specified component while purging Nitrogen through pipework

8.7 pressure test joints (containment)

8.8 evacuate to below 2000 microns

8.9 re-charge with specified refrigerant weight

8.10 run system and check operation

8.11 remove charging equipment

8.12 seal system and complete leak test with appropriate equipment

8.13 complete service records as appropriate.

Learning outcome
The learner will: 9 Understand the decommissioning procedures for hydrocarbon RAC systems
Assessment criteria
The learner can: 9.1 identify the safe procedures for handling potentially hazardous systems materials, including: hydrocarbon refrigerants 9.2 identify work sequences for decommissioning and making safe a system in accordance with appropriate industry procedures.

Unit 312 Understand CO_2 air conditioning system installation and commissioning techniques

UAN:	**T/602/4549**
Level:	3
Credit value:	11
GLH:	100
Endorsement by a sector or regulatory body:	This unit is endorsed by SummitSkills.

Learning outcome
The learner will: 1 Understand the working principles and layouts of CO2 air conditioning systems
Assessment criteria
The learner can: 1.1 critically compare carbon dioxide (R-744) properties to HFC refrigerant and ammonia in terms of: • pressure and compression ratio • density • volume • volumetric refrigeration capacity • critical point • heat transfer 1.2 define the terms triple point, critical point and supercritical fluid in relation to a Ph diagram and state the procedure for taking carbon dioxide liquid through the triple point 1.3 specify the risks arising from high co-efficient of expansion of carbon dioxide 1.4 evaluate the relationship between pressure and temperature of carbon dioxide 1.5 determine the working principles for all of the following commonly used types of carbon dioxide systems: • cascade • direct expansion • heat pumps • trans critical • volatile secondary • VRV • combinations of above including booster systems

1.6 explain how a trans-critical system operates in:
- trans-critical mode
- sub-critical mode

1.7 specify the working principles of all the following equipment used in volatile secondary, sub-critical and trans-critical carbon dioxide systems:
- compressors
- evaporators
- condensers/gas coolers
- heat exchangers
- control and isolating valves
- safety valves
- refrigerant pumps
- pressure vessels including oil separators
- heat pumps/recovery systems
- control systems

1.8 specify the problems that excessive moisture levels in the refrigerant can cause in relation to:
- lubricating oil
- internal corrosion
- valve blockages

1.9 describe the operating principles of a trans-critical system in relation to a refrigeration circuit diagram

1.10 state the methods of leak detection used for carbon dioxide air conditioning systems

1.11 state the direct and indirect global warming potential of carbon dioxide air conditioning systems.

Learning outcome
The learner will: 2 Understand the design principles for CO2 air conditioning systems
Assessment criteria
The learner can: 2.1 describe how a volatile secondary system works in relation to: • refrigerant pump operation • safety devices • high side plant function 2.2 determine methods to control and limit carbon dioxide standing pressures 2.3 state safe methods of pressure relief from components containing carbon dioxide: • liquid • vapour 2.4 define maximum allowable pressure specifications for sub-critical and trans-critical systems 2.5 specify a control strategy the following types of system: • direct expansion • trans-critical • VRV

2.6	identify suitable compressor sizes for equivalent CO2, Ammonia and HFC refrigerant work tasks
2.7	compare suitable pipe sizes for equivalent CO2, Ammonia and HFC refrigerant system installations.

Learning outcome
The learner will:
3 Understand the legislative and organisational procedures for the installation and commissioning of CO2 air conditioning systems
Assessment criteria
The learner can:
3.1 state the appropriate sources of health and safety information when installing and de-commissioning CO2 air conditioning systems
3.2 identify and interpret CO2 material safety data sheets
3.3 describe the safety hazards of carbon dioxide relative to: • exposure to gas, liquid and solid carbon dioxide • working in confined spaces in trenches, basements and roof voids (practical limit) • leak detection • working in machinery rooms • noise • transport and handling of carbon dioxide • third Party access to work areas
3.4 state the regulations, codes of practice, and industry recommendations appropriate to installing and de-commissioning CO2 air conditioning systems, including working with refrigerants
3.5 state appropriate persons whom it may be necessary to advise before a CO2 air conditioning system is isolated in order to undertake work
3.6 state the actions that should be taken to liaise with other persons upon completion of work procedures with regard to: • safe system shutdown • labelling of components
3.7 specify the organisational procedures for reporting and agreeing changes and or variations to work plans.

Learning outcome
The learner will: 4 Understand the procedures for planning and preparing for the installation and commissioning of CO2 air conditioning systems
Assessment criteria
The learner can: 4.1 describe protection measures, during installation of and on completion of pipework on RAC systems to: • building fabric, fixtures and fittings • new carbon dioxide systems • modifications/removal of existing carbon dioxide 4.2 describe PPE appropriate for all the installation and commissioning tasks on carbon dioxide systems 4.3 identify and interpret sources of information on carbon dioxide air conditioning systems 4.4 specify the procedures for organising and requisitioning the materials, tools and equipment required for the completion of installation and commissioning work activities 4.5 state the specific requirements for safely handling carbon dioxide cylinders 4.6 identify different tools, equipment and resources required for working on carbon dioxide systems 4.7 identify the supervision, planning and administration needs for an air conditioning project, including: • planning programmes of work • scheduling deliveries • charting progress • need for communication/liaising with other relevant persons/trades • maintaining cash flow • factors which may result in delays • contingency planning 4.8 state the requirements for organising: • resources • safe site storage of materials, tools and equipment • delivery of materials.

Learning outcome
The learner will: 5 Understand the procedures for the installation of CO2 air conditioning systems
Assessment criteria
The learner can: 5.1 state the maximum allowable pressures for carbon dioxide systems by reference to manufacturers' drawings, standards and industry codes 5.2 identify and select fittings and components with suitable pressure ratings for carbon dioxide systems

5.3 determine how to calculate maximum pressures for copper pipe thicknesses relative to carbon dioxide systems

5.4 critically compare advantages and disadvantages of copper and steel piping systems

5.5 specify what effect the pressure equipment regulations have on carbon dioxide system joint categories

5.6 determine how to select pipe brackets for either copper or steel pipework in respect of:

- spacing intervals
- expansion and contraction measures
- insulation and vapour seals

5.7 identify suitable standards for the completion of different types of pipe work joint, including:

- brazed joints
- welded joints
- mechanical joints

5.8 illustrate appropriate pressure equipment directive joint category of carbon dioxide piping by reference to standards

5.9 define the precautions to be taken with the installation of pressure relief piping on carbon dioxide systems.

Learning outcome
The learner will: 6 Understand the procedures for the commissioning of CO2 air conditioning systems
Assessment criteria
The learner can: 6.1 identify manufacturers' instructions, regulations and industry standards to define commissioning requirements for systems and components 6.2 determine the content of a pre-commissioning checklist for one type of carbon dioxide system 6.3 describe a range of routine checks on carbon dioxide equipment and pipework systems as part of a pre commissioning programme 6.4 determine the content of a plant log sheet 6.5 specify the content of a risk assessment and method statement to cover the charging and pressure testing of a carbon dioxide air conditioning system 6.6 classify strength and tightness pressure test levels related to system maximum allowable pressures for sub-critical and trans-critical systems 6.7 specify the procedures for completing system records and commissioning documentation 6.8 describe the process for handing over system to customer, including: • demonstrating operation of system controls • completing and passing on appropriate commissioning documentation.

Learning outcome
The learner will: 7 Understand the procedures for de-commissioning CO2 air conditioning systems
Assessment criteria
The learner can: 7.1 identify work sequences for permanently decommissioning: • a complete carbon dioxide system • part of a carbon dioxide system 7.2 state how oil and refrigerant could be removed from a system and disposed off 7.3 propose a risk assessment and method statement for simulated decommissioning activities 7.4 define a safe carbon dioxide refrigerant handling procedure for the following key tasks: • removal/venting of carbon dioxide from a system 7.5 explain how to deal with internal blockages due to “dry ice” forming within the system 7.6 state the implications that the suspension of air conditioning system operation can have on other person(s), including: • customers/clients • other site workers • site visitors 7.7 state the decommissioning procedures required to prevent the inadvertent operation of the installed air conditioning system 7.8 state the action to take when normal emptying or shut off mechanisms for air conditioning systems do not operate.

Unit 313 Understand CO_2 air conditioning system service and maintenance techniques

UAN:	**Y/602/4558**
Level:	3
Credit value:	10
GLH:	94
Endorsement by a sector or regulatory body:	This unit is endorsed by SummitSkills.

Learning outcome
The learner will: 1 Understand the working principles and layouts of CO2 air conditioning systems
Assessment criteria
The learner can: 1.1 critically compare carbon dioxide (R-744) properties to two HFC refrigerants in terms of: • pressure and compression ration • density • volume • specific refrigeration effect • critical point • heat transfer 1.2 define the terms triple point, critical point and supercritical fluid in relation to a Ph diagram and state the procedure for taking carbon dioxide liquid through the triple point 1.3 specify the risks arising from high co-efficient of expansion of carbon dioxide 1.4 evaluate the relationship between pressure and temperature of carbon dioxide 1.5 explain the working principles of the following commonly used carbon dioxide systems: • direct expansion • cascade • volatile secondary • trans-critical • heat pumps • VRV • combinations of the above including booster systems

1.6 explain how a trans-critical system operates in:
- trans-critical mode
- sub-critical mode

1.7 explain the working principles of all the following equipment used in carbon dioxide systems:
- compressors
- condensers/gas coolers
- control and isolating valves
- control systems
- evaporators
- heat exchangers
- heat pumps/recovery systems
- pressure vessels including oil separators
- refrigerant pumps
- safety valves

1.8 state the safe methods and procedures for safely isolating and removing components from the systems/equipment listed in

1.9 specify the problems that excessive moisture levels in the refrigerant can cause in relation to:
- lubricating oil
- internal corrosion
- valve blockages

1.10 state the methods of leak detection used for carbon dioxide air conditioning systems

1.11 state the direct and indirect global warming potential of carbon dioxide refrigeration systems.

Learning outcome
The learner will: 2 Understand the design principles for CO2 air conditioning systems
Assessment criteria
The learner can: 2.1 describe how a volatile secondary system works in relation to: • refrigerant pump operation • safety devices • high side plant function 2.2 determine pressure relief methods to control and limit carbon dioxide standing pressures 2.3 state safe methods of pressure relief from components containing carbon dioxide: • Liquid • Vapour 2.4 define maximum allowable pressure specifications for sub-critical and trans-critical systems 2.5 explain the importance of the material specification for pressure vessels and piping with regard to coincident low temperature/high pressures during use in carbon dioxide systems

2.6 propose a control strategy for the following types of system:
- direct expansion
- volatile secondary
- cascade
- trans-critical

2.7 identify suitable compressor sizes for equivalent CO2, Ammonia and HFC refrigerant work tasks

2.8 compare suitable pipe sizes for equivalent CO2, Ammonia and HFC refrigerant system installations.

