

# **Red Seal** Occupational Standard **Refrigeration and Air Conditioning Mechanic**



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# Red Seal Occupational Standard

# Refrigeration and Air Conditioning Mechanic



Title: Refrigeration and Air Conditioning Mechanic

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### Foreword

# The Canadian Council of Directors of Apprenticeship (CCDA) recognizes this Red Seal Occupational Standard (RSOS) as the Red Seal standard for the Refrigeration and Air Conditioning Mechanic trade.

#### Background

The first National Conference on Apprenticeship in Trades and Industries, held in Ottawa in 1952, recommended that the federal government be requested to cooperate with provincial and territorial apprenticeship committees and officials in preparing analyses of a number of skilled occupations. Employment and Social Development Canada (ESDC) funds the Red Seal Program, which, under the guidance of the CCDA, develops a national occupational standard for each of the Red Seal trades.

Standards have the following objectives:

- to describe and group the tasks performed by skilled workers;
- to identify which tasks are performed in every province and territory;
- to develop instruments for use in the preparation of Interprovincial Red Seal Examinations and assessment tools for apprenticeship and certification authorities;
- to develop common tools for apprenticeship on-the-job and technical training in Canada;
- to facilitate the mobility of apprentices and skilled workers in Canada;
- to supply employers, employees, associations, industries, training institutions and governments with occupational standards.

Any questions, comments, or suggestions for changes, corrections, or revisions to this standard or any of its related products may be forwarded to:

Trades and Apprenticeship Division Apprenticeship and Sectoral Initiatives Directorate Employment and Social Development Canada 140 Promenade du Portage, Phase IV Gatineau, Quebec K1A 0J9

### Acknowledgements

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Peter Arkesteyn, RSE	British Columbia
Andre Barbosa, RSE	Ontario
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Don Lyons, RSE	Saskatchewan
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Adam Prest, RSE	Ontario
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Ryan Sutherland, RSE	Manitoba

This standard was prepared by the Apprenticeship and Sectoral Initiatives Directorate of ESDC. The coordinating, facilitating and processing of this standard were undertaken by employees of the standards development team of the Trades and Apprenticeship Division and of Nova Scotia, the host jurisdiction for this trade.

### **Structure of the Occupational Standard**

This standard contains the following sections:

**Methodology:** an overview of the process for development, review, validation and weighting of the standard

**Description of the Refrigeration and Air Conditioning Mechanic Trade:** an overview of the trade's duties, work environment, job requirements, similar occupations and career progression

**Trends in the Refrigeration and Air Conditioning Mechanic Trade:** some of the trends identified by industry as being the most important for workers in this trade

**Skills for Success Summary:** an overview of how each of the skills for success (formerly called essential skills) is applied in this trade

**Roles and Opportunities for Skilled Trades in a Sustainable Future:** an overarching description of how in the context of climate change, skilled trades play a large role in implementing solutions and adjusting to changes in the world. In addition to highlighting the importance of this awareness, the standard may also contain more details on activities, skills and knowledge elements that are specific to the trade

**Industry Expected Performance:** description of the expectations regarding the level of performance of the tasks, including information related to specific codes, regulations and standards that must be observed

Language Requirements: description of the language requirements for working and studying in this trade in Canada

**Pie Chart of Red Seal Examination Weightings:** a graph which depicts the national percentages of exam questions assigned to the major work activities

**Task Matrix and Weightings:** a chart which outlines graphically the major work activities, tasks and subtasks of this standard and the national percentages of exam questions assigned to the major work activities and tasks

Harmonization of Apprenticeship Training: the aspects of apprenticeship training that participating provinces and territories have agreed upon to substantively align apprenticeship systems across Canada

Major Work Activity (MWA): the largest division within the standard that is comprised of a distinct set of trade activities

Task: distinct actions that describe the activities within a major work activity

Task Descriptor: a general description of the task

Sub-task: distinct actions that describe the activities within a task

#### Skills:

**Performance Criteria:** description of the activities that are done as the sub-task is performed

**Evidence of Attainment:** proof that the activities of the sub-task meet the expected performance of a tradesperson who has reached journeyperson level

**Range of Variables:** elements and examples (not all inclusive) that provide a more indepth description of a term used in the performance criteria and evidence of attainment

#### Knowledge:

**Learning Outcomes:** describes what should be learned relating to a sub-task while participating in technical or in-school training

**Learning Objectives:