Learning outcome
The learner will: 3 Understand the legislative and organisational procedures for the servicing and maintenance of CO2 air conditioning systems
Assessment criteria
The learner can: 3.1 state the appropriate sources of health and safety information when servicing and maintenance a CO2 air conditioning systems 3.2 identify and interpret CO2 material safety data sheets 3.3 describe the safety hazards of carbon dioxide relative to: • exposure to gas, liquid and solid carbon dioxide • working in confined spaces in trenches, basements and roof voids (practical limit) • leak detection • working in machinery rooms • noise • transport and handling of carbon dioxide • third Party access to work areas 3.4 state the regulations, codes of practice, and industry recommendations appropriate to servicing and maintenance of CO2 air conditioning systems, including working with refrigerants 3.5 state appropriate persons whom it may be necessary to advise before a CO2 air conditioning system is isolated in order to undertake work 3.6 state the actions that should be taken to liaise with other persons upon completion of work procedures with regard to: 3.7 safe system shutdown 3.8 labelling of components 3.9 specify the organisational procedures for reporting and agreeing changes and or variations to work plans.

Learning outcome
The learner will: 4 Understand the procedures for planning and preparing for the service and maintenance of CO2 air conditioning systems
Assessment criteria
The learner can: 4.1 describe protection measures, during installation of and on completion of pipework on RAC systems to: • building fabric, fixtures and fittings • new carbon dioxide systems • modifications/removal of existing carbon dioxide systems 4.2 describe PPE appropriate for servicing and maintenance tasks on carbon dioxide systems 4.3 identify and interpret sources of information on carbon dioxide air conditioning systems 4.4 specify the procedures for organising and requisitioning the materials, tools and equipment required for the completion of servicing and maintenance work activities 4.5 state specific requirements for safely handling carbon dioxide cylinders 4.6 identify different tools, equipment and resources required for working on carbon dioxide systems 4.7 state the requirements for organising: • resources • safe site storage of materials, tools and equipment • delivery of materials.

Learning outcome
The learner will: 5 Understand procedures for the inspection and servicing of CO2 air conditioning systems
Assessment criteria
The learner can: 5.1 explain how to check pipe brackets for carbon dioxide pipework in respect of: • spacing intervals • expansion and contraction measures • insulation and vapour seals 5.2 identify suitable standards for the following pipework joints: • brazed joints • welded joints • mechanical joints 5.3 describe the checks for pressure relief piping on carbon dioxide systems 5.4 identify manufacturers' instructions, standards and maintenance schedules to determine periodic servicing requirements for systems and components

5.5 describe a range of routine checks on carbon dioxide equipment and pipework systems

5.6 explain procedures for:

- removal of moisture from a system
- safe removal, storage and disposal of refrigerant
- safe removal, storage and disposal of waste oil

5.7 describe procedures to:

- safely vent carbon dioxide avoiding “dry ice” to allow a component to be removed from a system
- refit a component and establish system tightness test pressure (s) from the system allowable pressure(s)
- develop a risk assessment and method statement for the above activities

5.8 explain how to deal with internal blockages due to “dry ice” forming within the system.

Learning outcome
The learner will: 6 Understand the procedures for the maintenance of CO2 air conditioning systems
Assessment criteria
The learner can: 6.1 identify and use manufacturer instructions, regulations and industry standards to determine planned periodic maintenance schedules for systems and components 6.2 describe a range of routine checks on carbon dioxide equipment and pipework systems as part of a planned periodic maintenance programme including: • planned maintenance checks that would be carried out on the following major plant components: – compressors – pressure vessels – heat exchangers – control valves – refrigerant pumps – pressure relief devices 6.3 state the procedures for visually inspecting pipework for leakage and confirmation of adequate pipework support 6.4 state the types of fault that a visual inspection of insulation and vapour seals could identify 6.5 explain how to check for high moisture levels and take appropriate corrective action, including: • checking refrigerant and oil charges • refrigerant top up as required • oil top up as required 6.6 critically compare the advantages and disadvantages of different types of lubricating oil used in carbon dioxide systems.

Learning outcome
The learner will: 7 Understand the procedures for de-commissioning CO2 air conditioning systems
Assessment criteria
The learner can: 7.1 identify work sequences for permanently decommissioning: • a complete carbon dioxide system • part of a carbon dioxide system 7.2 state how oil and refrigerant could be removed from a system and disposed of 7.3 propose a risk assessment and method statement for simulated decommissioning activities 7.4 define a safe carbon dioxide refrigerant handling procedure for the following key tasks: • removal/venting of carbon dioxide from a system 7.5 state the implications that the suspension of air conditioning system operation can have on other person(s), including: • customers/clients • other site workers • site visitors 7.6 state the decommissioning procedures required to prevent the inadvertent operation of the installed air conditioning system 7.7 state the action to take when normal emptying or shut off mechanisms for air conditioning systems do not operate.

Unit 314 Install and commission CO_2 air conditioning systems

UAN:	**Y/602/6097**
Level:	3
Credit value:	3
GLH:	4
Endorsement by a sector or regulatory body:	This unit is endorsed by SummitSkills.

Learning outcome
The learner will: 1 Be able to plan and prepare for the installation and commissioning of CO2 air conditioning systems
Assessment criteria
The learner can: 1.1 conduct a review of the work location to identify any factors which may impact upon the work 1.2 confirm that relevant people have been provided with job information (as appropriate) and identify points within the work process when liaison with identified relevant persons may be necessary 1.3 identify manufacturers' instructions, regulations and industry standards to determine installation and commissioning requirements for systems and components 1.4 use manufacturer's instructions, regulations and industry standards to determine requirements for systems and components, including procedures to: • confirm that components have suitable pressure ratings for carbon dioxide systems and are suitable for use • confirm that fittings have suitable pressure ratings for carbon dioxide systems and are suitable for use • determine strength test pressure(s) from the system maximum allowable pressure(s) • determine tightness test pressure(s) from the system maximum allowable pressure(s) 1.5 produce a risk assessment and method statement for the charging and venting of carbon dioxide 1.6 confirm that authorisation has been provided by relevant persons prior to the completion of work activity 1.7 select appropriate PPE for the completion of work activities.

Learning outcome
The learner will: 2 Be able to carry out the installation of CO2 air conditioning systems
Assessment criteria
The learner can: 2.1 identify and interpret appropriate sources of information which impact upon the installation of CO2 air conditioning pipework, systems and components, including: • regulatory documents • industry codes of practice • manufacturer's instructions • installation specification 2.2 assemble and join CO2 air conditioning system components to meet the requirements of the installation specification 2.3 position and fix CO2 air conditioning system components and pipework correctly, in respect of: • Spacing intervals • Expansion and contraction methods • Insulation and vapour seals 2.4 confirm that installed system components and pipework are correctly installed in accordance with the installation specification 2.5 adjust and set safety and control features as appropriate 2.6 complete procedures to remove and refit components to CO2 air conditioning systems.

Learning outcome
The learner will: 3 Be able to carry out the commissioning of CO2 air conditioning systems
Assessment criteria
The learner can: 3.1 use manufacturer's instructions, regulations and industry standards to prepare a pre- commissioning checklist for one of the following types of system: • direct expansion • heat pump • trans-critical • volatile secondary • VRV 3.2 conduct the following checks on carbon dioxide equipment and systems: • visual inspection of pipework for leakage • visual inspection of pipework for adequate support • visual inspection of insulation and vapour seals • visual check for high moisture levels

- visual check of pressure relief valves and relief piping

3.3 demonstrate procedures for testing CO2 air conditioning systems, including:
- establishing system allowable pressure(s)
- conducting a strength pressure test
- conducting a tightness pressure test

3.4 demonstrate procedures for charging CO2 air conditioning systems, including:
- Evacuating a system
- Breaking a vacuum with carbon dioxide Vapour
- Charging a system with Oil
- Charging a system with carbon dioxide

3.5 demonstrate CO2 air conditioning system operation to confirm that system and equipment is functioning correctly

3.6 demonstrate procedures for adjusting system operating parameters through:
- adjusting safety and system controls
- topping up refrigerant levels as required
- topping up oil levels as required
- safely vent CO2, avoiding “dry ice”

3.7 produce documentary records to provide system users with information necessary for continuing operation of CO2 air conditioning systems, including:
- record of refrigerant operating levels
- record of oil operating levels
- records of :
  - refrigerant quantity added
  - refrigerant quantity removed
  - oil quantity added
  - oil quantity removed
- log of system in operation.

Learning outcome
The learner will: 4 Be able to carry out the de-commissioning of CO2 air conditioning systems
Assessment criteria
The learner can: 4.1 produce appropriate risk assessments and method statements to ensure decommissioning activities can be completed safely 4.2 demonstrate work sequences for permanently decommissioning: • a complete CO2 air conditioning system • part of a CO2 air conditioning system 4.3 demonstrate how oil and refrigerant could be safely removed from a system and disposed of.

Unit 315 Service and maintain CO_2 air conditioning systems

UAN:	**R/602/4591**
Level:	3
Credit value:	3
GLH:	4
Endorsement by a sector or regulatory body:	This unit is endorsed by SummitSkills.

Learning outcome
The learner will: 1 Be able to plan and prepare for the servicing and maintenance of CO2 air conditioning systems
Assessment criteria
The learner can: 1.1 conduct a review of the work location to identify any factors which may impact upon the work 1.2 confirm that relevant people have been provided with job information (as appropriate) and identify points within the work process when liaison with identified relevant persons may be necessary 1.3 identify manufacturers' instructions, regulations, industry standards and maintenance schedules to determine planned periodic maintenance schedules and servicing requirements for systems and components 1.4 use manufacturers' instructions, regulations and industry standards and maintenance schedules to determine planned servicing requirements for three of the following components: • compressor • expansion valve • gas cooler • heat exchanger • refrigerant pump

1.5 use manufacturers' instructions, regulations and industry standards and maintenance schedules to determine planned periodic maintenance schedules for any of the following system types:
- direct expansion
- heat pump
- trans-critical
- volatile secondary
- VRV

1.6 produce a risk assessment and method statement for the charging and venting of carbon dioxide

1.7 confirm that authorisation has been provided by relevant persons prior to the completion of work activity

1.8 select appropriate PPE for the completion of work activities.

Learning outcome
The learner will: 2 Be able to carry out the servicing and maintenance of CO2 air conditioning systems
Assessment criteria
The learner can: 2.7 conduct the following checks on carbon dioxide equipment and systems: • visual inspection of pipework for leakage • visual inspection of pipework for adequate support • visual inspection of insulation and vapour seals • visual check for high moisture levels • visual check of pressure relief valves and relief piping 2.8 demonstrate CO2 air conditioning system operation to confirm that system and equipment is functioning correctly 2.9 demonstrate the procedures for: • safe removal of oil from a compressor • completion of waste transfer paperwork for removed oil 2.10 produce documentary records to provide system users with information necessary for continuing operation of CO2 air conditioning systems, including: • record of refrigerant operating levels • record of oil operating levels • records of : – refrigerant quantity added – refrigerant quantity removed – oil quantity added – oil quantity removed • log of system in operation.

Learning outcome
The learner will: 3 Be able to identify and rectify faults in CO2 air conditioning systems
Assessment criteria
The learner can: 3.1 demonstrate procedures for adjusting system operating parameters through: • adjusting and setting safety and system controls • topping up refrigerant levels as required • topping up oil levels as required • safely venting CO2, avoiding “dry ice” 3.2 apply logical fault diagnosis procedures for CO2 air conditioning systems 3.3 complete procedures to remove and refit components in order to rectify faults in CO2 air conditioning systems 3.4 confirm system is functioning in accordance with the performance specification after completion of repairs through completion of appropriate checks, including: • checking refrigerant charge • checking oil charge.

Learning outcome
The learner will: 4 Be able to carry out the de-commissioning of CO2 air conditioning systems
Assessment criteria
The learner can: 4.1 produce appropriate risk assessments and method statements to ensure decommissioning activities can be completed safely 4.2 demonstrate work sequences for permanently decommissioning: • a complete CO2 air conditioning system • part of a CO2 air conditioning system 4.3 demonstrate how oil and refrigerant could be safely removed from a system and disposed of.

Unit 316 Understand hydrocarbon RAC system design, installation, commissioning and servicing and maintenance techniques

UAN:	**M/502/9299**
Level:	3
Credit value:	2
GLH:	15
Endorsement by a sector or regulatory body:	This unit is endorsed by SummitSkills.

Learning outcome
The learner will: 1 Understand the specific health and safety requirements which apply to the design, installation, commissioning, servicing, maintaining and de-commissioning of hydrocarbon RAC systems
Assessment criteria
The learner can: 1.1 explain the hazards associated with hydrocarbon refrigerants: • flammability • low boiling point • asphyxiation (heavier than air) • LFL • UFL • sources of ignition • practical limits • density 1.2 specify the commonly used refrigerant designations 1.3 produce hydrocarbon specific risk assessments in accordance with their level of responsibility 1.4 identify appropriate fire extinguishers for work on hydrocarbon RAC systems.

Learning outcome
The learner will: 2 Understand the legislative and organisational procedures for the design, installation, commissioning, servicing, maintaining and de-commissioning of hydrocarbon RAC systems
Assessment criteria The learner can: 2.1 state the appropriate sources of health and safety information which apply when designing, installing, commissioning servicing, maintaining and de-commissioning of hydrocarbon RAC systems 2.2 specify the regulations, codes of practice, and industry recommendations appropriate to the designing, installing, commissioning servicing, maintaining and de-commissioning of hydrocarbon RAC systems 2.3 confirm the occupancy classifications and charge size limitations for refrigeration systems 2.4 specify charge size limitations for human comfort cooling and heating for air conditioning systems.

Learning outcome
The learner will: 3 Understand the main principles for the design of hydrocarbon RAC systems
Assessment criteria
The learner can: 3.5 specify the specific system features and components which apply to hydrocarbon systems • electrical devices • electrical enclosures • associated electrical devices (including halocarbon systems) • compressors (including starter and associated electrics) 3.6 explain the features and characteristics of: • Critical charge systems • Oil compatibility 3.7 define the properties, advantages and disadvantages of hydrocarbon refrigerants, including: • leakage implications (direct and indirect) • thermodynamic properties • cooling capacity and energy efficiency • density • not stenched 3.8 explain why hydrocarbons are not suitable for retro-filling into halocarbon systems

3.9 specify typical applications of hydrocarbon RAC systems:
- integral (plug in systems)
- fluid chillers
- high stage CO2 cascade systems
- split AC systems
- domestic fridge freezers (ISO Butane)

3.10 explain the design characteristics and standard configurations for the following hydrocarbon systems:
- integral (plug in systems)
- fluid chillers
- high stage CO2 cascade systems
- split AC systems
- domestic fridge freezers (ISO butane).

Learning outcome
The learner will: 4 Understand the specific requirements for installing hydrocarbon RAC systems
Assessment criteria
The learner can: 4.1 define the installation standards which apply to the jointing and connection of hydrocarbon RAC system pipework 4.2 specify the standard/approved jointing methods and procedures for the connection of hydrocarbon RAC system pipework and components 4.3 interpret specifications accurately to identify the correct components/fittings that are required and confirm that they are installed in the correct place.

Learning outcome
The learner will: 5 Understand the specific requirements for commissioning hydrocarbon RAC systems
Assessment criteria
The learner can: 5.1 identify occupancy class 5.2 determine the maximum refrigerant charge based on occupancy class 5.3 calculate the maximum charge based on the practical limit and explain how to determine when charge is correct 5.4 determine from calculations the system specific maximum charge 5.5 explain the methods and procedures for: • strength integrity testing • tightness testing • leak testing • evacuation and dehydration

5.6	specify the procedures for charging hydrocarbon refrigerants into systems
5.7	specify the records which are to be completed prior to handover and the information that should be left for system users
5.8	state the requirements for the safe labelling of hydrocarbon RAC systems.

Learning outcome
The learner will:
6 Understand service and maintenance procedures for hydrocarbon RAC systems
Assessment criteria
The learner can:
6.1 specify appropriate 'like for like' replacement components for the following: • electrical devices • electrical enclosures • associated electrical devices (including halocarbon systems) • compressors (including starter and associated electrics)
6.2 explain the importance of maintaining the integrity of sealed electrical enclosures
6.3 describe the appropriate methods for accessing and sealing hydrocarbon systems
6.4 specify the sources of information that are required for servicing, maintenance and fault diagnosis procedures, including: • manufacturer information/guidance • industry standards/codes of practice • information from system users
6.5 explain how to use fault diagnosis techniques to determine whereabouts in a hydrocarbon RAC system a fault has occurred
6.6 specify the requirements for recovering hydrocarbon refrigerants, including situations when it may be safe to vent refrigerant to atmosphere
6.7 state the requirements for the safe use of vacuum pumps when evacuating hydrocarbon systems
6.8 explain the procedure for safely removing and replacing hydrocarbon RAC system components.

Learning outcome
The learner will: 7 Understand the procedures for re-commissioning hydrocarbon RAC systems
Assessment criteria
The learner can: 7.1 calculate the safe fill weight for the recovery cylinder (density difference between HFCs and HCs) 7.2 explain the procedure for safely and correctly re-commissioning a hydrocarbon RAC system, including requirements for: • connecting equipment in preparation for recovery • recovering hydrocarbon refrigerant to a prescribed pressure • filling the system with Nitrogen to a prescribed pressure and releasing to atmosphere • un-brazing and re-brazing (while purging Nitrogen through pipework) of replaced component • pressure testing of joints (containment) • evacuating the system to below 2000 microns • re-charging the system with the correctly determined / specified refrigerant weight • running the system to confirm correct operation • safe removal of charging equipment • sealing of system and completion of leak testing with appropriate equipment 7.3 specify the procedures for the accurate completion of servicing/maintenance/commissioning records as appropriate.

Learning outcome
The learner will: 8 Understand the decommissioning procedures for hydrocarbon RAC systems
Assessment criteria
The learner can: 8.1 specify the safe procedures for handling potentially hazardous system materials, including: hydrocarbon refrigerants 8.2 explain the work sequences for decommissioning and making safe a system in accordance with appropriate industry procedures.

Unit 318 Understand ammonia refrigeration system installation and commissioning techniques

UAN:	**D/502/9301**
Level:	3
Credit value:	11
GLH:	100
Endorsement by a sector or regulatory body:	This unit is endorsed by SummitSkills.

Learning outcome
The learner will: 1 Understand the working principles and layouts of ammonia refrigeration systems, equipment and components
Assessment criteria
The learner can: 1.1 define the function and operating principles for the following refrigeration system arrangements: • two stage system arrangements • multi-temperature systems 1.2 identify the functions and uses of the following items of specialist equipment associated with the refrigeration systems arrangements outlined in 1.1: • surge drum and inter-stage cooler/ Evaporative condensers • oil separation and return systems/ Pressure relief valves and bursting discs • refrigerant pumps/ Recovery systems/ Leak detection systems • air handling and ventilation systems 1.3 specify the ways that compressors can be used in refrigeration systems and identify capacity control methods for the following types of compressor: • reciprocating • twin helical screw • mono screw 1.4 state the properties of Ammonia with regard to suitability for high, low and ultra-low temperature operation

1.5 specify the procedures for plotting vapour compression cycles on pressure/enthalpy charts for:
- compound installations

1.6 identify and calculate values for :
- refrigeration capacity
- total power required
- mass flow rates for high and low stages of compression
- condenser capacity and heat energy for reclaim
- dryness fraction
- specific volume at suction
- compressor volumetric efficiency
- pressure ratios
- coefficient of performance
- super heat and sub cooling values

1.7 state the methods for using psychometric charts for refrigeration purposes.

Learning outcome
The learner will: 2 Understand the operating principles and characteristics of controls used for ammonia refrigeration systems
Assessment criteria
The learner can: 2.1 state the operating principles for controls relating to: • temperature variables • pressure variables • liquid refrigerant and oil variables • leakage of refrigerant 2.2 identify methods for capacity control through the use of saturated suction temperature/pressure 2.3 specify the controls, control sequence of operation and the electrical circuit requirements for safe defrost operation of cold stores operating below a store temperature of 1˚c.

Learning outcome
The learner will: 3 Understand the design principles which apply for the arrangement of ammonia refrigeration systems
Assessment criteria
The learner can: 3.1 identify criteria for designing cold stores, including: • product specific heat capacity • electrical load of components • material and fabric quality (u value rating) • construction methods for cold rooms

3.2	calculate cold store operational parameters including: • heat gain for various product loads • power consumption from main components • total cold store power consumption • annual maintenance cost
3.3	state the causes of and problems associated with 'frost heave'
3.4	explain how problem areas in the cold store envelope develop as a result of: • rain water • condensation • inadequate ventilation • door/access control
3.5	specify under floor heating methods and controls used in the design of cold stores, including: • electric • glycol circulation • air circulation
3.6	identify requirements for door positioning in cold stores: • externally located with solar gains • internally located with surrounding ambient temperatures.

Learning outcome	
The learner will:	
4	Understand the legislative and organisational procedures for the installation and commissioning of ammonia refrigeration systems
Assessment criteria	
The learner can:	
4.1	state the appropriate health and safety legislation and documentation which applies when installing and commissioning refrigeration systems
4.2	state the regulations, codes of practice, and industry recommendations appropriate to installation and commissioning of refrigeration systems, including requirements for safe working with refrigerants
4.3	state appropriate persons whom it may be necessary to advise before a refrigeration system is isolated in order to undertake work
4.4	state the actions that should be taken to liaise with other persons upon completion of work procedures with regard to: • safe system shutdown and isolation • labelling of components
4.5	specify the organisational procedures for reporting and agreeing changes and or variations to work plans

4.6	identify client and employer requirements for procedures to be followed when work has been completed: • tidy and clear site • complete stakeholder documentation (client, suppliers and employers for example, hazardous waste consignment documentation) • arrange suitable system evaluation and inspection audits throughout the year.

Learning outcome
The learner will: 5 Understand the procedures for planning and preparing for the installation and commissioning of ammonia refrigeration systems
Assessment criteria
The learner can: 5.1 explain what information and documentation is required in order to plan installation and commissioning activities 5.2 identify which people should be communicated with to enable planning and preparation 5.3 state how to check for any pre-existing damage to customer/client property, such as: • building wall/floor fabric • appliances and components • building décor and floor finishes 5.4 define the measures required to protect the building fabric/customer property, before and throughout completion of installation and commissioning work, including: • use of dust sheets • protection from flame damage • protection of customer/client • protection of appliances and components 5.5 specify procedures for conducting a preliminary site survey with regard to: • establishing a suitable position for major components • locating all necessary services to ensure they are available such as- electric, drainage, water • planning pipe runs • planning equipment foundations • measuring access points for large refrigeration plant • plant room requirements • roof loading requirements • noise levels • occupancy • health and safety • environmental considerations 5.6 identify Personal Protective Equipment relevant to the installation and commissioning work activities

5.7 specify the procedures for organising and requisitioning the materials, tools and equipment required for the completion of installation and commissioning work activities

5.8 identify the supervision, planning and administration needs for a refrigeration project including:

- planning programmes of work
- scheduling deliveries
- charting progress
- need for communication/liaising with other relevant persons/trades
- maintaining cash flow and profit
- factors which may result in delays
- contingency and disaster recovery planning

5.9 state the requirements for organising:

- resources
- safe site storage of materials, tools and equipment
- delivery of materials.

Learning outcome
The learner will: 6 Understand the procedures for installing ammonia refrigeration systems, equipment and components
Assessment criteria
The learner can: 6.1 explain how to fit and fix pipework, equipment and components of various weights and sizes to a range of different backgrounds: • brick and block • re-enforced concrete • rolled Steel Joists and 'U' channel 6.2 describe the care and maintenance procedures required for tools and equipment to be used, including requirements for confirming that appropriate items of equipment are correctly calibrated 6.3 state the features and characteristics of different brackets used for securing refrigeration pipework, equipment and components 6.4 state the purpose of location of cold store contraction joints.

Learning outcome
The learner will: 7 Understand the procedures for the completion of pre-commissioning and commissioning of ammonia refrigeration systems
Assessment criteria
The learner can: 7.1 explain the processes and procedures for: • strength integrity testing • tightness testing • evacuation and dehydration methods

7.2 state the requirements for system commissioning in terms of :
- testing
- adjusting
- balancing
- training of operating and maintenance personnel

7.3 specify the procedures for determining what quantity of ammonia is required

7.4 explain how to charge ammonia into the system

7.5 determine when charge is correct using system parameters
- weight of refrigerant
- running conditions (levels in surge drum and inter-cooler)
- temperatures, pressures and current

7.6 describe the correct starting procedures for:
- controls
- fan and compressor motors
- defrosting

7.7 specify the commissioning methods for the main refrigeration system components, including:
- cooling towers
- evaporative condensers
- water cooled condenser
- air cooled condensers
- refrigerant recovery systems
- leak detection and ventilation systems

7.8 state the commissioning methods for:
- oil lubrication circuits
- screw compressors
- reciprocating compressors

7.9 specify the commissioning methods for cold stores, including requirements for:
- under floor heating arrangements
- jointing and sealing
- door furniture
- drains
- bringing store floor down to operating temperature
- lighting
- defrost

7.10 specify the procedures for completing system records and commissioning documentation

7.11 describe the process for handing over system to customer, including:
- demonstrating operation of system controls
- instruction of ammonia safety ventilation system
- completing and passing on appropriate commissioning documentation.

Learning outcome
The learner will: 8 Understand the decommissioning procedures for ammonia refrigeration systems
Assessment criteria
The learner can: 8.1 state the implications that the suspension of a refrigeration system can have on other person(s), including: • customers/clients • other site workers • site visitors 8.2 identify the safe procedures for handling potentially hazardous system materials, including refrigerants and heavy/awkward items which require mechanical and manual handling 8.3 specify the procedures for the safe recovery, recycling, reclaim and disposal of refrigerant 8.4 identify work sequences for decommissioning and making safe a refrigeration system following industry procedures 8.5 state the procedures required to prevent the inadvertent operation of a decommissioned refrigeration system.

Unit 319 Understand CO_2 refrigeration system installation and commissioning techniques

UAN:	**Y/602/4561**
Level:	3
Credit value:	11
GLH:	100
Endorsement by a sector or regulatory body:	This unit is endorsed by SummitSkills.

Learning outcome
The learner will: 1 Understand the working principles and layouts of CO2 refrigeration systems
Assessment criteria
The learner can: 1.1 critically compare carbon dioxide (R-744) properties to HFC refrigerant and ammonia in terms of: • pressure and compression ratio • density • volume • volumetric refrigeration capacity • critical point • heat transfer 1.2 define the terms triple point critical point and supercritical fluid in relation to a Ph diagram and state the procedure for taking carbon dioxide liquid through the triple point 1.3 specify the risks arising from high co-efficient of expansion of carbon dioxide 1.4 evaluate the relationship between pressure and temperature of carbon dioxide 1.5 determine the working principles for all of the following commonly used types of carbon dioxide systems: • direct expansion • cascade • volatile secondary • trans-critical • heat pumps • combinations of the above including booster systems

1.6 specify the working principles of all the following equipment used in volatile secondary, sub-critical and trans-critical carbon dioxide systems:
- compressors
- evaporators
- condensers/gas coolers
- heat exchangers
- control and isolating valves
- safety valves
- refrigerant pumps
- pressure vessels including oil separators
- heat recovery
- control systems

1.7 specify the problems that excessive moisture levels in the refrigerant can cause in relation to:
- lubricating oil
- internal corrosion
- valve blockages

1.8 describe the operating principles of a trans-critical system in relation to a refrigeration circuit diagram

1.9 state the methods of leak detection used for carbon dioxide refrigeration systems

1.10 state the direct and indirect global warming potential of carbon dioxide refrigeration systems.

Learning outcome
The learner will: 2 Understand the design principles for CO2 refrigeration systems
Assessment criteria
The learner can: 2.1 describe how a volatile secondary system works in relation to: • refrigerant pump operation • safety devices • high side plant function 2.2 determine methods to control and limit carbon dioxide standing pressures with: • a separate refrigeration plant • pressure relief measures 2.3 state safe methods of pressure relief from components containing carbon dioxide: • liquid • vapour 2.4 define maximum allowable pressure specifications for sub-critical and trans-critical systems

2.5 propose a control strategy for one of the following types of system:
- direct expansion
- volatile secondary
- cascade
- trans-critical

2.6 identify suitable compressor sizes for equivalent CO2, Ammonia and HFC refrigerant work tasks

2.7 compare suitable pipe sizes for equivalent CO2, Ammonia and HFC refrigerant system installations

2.8 describe the outcomes should carbon dioxide leak from the low side into a high side plant which has either ammonia or an HFC as the refrigerant.

Learning outcome
The learner will: 3 Understand the legislative and organisational procedures for the installation and commissioning of CO2 refrigeration systems
Assessment criteria
The learner can: 3.1 state the appropriate sources of health and safety information when installing and de-commissioning a CO2 refrigeration systems 3.2 identify and interpret CO2 material safety data sheets 3.3 describe the safety hazards of carbon dioxide relative to: • exposure to gas, liquid and solid carbon dioxide • working in confined spaces in trenches, basements and roof voids (practical limit) • leak detection • working in machinery rooms • noise • transport and handling of carbon dioxide • third party access to work areas 3.4 state the regulations, codes of practice, and industry recommendations appropriate to installing and de-commissioning CO2 refrigeration systems, including working with refrigerants 3.5 state appropriate persons whom it may be necessary to advise before a CO2 refrigeration system is isolated in order to undertake work 3.6 state the actions that should be taken to liaise with other persons upon completion of work procedures with regard to: • safe system shutdown • labelling of components 3.7 specify the organisational procedures for reporting and agreeing changes and or variations to work plans.

Learning outcome
The learner will: 4 Understand the procedures for planning and preparing for the installation and commissioning of CO2 refrigeration systems
Assessment criteria
The learner can: 4.1 describe protection measures, during installation of and on completion of pipework on RAC systems to: • building fabric, fixtures and fittings • new carbon dioxide systems • modifications/removal of existing carbon dioxide systems 4.2 describe PPE appropriate for all the installation and commissioning tasks on carbon dioxide systems 4.3 identify and interpret sources of information on carbon dioxide refrigeration systems 4.4 specify the procedures for organising and requisitioning the materials, tools and equipment required for the completion of installation and commissioning work activities 4.5 state the specific requirements for safely handling carbon dioxide cylinders 4.6 identify different tools, equipment and resources required for working on carbon dioxide systems 4.7 identify the supervision, planning and administration needs for a refrigeration project, including: • planning programmes of work • scheduling deliveries • charting progress • need for communication/liaising with other relevant persons/trades • maintaining cash flow • factors which may result in delays • contingency planning 4.8 state the requirements for organising: • resources • safe site storage of materials, tools and equipment • delivery of materials.

Learning outcome
The learner will: 5 Understand the procedures for the installation of CO2 refrigeration systems
Assessment criteria
The learner can: 5.1 state the maximum allowable pressures for carbon dioxide systems by reference to manufacturers' drawings, standards and industry codes

5.2	justify the importance of material specification for pressure vessels and piping regarding coincident low temperature / high pressures during use in carbon dioxide systems
5.3	identify and select fittings and components with suitable pressure ratings for carbon dioxide systems
5.4	determine how to calculate maximum pressures for copper pipe thicknesses relative to carbon dioxide systems
5.5	critically compare advantages and disadvantages of Copper and Steel piping systems
5.6	specify what effect the pressure equipment regulations have on carbon dioxide system joint categories
5.7	determine how to select pipe brackets for either copper or steel pipework in respect of: • spacing intervals • expansion and contraction measures • insulation and vapour seals
5.8	identify suitable standards for the completion of different types of pipe work joint, including: • brazed joints • welded joints • mechanical joints
5.9	illustrate appropriate pressure equipment directive joint category of carbon dioxide piping by reference to standards
5.10	define the precautions to be taken with the installation of pressure relief piping on carbon dioxide systems.

Learning outcome
The learner will: 6 Understand the procedures for the commissioning of CO2 refrigeration systems
Assessment criteria
The learner can: 6.1 identify manufacturers' instructions, regulations and industry standards to define commissioning requirements for systems and components 6.2 determine the content of a pre-commissioning checklist for one type of carbon dioxide system 6.3 describe a range of routine checks on carbon dioxide equipment and pipework systems as part of a pre-commissioning programme 6.4 determine the content of a plant log sheet 6.5 specify the content of a risk assessment and method statement to cover the charging and pressure testing of a carbon dioxide air conditioning system 6.6 classify strength and tightness pressure test levels related to system Maximum Allowable Pressures for sub-critical and trans-critical systems 6.7 specify the procedures for completing system records and commissioning documentation 6.8 describe the process for handing over system to customer, including: • demonstrating operation of system controls

• completing and passing on appropriate commissioning documentation.

Learning outcome
The learner will: 7 Understand the procedures for de-commissioning CO2 refrigeration systems
Assessment criteria
The learner can: 7.1 identify work sequences for permanently decommissioning: • a complete carbon dioxide system • part of a carbon dioxide system 7.2 state how oil and refrigerant could be removed from a system and disposed of 7.3 propose a risk assessment and method statement for simulated decommissioning activities 7.4 define a safe carbon dioxide refrigerant handling procedure for the following key tasks: • removal/venting of carbon dioxide from a system 7.5 explain how to deal with internal blockages due to “dry ice” forming within the system 7.6 state the implications that the suspension of refrigeration system operation can have on other person(s), including: • customers/clients • other site workers • site visitors 7.7 state the decommissioning procedures required to prevent the inadvertent operation of the installed refrigeration system 7.8 state the action to take when normal emptying or shut off mechanisms for refrigeration systems do not operate.

Unit 320 Understand ammonia refrigeration system service and maintenance techniques

UAN:	**K/502/9303**
Level:	3
Credit value:	10
GLH:	93
Endorsement by a sector or regulatory body:	This unit is endorsed by SummitSkills.

Learning outcome
The learner will: 1 Understand the working principles and layouts of ammonia refrigeration systems, equipment and components
Assessment criteria
The learner can: 1.1 define the function and operating principles for the following refrigeration system arrangements: • secondary systems using brines, anti-freezes and alcohols • compound system arrangements • multi-temperature systems • cascade system arrangements 1.2 identify the functions and uses of the following items of specialist equipment associated with the refrigeration systems arrangements outlined in 1.1: • open and closed flash intercoolers • expansion tanks • oil returns • recovery systems • leak detection systems • air handling and ventilation systems • reversing valves • refrigerant pumps and liquid overfeed systems 1.3 state the function and operating principles of: • reciprocating compressors • twin helical screw compressors • mono screw compressors 1.4 define the function and operating principles of :

- air and water cooled condensers
- cooling towers
- evaporative condensers

1.5 state the function and operating principles of:
- flooded evaporators
- direct expansion evaporators

1.6 describe the function and operating principles for the following expansion devices:
- float (high and low pressure)
- thermostatic
- electronic

1.7 define the function and operating principles for :
- liquid accumulators
- sub-coolers
- oil recovery systems
- heat recovery
- centrifugal pumps
- magnetic level switches

1.8 describe the functions and operating principles of hot gas and electric defrost arrangements

1.9 explain the functions and operating principles for capacity control in refrigeration systems which use :
- two or more reciprocating compressors
- twin helical screw compressor(s)
- mono screw compressor.

Learning outcome
The learner will: 2 Understand the operating principles and characteristics of controls used for ammonia refrigeration systems
Assessment criteria
The learner can: 2.1 state the operating principles for controls relating to: • temperature variables • pressure variables • liquid refrigerant and oil variables • leakage of refrigerant 2.2 define the function and operating principles for the following pressure regulating valves fitted to multiple evaporator systems: • direct acting • pilot operated • externally compensated 2.3 state the uses and limitations of solenoid valves used in refrigeration systems 2.4 describe the design and performance requirements for the following vapour compression systems controls:

- controls required for unit protection eg HP cut out, LP cut out, oil pressure cut out
- crankcase heater
- flow switches
- level switches
- termination devices
- compressor delayed start
- pressure relief valves
- leak detection.

Learning outcome
The learner will: 3 Understand the design principles which apply for the arrangement of ammonia refrigeration systems
Assessment criteria
The learner can: 3.1 describe the controls, control operating sequence and the electrical circuit requirements for the safe defrost operation of cold stores operating below a store temperature of 1˚C 3.2 specify the control requirements for underfloor heating arrangements with: • glycol circulation • electric heater mats 3.3 state the properties of Primary and Secondary refrigerants with regard to suitability for high, low and ultra-low temperature operation 3.4 specify the procedures for plotting vapour compression cycles on pressure/enthalpy charts for: • compound installations • cascade arrangements • multi-evaporation temperatures with one stage of compression 3.5 state the procedures to calculate values for : • refrigeration capacity • total power required • mass flow rates for high and low stages of compression • condenser capacity and heat energy for reclaim • dryness fraction • specific volume at suction • compressor volumetric efficiency • compression ratios • coefficient of performance • super heat and sub cooling values

3.6 specify methods for using psychometric charts for dehumidification purposes in relation to:
- stock protection in warehouses, munitions and archival storage
- process drying such as timber, malt and chemicals

3.7 state the procedures for plotting data on the psychometric charts to help prevent condensation on wall surfaces separating frozen and chilled storage rooms

3.8 identify food storage physical data and storage conditions

3.9 specify suitable conditions for the efficient operation of refrigerant plant.

Learning outcome
The learner will: 4 Understand the legislative and organisational procedures for the servicing and maintenance of ammonia refrigeration systems
Assessment criteria
The learner can: 4.1 state the appropriate health and safety legislation and documentation which applies when installing and commissioning refrigeration systems 4.2 state the regulations, codes of practice, and industry recommendations appropriate to servicing and maintenance of refrigeration systems, including requirements for safe working with refrigerants 4.3 state appropriate persons whom it may be necessary to advise before an refrigeration system is isolated in order to undertake work 4.4 state the actions that should be taken to liaise with other persons upon completion of work procedures with regard to: • safe system shutdown and isolation • labelling of components 4.5 specify the organisational procedures for reporting and agreeing changes and or variations to work plans 4.6 identify client and employer requirements for procedures to be followed when work has been completed: • tidy and clear site • complete stakeholder documentation (client, suppliers and employers for example, hazardous waste consignment documentation) • arrange suitable system evaluation and inspection audits throughout the year.

Learning outcome
The learner will: 5 Understand the procedures for planning and preparing for the servicing and maintenance of ammonia refrigeration systems
Assessment criteria
The learner can: 5.1 explain what information is required in order to plan servicing and maintenance activities for the following: • systems: – compound and cascade – secondary fluid – cold stores for chilled and frozen storage • equipment: – multiple evaporators equipped with hot gas defrost arrangements – multiple compressors • condensing equipment: – cooling towers – evaporative condensers – water cooled condensers – multi – air cooled condensers 5.2 identify which people should be communicated with to enable planning and preparation 5.3 state how to check for any pre-existing damage to customer/client property, such as: • building wall/floor fabric • appliances and components • building décor and floor finishes 5.4 define the measures required to protect the building fabric/customer property, before and throughout completion of servicing and maintenance work, including: • use of dust sheets • protection from flame damage • protection of customer/client • protection of appliances and components 5.5 identify Personal Protective Equipment relevant to the servicing and maintenance work activities 5.6 specify the procedures for organising and requisitioning the materials, tools and equipment required for the completion of servicing and maintenance work activities 5.7 identify the supervision, planning and administration needs for a refrigeration project, including: • planning programmes of work • scheduling deliveries • charting progress • need for communication/liaising with other relevant persons/trades • maintaining cash flow and profit • factors which may result in delays • contingency planning 5.8 identify site requirements for:

- equipment
- materials
- access
- structures
- storage
- services – electrical, drainage, water.

Learning outcome
The learner will: 6 Understand the service and maintenance procedures for ammonia refrigeration systems
Assessment criteria
The learner can: 6.1 explain the requirements for regular maintenance planning with regard to: • daily inspections • monthly inspections • periodical inspections • annual inspections 6.2 state the requirements for routine preventative maintenance of refrigeration systems, including: • maintaining system refrigerating efficiency • to reduce indirect emissions of greenhouse gases 6.3 explain the effects that the following can have on system efficiency: • reduced coolant flow over air cooled condensers • reduced coolant flow in water cooled condensers • reduced air flow over evaporators • refrigerant leakage • high compressor suction superheat • compressor low volumetric efficiency • mechanical wear in compressor • reduced refrigerant feed to evaporating coil • excessive refrigerant feed to evaporating coil • oil entrainment 6.4 explain the methods for ensuring that the correct control settings are adopted for the following in order to maintain system efficiency: • room thermostat • high pressure cut out • low pressure cut out • fan control • defrost termination • constant pressure valves

6.5 identify symptoms which relate to common systems faults associated with:

- compressor (failure to start)
- condensers
- evaporators
- undercharge/overcharge
- control circuits
- noise and vibration
- inefficient defrost
- fan motors
- solenoid valve
- air flow

6.6 state the requirements for completing records and reports on the servicing and maintenance of refrigeration systems.

Learning outcome
The learner will: 7 Understand the procedures for identifying and rectifying faults on ammonia refrigeration systems
Assessment criteria
The learner can: 7.1 interpret information on refrigeration system component faults from: • advice from users • visual inspections or tests • diagnostic tests • data logging equipment 7.2 identify the procedures for isolating mains supplies to refrigeration system components in accordance with industry recommendations for: • refrigerant and oil fluids • water services • electrical 7.3 define the principles of adopting a systematic approach for fault diagnosis, including consideration of: • fault diagnostics without the use of mechanical or electrical instruments, i.e. litmus paper • using instruments to check component operation and characteristics • the influence of components upon system operation • the function and setting of controls and safety equipment 7.4 specify the work actions and sequences for rectifying faults in systems and components which will ensure minimum disruption to customers/clients and the work environment

7.5	state the fitting and fixing procedures for the replacement of the following refrigeration system equipment and components: • compressors, condensers and evaporators • shaft seals • pressure switches and relief devices • filters and strainers • expansion devices • valve gland packing
7.6	state the actions to be taken when a refrigeration system or component cannot be restored to full performance.

Learning outcome
The learner will: 8 Understand the procedures for the completion of pre-commissioning and commissioning of ammonia refrigeration systems
Assessment criteria
The learner can: 8.1 explain the processes and procedures for: • strength integrity testing • tightness testing • evacuation and dehydration methods 8.2 specify the procedures for determining what quantity of refrigerant is required 8.3 explain how to charge refrigerant into the system 8.4 determine when charge is correct using system parameters • weight of refrigerant • running conditions (levels in surge drum and inter-cooler) • temperatures, pressures and current 8.5 describe the correct starting procedures for: • controls • fan and compressor motors • defrosting 8.6 specify the commissioning methods for the main refrigeration system components, including: • cooling towers • evaporative condensers • water cooled condenser • air cooled condensers • refrigerant recovery systems • leak detection and ventilation systems 8.7 state the commissioning methods for: • oil lubrication circuits • screw compressors • reciprocating compressors

8.8 specify the commissioning methods for cold stores, including requirements for:
- under floor heating arrangements
- jointing and sealing
- door furniture
- drains
- bringing store floor down to operating temperature
- lighting
- defrost

8.9 specify the procedures for completing system records and commissioning documentation

8.10 describe the process for handing over systems to customers/clients, including:
- demonstrating operation of system controls
- instruction of ammonia safety ventilation system
- completing and passing on appropriate commissioning documentation.

Learning outcome
The learner will: 9 Understand the decommissioning procedures for ammonia refrigeration systems
Assessment criteria
The learner can: 9.1 state the implications that the suspension of a refrigeration system can have on other person(s), including: • customers/clients • other site workers • site visitors 9.2 identify the safe procedures for handling potentially hazardous system materials, including refrigerants and heavy/awkward items which require mechanical and manual handling 9.3 specify the procedures for the safe recovery, recycling, reclaim and disposal of refrigerant 9.4 identify work sequences for decommissioning and making safe a refrigeration system following industry procedures 9.5 state the procedures required to prevent the inadvertent operation of a decommissioned refrigeration system.

Unit 321 Understand CO_2 refrigeration system service and maintenance techniques

UAN:	**H/602/4563**
Level:	3
Credit value:	10
GLH:	94
Endorsement by a sector or regulatory body:	This unit is endorsed by SummitSkills.

Learning outcome
The learner will: 1 Understand the working principles and layouts of CO2 refrigeration systems
Assessment criteria
The learner can: 1.1 critically compare carbon dioxide (R-744) properties to HFC and ammonia refrigerants in terms of: • pressure and compression ration • density • volume • specific refrigeration effect • critical point • heat transfer 1.2 define the terms triple point, critical point and supercritical fluid in relation to a Ph diagram and state the procedure for taking carbon dioxide liquid through the triple point 1.3 specify the risks arising from high co-efficient of expansion of carbon dioxide 1.4 evaluate the relationship between pressure and temperature of carbon dioxide 1.5 explain the working principles of the following commonly used carbon dioxide systems: • direct expansion • cascade • volatile secondary • trans-critical • heat pumps • combinations of the above

1.6 explain the working principles of all the following equipment used in carbon dioxide systems:
- compressors
- evaporators
- condensers/gas coolers
- heat exchangers
- control and isolating valves
- safety valves
- refrigerant pumps
- pressure vessels including oil separators
- heat recovery

1.7 state the safe methods and procedures for safely isolating and removing components from the systems/equipment listed in

1.8 specify the problems that excessive moisture levels in the refrigerant can cause in relation to:
- lubricating oil
- internal corrosion
- valve blockages

1.9 describe the operating principles of a trans-critical system in relation to a refrigeration circuit diagram

1.10 state the global warming potential of carbon dioxide refrigeration systems.

Learning outcome
The learner will: 2 Understand the design principles for CO2 refrigeration systems
Assessment criteria
The learner can: 2.1 describe how a volatile secondary system works in relation to: • refrigerant pump operation • safety devices • high side plant function 2.2 determine methods to control and limit carbon dioxide standing pressures with: • a separate refrigeration plant • pressure relief measures 2.3 state safe methods of pressure relief from components containing carbon dioxide: • liquid • vapour 2.4 define maximum allowable pressure specifications for sub-critical and trans-critical systems 2.5 explain the importance of the material specification for pressure vessels and piping with regard to coincident low temperature/high pressures during use in carbon dioxide systems

2.6 propose a control strategy for one of the following types of system:
- direct expansion
- volatile secondary
- cascade
- trans-critical

2.7 identify suitable compressor sizes for equivalent CO2, Ammonia and HFC refrigerant work tasks

2.8 compare suitable pipe sizes for equivalent CO2, Ammonia and HFC refrigerant system installations.

Learning outcome
The learner will: 3 Understand the legislative and organisational procedures for the servicing and maintenance of CO2 refrigeration systems
Assessment criteria
The learner can: 3.1 state the appropriate sources of health and safety information when servicing and maintenance a CO2 refrigeration systems 3.2 identify and interpret CO2 material safety data sheets 3.3 describe the pressure equipment regulations effect on carbon dioxide system joint categories 3.4 describe the safety hazards of carbon dioxide relative to: • exposure to gas, liquid and solid carbon dioxide • working in confined spaces in trenches, basements and roof voids (practical limit) • leak detection • working in machinery rooms • noise • transport and handling of carbon dioxide • third party access to work areas 3.5 state the regulations, codes of practice, and industry recommendations appropriate to servicing and maintenance of CO2 refrigeration systems, including working with refrigerants 3.6 state appropriate persons whom it may be necessary to advise before a CO2 refrigeration system is isolated in order to undertake work 3.7 state the actions that should be taken to liaise with other persons upon completion of work procedures with regard to: • Safe system shutdown • Labelling of components 3.8 specify the organisational procedures for reporting and agreeing changes and or variations to work plans.

Learning outcome
The learner will: 4 Understand the procedures for planning and preparing for the service and maintenance of CO2 refrigeration systems
Assessment criteria
The learner can: 4.1 describe protection measures, during installation of and on completion of pipework on RAC systems to: • building fabric, fixtures and fittings • new carbon dioxide systems • modifications/removal of existing carbon dioxide systems 4.2 describe PPE appropriate for servicing and maintenance tasks on carbon dioxide systems 4.3 identify and interpret sources of information on carbon dioxide refrigeration systems 4.4 specify the procedures for organising and requisitioning the materials, tools and equipment required for the completion of servicing and maintenance work activities 4.5 state specific requirements for safely handling carbon dioxide cylinders 4.6 identify different tools, equipment and resources required for working on carbon dioxide systems 4.7 state the requirements for organising: • resources • safe site storage of materials, tools and equipment • delivery of materials.

Learning outcome
The learner will: 5 Understand procedures for the inspection and servicing of CO2 refrigeration systems
Assessment criteria
The learner can: 5.1 explain how to check pipe brackets for carbon dioxide pipework in respect of: • spacing intervals • expansion and contraction measures • insulation and vapour seals 5.2 identify suitable standards for the following pipework joints: • brazed joints • welded joints • mechanical joints 5.3 describe the checks for pressure relief piping on carbon dioxide systems 5.4 identify manufacturers' instructions, standards and maintenance schedules to determine periodic servicing requirements for systems and components

5.5 describe a range of routine checks on carbon dioxide equipment and pipework systems

5.6 explain procedures for:

- removal of moisture from a system
- safe removal, storage and disposal of refrigerant
- safe removal, storage and disposal of waste oil

5.7 describe procedures to:

- safely vent carbon dioxide avoiding “dry ice” to allow a component to be removed from a system
- refit a component and establish system tightness test pressure(s) from the system allowable pressure(s)
- develop a risk assessment and method statement for the above activities

5.8 explain how to deal with internal blockages due to “dry ice” forming within the system

5.9 explain what would happen if carbon dioxide leaked into a high side plant which has either ammonia or an HFC as the refrigerant.

Learning outcome
The learner will: 6 Understand the procedures for the maintenance of CO2 refrigeration systems
Assessment criteria
The learner can: 6.1 identify and use manufacturer instructions, regulations and industry standards to determine planned periodic maintenance schedules for systems and components 6.2 describe a range of routine checks on carbon dioxide equipment and pipework systems as part of a planned periodic maintenance programme including: • planned maintenance checks that would be carried out on the following major plant components: – compressors – pressure vessels – heat exchangers – control valves – refrigerant pumps – pressure relief devices 6.3 state the procedures for visually inspecting pipework for leakage and confirmation of adequate pipework support 6.4 state the types of fault that a visual inspection of insulation and vapour seals could identify 6.5 explain how to check for high moisture levels • checking refrigerant and oil charges • refrigerant top up as required • oil top up as required 6.6 critically compare the advantages and disadvantages of two types of lubricating oil used in carbon dioxide systems.

Learning outcome
The learner will: 7 Understand the procedures for de-commissioning CO2 refrigeration systems
Assessment criteria
The learner can: 7.1 identify work sequences for permanently decommissioning: • a complete Carbon dioxide system • part of a carbon dioxide system 7.2 state how oil and refrigerant could be removed from a system and disposed of 7.3 propose a risk assessment and method statement for simulated decommissioning activities 7.4 define a safe carbon dioxide refrigerant handling procedure for the following key tasks: • evacuation of system • removal/venting of carbon dioxide from a system 7.5 state the implications that the suspension of refrigeration system operation can have on other person(s), including: • customers/clients • other site workers • site visitors 7.6 state the decommissioning procedures required to prevent the inadvertent operation of the installed refrigeration system 7.7 state the action to take when normal emptying or shut off mechanisms for refrigeration systems do not operate.

Unit 322 Install and commission ammonia refrigeration systems

UAN:	**A/502/9306**
Level:	3
Credit value:	3
GLH:	4
Endorsement by a sector or regulatory body:	This unit is endorsed by SummitSkills.

Learning outcome
The learner will: 1 Be able to plan and prepare for the installation and commissioning of ammonia refrigeration systems
Assessment criteria
The learner can: 1.1 confirm that all information is available prior to planning installation or commissioning activities 1.2 confirm that all tools, equipment and materials are available and fit for use prior to commencement of the work 1.3 confirm that all persons relevant to the installation or commissioning activity are identified and that lines of communication are established 1.4 carry out site survey to identify any variations or deviations to planned work or any structural or access issues which need to be resolved prior to work commencement 1.5 identify safe storage arrangements for tools, equipment and materials prior to commencement of installation or commissioning activity 1.6 plan safe access to work areas and confirm with responsible person on site 1.7 ensure that all necessary risk assessment and safe working procedure development has been undertaken prior to work commencement 1.8 confirm the site arrangements for: • security • fire precaution and control

1.9 complete preparatory work as necessary in relation to location, siting and fixing of cold stores, including:

- insulated panels
- steel framework – internal or external arrangements
- piping
- jointing by brazing or flaring
- confirming requirements for:
  - cleanliness inside pipes by purging with OFN
  - insulation
  - electrical supply
  - condensate disposal
  - positioning of evaporative condensers
  - control arrangements.

Learning outcome
The learner will: 2 Be able to carry out the installation of ammonia refrigeration systems
Assessment criteria
The learner can: 2.1 identify and interpret appropriate sources of information which impact upon the installation of refrigeration pipework, systems and components, including: • regulatory documents • industry codes of practice • manufacturer's instructions • installation specification 2.2 demonstrate appropriate methods for positioning and fixing: • cold store arrangements, including: – underfloor heating arrangements, to include the laying of glycol heating pipe circuit or electric heater mats, insulation floor slabs and vapour barriers – door furniture – lighting – condensate drains – pipework and pipe insulation – internal racking • pressure, temperature and flow controls • insulation floor slabs • vapour barriers • leak detection and ventilation systems 2.3 confirm that contraction joints are fixed correctly in position within the floor slab as required 2.4 erect steel frameworks required for refrigeration systems 2.5 position and fix slip sheet and supervise the laying of the appropriate floor slab 2.6 complete the sealing junction locations, including: • roof and wall • floor and wall

2.7 complete the interconnection and fixing of electrical power and communication components

2.8 confirm that installed system components and pipework are correctly installed in accordance with the installation specification

2.9 confirm that the worksite has been cleared in preparation for system testing.

Learning outcome

The learner will:

3 Be able to carry out the pre-commissioning of ammonia refrigeration systems

Assessment criteria

The learner can:

3.1 revisit risk assessment and safe working procedure to confirm currency and validity prior to commencement of pre-commissioning

3.2 identify placement of components to design drawings

3.3 carry out the following pre-commissioning checks and tests in accordance with industry and safety requirements:

- preliminary checks, including:
  - unit inspection
  - confirmation of: plant details, unit nameplate detail and compressor details
- pre-start check list, consisting of:
  - heat exchanger checks
  - mechanical check list
  - electrical check list
  - user connections
  - power supply tests
  - crankcase heaters
  - pressure regulators
  - oil heater options
  - transformer voltage checks
  - electronic controller, software, configuration etc
- visual inspection of installation; checking:
  - component serial numbers
  - piping circuits
  - controls to design specifications
  - refrigerant distributors
  - oil levels
  - pumps

3.4 demonstrate procedures for removing and replacing the refrigerant

3.5 carry out the following tests in accordance with appropriate legislation:

- strength integrity test
- pressure tightness test
- evacuation and dehydration methods

3.6 charge plant with correct refrigerant

3.7 carry out electrical tests to confirm that system is safe to switch on:

- visual integrity check
- continuity
- insulation resistance
- polarity
- resistance to earth

3.8 open service valves, run plant and:

- check for correct rotation of all fans
- check control operation and adjust as necessary to required design settings
- check defrost system
- leak test system
- check air circulation in storage areas.

Learning outcome
The learner will: 4 Be able to carry out the commissioning of ammonia refrigeration systems
Assessment criteria
The learner can: 4.1 confirm that the system provides refrigeration 4.2 complete compressor start and safety device tests 4.3 check and confirm the starting procedures for: • controls • fan and compressor motors • defrosting 4.4 check capacity control operation for : • screw compressors • reciprocating compressors and confirm that all machinery guards and warning notices are in place 4.5 demonstrate commissioning methods for cold stores, including requirements for: • under floor heating arrangements • jointing and sealing • door furniture • drains • bringing store floor down to operating temperature • lighting • defrost 4.6 record operating conditions on the appropriate log sheet for: • compressors • evaporators • condensers

- liquid refrigerant pumps
- auxiliary components as required by specialist refrigeration systems such as:
  - compound inter-cooling arrangements
  - secondary fluid chillers, (brine etc)

4.7 remove analysers/gauges from systems ensuring:
- minimal vapour refrigerant loss
- no liquid refrigerant loss

4.8 replace valve caps and confirm valves are leak free.

Learning outcome
The learner will: 5 Be able to handover ammonia refrigeration systems
Assessment criteria
The learner can: 5.1 complete system records for hand over documentation, including those which detail: • strength integrity test • pressure tightness test • evacuation and dehydration • compressor starter tests • safety device tests • system refrigerant charge and type • performance testing • control settings • electrical testing 5.2 complete refrigeration system records including: • operational log sheet • running current log sheet 5.3 demonstrate system operation and operating controls to customer 5.4 pass over system documentation and records to customer 5.5 report to line manager that installation is complete and fill in appropriate company documentation.

Learning outcome
The learner will: 6 Be able to carry out the de-commissioning of ammonia refrigeration systems
Assessment criteria
The learner can: 6.1 produce appropriate risk assessments and method statements to ensure decommissioning activities can be completed safely 6.2 demonstrate work sequences for decommissioning and making safe: • a complete ammonia refrigeration system • part of an ammonia system

6.3	demonstrate how oil and refrigerant could be safely recovered from a system and disposed of.

Unit 323 Install and commission CO_2 refrigeration systems

UAN:	**H/602/4594**
Level:	3
Credit value:	3
GLH:	4
Endorsement by a sector or regulatory body:	This unit is endorsed by SummitSkills.

Learning outcome
The learner will: 1 Be able to plan and prepare for the installation and commissioning of CO2 refrigeration systems
Assessment criteria
The learner can: 1.1 conduct a review of the work location to identify any factors which may impact upon the work 1.2 confirm that relevant people have been provided with job information (as appropriate) and identify points within the work process when liaison with identified relevant persons may be necessary 1.3 identify manufacturers' instructions, regulations and industry standards to determine installation and commissioning requirements for systems and components 1.4 use manufacturer's instructions, regulations and industry standards to determine requirements for systems and components, including procedures to: • confirm that components have suitable pressure ratings for carbon dioxide systems and are suitable for use • confirm that fittings have suitable pressure ratings for carbon dioxide systems and are suitable for use • determine Strength Test Pressure(s) from the system Maximum Allowable Pressure(s) • determine tightness test pressure(s) from the system maximum allowable pressure(s) 1.5 produce a risk assessment and method statement for the charging and venting of carbon dioxide 1.6 confirm that authorisation has been provided by relevant persons prior to the completion of work activity 1.7 select appropriate PPE for the completion of work activities.

Learning outcome
The learner will: 2 Be able to carry out the installation and commissioning of CO2 refrigeration systems
Assessment criteria
The learner can: 2.1 identify and interpret appropriate sources of information which impact upon the installation of CO2 refrigeration pipework, systems and components, including: • regulatory documents • industry codes of practice • manufacturer's instructions • installation specification 2.2 assemble and join CO2 refrigeration system components to meet the requirements of the installation specification 2.3 position and fix CO2 refrigeration system components and pipework correctly, in respect of: • spacing intervals • expansion and contraction methods • insulation and vapour seals 2.4 confirm that installed system components and pipework are correctly installed in accordance with the installation specification 2.5 adjust and set safety and control features as appropriate 2.6 complete procedures to remove and refit components to CO2 refrigeration systems.

Learning outcome
The learner will: 3 Be able to carry out the commissioning of CO2 refrigeration systems
Assessment criteria
The learner can: 3.1 use manufacturer's instructions, regulations and industry standards to prepare a pre- commissioning checklist for one of the following types of system: • direct expansion • trans-critical • volatile secondary • cascade 3.2 conduct the following checks on carbon dioxide equipment and systems: • visual inspection of pipework for leakage • visual inspection of pipework for adequate support • visual inspection of insulation and vapour seals • visual check for high moisture levels • visual check of pressure relief valves and relief piping

3.3 demonstrate procedures for testing CO2 refrigeration systems, including:
- establishing system allowable pressure(s)
- conducting a strength pressure test
- conducting a tightness pressure test

3.4 demonstrate procedures for charging CO2 refrigeration systems, including:
- evacuating a system
- breaking a vacuum with carbon dioxide vapour
- charging a system with oil
- charging a system with carbon dioxide

3.5 demonstrate CO2 refrigeration system operation to confirm that system and equipment is functioning correctly

3.6 demonstrate procedures for adjusting system operating parameters through:
- adjusting safety and system controls
- topping up refrigerant levels as required
- topping up oil levels as required
- safely venting CO2, avoiding “dry ice”

3.7 produce documentary records to provide system users with information necessary for continuing operation of CO2 refrigeration systems, including:
- record of refrigerant operating levels
- record of oil operating levels
- records of:
  - refrigerant quantity added
  - refrigerant quantity removed
  - oil quantity added
  - oil quantity removed
- log of system in operation.

Learning outcome
The learner will: 4 Be able to carry out the de-commissioning of CO2 refrigeration systems
Assessment criteria
The learner can: 4.1 produce appropriate risk assessments and method statements to ensure decommissioning activities can be completed safely 4.2 demonstrate work sequences for permanently decommissioning: • a complete CO2 refrigeration system • part of a CO2 refrigeration system 4.3 demonstrate how oil and refrigerant could be safely removed from a system and disposed of.

Unit 324 Service and maintain ammonia refrigeration systems

UAN:	**J/502/9308**
Level:	3
Credit value:	3
GLH:	4
Endorsement by a sector or regulatory body:	This unit is endorsed by SummitSkills.

Learning outcome
The learner will: 1 Be able to plan and prepare for the servicing and maintenance of ammonia refrigeration systems
Assessment criteria
The learner can: 1.1 confirm that all information is available prior to planning service or maintenance activities 1.2 confirm that all tools, equipment and materials are available and fit for use prior to commencement of the work 1.3 confirm that all persons relevant to the service or maintenance activity are identified and that lines of communication are established 1.4 carry out site survey to identify any variations or deviations to planned work or any structural or access issues which need to be resolved prior to work commencement 1.5 identify safe storage arrangements for tools, equipment and materials prior to commencement of service or maintenance activity 1.6 plan safe access to work areas and confirm with responsible person on site 1.7 ensure that all necessary risk assessment and safe working procedure development has been undertaken prior to work commencement 1.8 complete preparatory work as necessary for system service and maintenance activities, to include consideration of: • location • function • cooling loads served • records • labelling.

Learning outcome
The learner will: 2 Be able to carry out the servicing and maintenance of ammonia refrigeration systems
Assessment criteria
The learner can: 2.1 identify appropriate sources of information which impact upon the servicing and maintenance of ammonia refrigeration systems, including: • regulatory documents • industry codes of practice • manufacturer's instructions • maintenance and service schedules 2.2 interpret maintenance schedules to identify required work activities 2.3 perform the following service and maintenance tasks safely and efficiently: • cleaning and checking the condition of: – condensers (including fans) – filters – indoor units – evaporators (including fans) • checking the condition of: – pipework and its insulation – electrical wiring, fuses and connections • checking: – water cooled condenser flow rate – air flow rate through condenser and evaporator – oil compressor charge – operation of all safety devices – condition and operation of all compression drives 2.4 check system operating conditions against control settings 2.5 measure humidity and temperature in the controlled space 2.6 reconnect or re-install system components after maintenance and then carry out the following checks and tests before running the system: • tightness testing • evacuation and dehydration • electrical testing 2.7 demonstrate procedures for replacing the refrigerant type in refrigeration systems, including: • selecting suitable replacement refrigerant types for different systems • safely disposing of refrigerant that is to be replaced • re-commissioning the system on completion of refrigerant replacement 2.8 re-charge refrigerant to correct quantity and check for leakage 2.9 complete system performance test 2.10 complete appropriate maintenance documentation and records.

Learning outcome
The learner will: 3 Be able to identify and rectify faults in ammonia refrigeration systems
Assessment criteria
The learner can: 3.1 diagnose common faults associated with: • compressors • condensers • suction and discharge • compressor oil supply • refrigerant supply • metering • electrical connections/supply 3.2 rectify common faults associated with: • compressors • condensers • suction and discharge • compressor oil supply • refrigerant supply • metering • electrical connections/supply.

Learning outcome
The learner will: 4 Be able to carry out the commissioning of ammonia refrigeration systems
Assessment criteria
The learner can: 4.1 revisit risk assessment and safe working procedure to confirm currency and validity prior to commencement of testing 4.2 carry out the checks and tests in accordance with industry and safety requirements, including: • checking: – safety mechanisms – emergency procedures – insulated structure for heat leakage (use of thermographic testing techniques – the performance of the refrigeration system – the electrical energy consumption of the plant – defrost system controls and operation – sediment levels in brine tanks – filters (and cleaning) – pumping arrangements for noise, vibration, rotary shaft seals, stuffing boxes

- inspecting:
  - condenser coils and fans
  - evaporators and fans
  - pressure relief valves
  - condensate drains
- testing specific gravity of secondary refrigerant

4.3 carry out the following tests in accordance with appropriate legislation:
- strength integrity test
- pressure tightness test
- evacuation and dehydration methods

4.4 compare pipework length with system factory charge and determine whether extra refrigerant charge is required

4.5 add additional refrigerant charge by weight in accordance with manufacturer's instructions

4.6 carry out basic electrical tests to confirm that system is safe to switch on:
- visual integrity check
- continuity
- insulation resistance
- polarity
- resistance to earth

4.7 open system valves and run system

4.8 complete checks to confirm system is leak free

4.9 confirm that the system provides cooling and/or heating by measuring air flow temperature difference across indoor and outdoor unit heat exchangers

4.10 record temperature differences

4.11 remove analysers/gauges from systems ensuring:
- minimal vapour refrigerant loss
- no liquid refrigerant loss

4.12 replace valve caps and confirm valves are leak free.

Learning outcome
The learner will: 5 Be able to handover ammonia refrigeration systems
Assessment criteria
The learner can: 5.1 complete system records for hand over documentation, including those which detail • strength integrity test • pressure tightness test • evacuation and dehydration • system refrigerant charge and type • performance testing • electrical testing 5.2 demonstrate system operation and operating controls to customer 5.3 pass over system documentation and records to customer

5.4	report to line manager that servicing or maintenance work is complete and fill in appropriate company documentation.

Learning outcome
The learner will: 6 Be able to carry out the de-commissioning of ammonia refrigeration systems
Assessment criteria
The learner can: 6.1 follow appropriate risk assessments and method statements to ensure decommissioning activities are completed safely 6.2 demonstrate work sequences for decommissioning and making safe: • a complete ammonia refrigeration system • part of an ammonia refrigeration system 6.3 demonstrate how oil, refrigerant and cleaning solvents can be safely recovered from a system and disposed of in accordance with appropriate regulations.

Unit 325 Service and maintain CO_2 refrigeration systems

UAN:	**K/602/4595**
Level:	3
Credit value:	3
GLH:	4
Endorsement by a sector or regulatory body:	This unit is endorsed by SummitSkills.

Learning outcome
The learner will: 1 Be able to plan and prepare for the servicing and maintenance of CO2 refrigeration systems
Assessment criteria
The learner can: 1.1 conduct a review of the work location to identify any factors which may impact upon the work 1.2 confirm that relevant people have been provided with job information (as appropriate) and identify points within the work process when liaison with identified relevant persons may be necessary 1.3 identify manufacturers' instructions, regulations, industry standards and maintenance schedules to determine planned periodic maintenance schedules and servicing requirements for systems and components 1.4 use manufacturers' instructions, regulations and industry standards and maintenance schedules to determine planned servicing requirements for three of the following components: • compressor • expansion valve • gas cooler • heat exchanger • refrigerant pump 1.5 use manufacturers' instructions, regulations and industry standards and maintenance schedules to determine planned periodic maintenance schedules for one of the following system types: • direct expansion • cascade • trans-critical • volatile secondary

1.6 produce a risk assessment and method statement for the Charging and venting of carbon dioxide

1.7 confirm that authorisation has been provided by relevant persons prior to the completion of work activity

1.8 select appropriate PPE for the completion of work activities.

Learning outcome

The learner will:

2 Be able to carry out the servicing and maintenance of CO2 refrigeration systems

Assessment criteria

The learner can:

2.1 conduct the following checks on carbon dioxide equipment and systems:

- visual inspection of pipework for leakage
- visual inspection of pipework for adequate support
- visual inspection of insulation and vapour seals
- visual check for high moisture levels
- visual check of pressure relief valves and relief piping

2.2 demonstrate CO2 refrigeration system operation to confirm that system and equipment is functioning correctly

2.3 demonstrate the procedures for:

- safe removal of oil from a compressor
- completion of waste transfer paperwork for removed oil

2.4 produce documentary records to provide system users with information necessary for continuing operation of CO2 refrigeration systems, including:

- record of refrigerant operating levels
- record of oil operating levels
- records of:
  - refrigerant quantity added
  - refrigerant quantity removed
  - oil quantity added
  - oil quantity removed
- log of system in operation.

Learning outcome

The learner will:

3 Be able to identify and rectify faults in CO2 refrigeration systems

Assessment criteria

The learner can:

3.1 demonstrate procedures for adjusting system operating parameters through:

- adjusting safety and system controls
- topping up refrigerant levels as required
- topping up oil levels as required
- safely venting CO2, avoiding “dry ice”

3.2	apply logical fault diagnosis procedures for CO2 refrigeration systems
3.3	complete procedures to remove and refit components in order to rectify faults in CO2 refrigeration systems
3.4	confirm system is functioning in accordance with the performance specification after completion of repairs through completion of appropriate checks, including: • checking refrigerant charge • checking oil charge.

Learning outcome
The learner will: 4 Be able to carry out the de-commissioning of CO2 refrigeration systems
Assessment criteria
The learner can: 4.1 produce appropriate risk assessments and method statements to ensure decommissioning activities can be completed safely 4.2 demonstrate work sequences for permanently decommissioning: • a complete CO2 refrigeration system • part of a CO2 refrigeration system 4.3 demonstrate how oil and refrigerant could be safely removed from a system and disposed of.

Appendix 1 Relationships to other qualifications

Links to other qualifications and frameworks

This qualification will be contained within the Summit Skills Apprenticeship framework. Please visit Summit Skills website at **www.summitskills.org.uk** for more details

Literacy, language, numeracy and ICT skills development

This qualification includes opportunities to develop and practise many of the skills and techniques required for success in the following qualifications:

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

There might also be opportunities to develop skills and/or portfolio evidence if candidates are completing any Key Skills alongside this qualification.

Appendix 2 Sources of general information

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

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

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

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

- Regulatory Arrangements for the Qualifications and Credit Framework (2008)
- SQA Awarding Body Criteria (2007)
- NVQ Code of Practice (2006)

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

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

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

- **Walled Garden:** how to register and certificate candidates on line
- **Qualifications and Credit Framework (QCF)**: general guidance about the QCF and how qualifications will change, as well as information on the IT systems needed and FAQs
- **Events**: dates and information on the latest Centre events
- **Online assessment**: how to register for e-assessments.

Useful contacts

UK learners **General qualification information**	T: +44 (0)844 543 0033 E: **learnersupport@cityandguilds.com**
International learners General qualification information	T: +44 (0)844 543 0033 F: +44 (0)20 7294 2413 E: **intcg@cityandguilds.com**
Centres Exam entries, Certificates, Registrations/enrolment, Invoices, Missing or late exam materials, Nominal roll reports, Results	T: +44 (0)844 543 0000 F: +44 (0)20 7294 2413 E: **centresupport@cityandguilds.com**
Single subject qualifications Exam entries, Results, Certification, Missing or late exam materials, Incorrect exam papers, Forms request (BB, results entry), Exam date and time change	T: +44 (0)844 543 0000 F: +44 (0)20 7294 2413 F: +44 (0)20 7294 2404 (BB forms) E: **singlesubjects@cityandguilds.com**
International awards Results, Entries, Enrolments, Invoices, Missing or late exam materials, Nominal roll reports	T: +44 (0)844 543 0000 F: +44 (0)20 7294 2413 E: **intops@cityandguilds.com**
Walled Garden Re-issue of password or username, Technical problems, Entries, Results, e-assessment, Navigation, User/menu option, Problems	T: +44 (0)844 543 0000 F: +44 (0)20 7294 2413 E: **walledgarden@cityandguilds.com**
Employer Employer solutions, Mapping, Accreditation, Development Skills, Consultancy	T: +44 (0)121 503 8993 E: **business@cityandguilds.com**
Publications Logbooks, Centre documents, Forms, Free literature	T: +44 (0)844 543 0000 F: +44 (0)20 7294 2413

If you have a complaint, or any suggestions for improvement about any of the services that we provide, email: **feedbackandcomplaints@cityandguilds.com**

About City & Guilds

As the UK's leading vocational education organisation, City & Guilds is leading the talent revolution by inspiring people to unlock their potential and develop their skills. We offer over 500 qualifications across 28 industries through 8500 centres worldwide and award around two million certificates every year. City & Guilds is recognised and respected by employers across the world as a sign of quality and exceptional training.

City & Guilds Group

The City & Guilds Group operates from three major hubs: London (servicing Europe, the Caribbean and Americas), Johannesburg (servicing Africa), and Singapore (servicing Asia, Australia and New Zealand). The Group also includes the Institute of Leadership & Management (management and leadership qualifications), City & Guilds Land Based Services (land-based qualifications), the Centre for Skills Development (CSD works to improve the policy and practice of vocational education and training worldwide) and Learning Assistant (an online e-portfolio).

Published by City & Guilds, a registered charity established to promote education and training.

City & Guilds
1 Giltspur Street
London EC1A 9DD
T +44 (0)844 543 0000
F +44 (0)20 7294 2413
www.cityandguilds.com

HB-01-6187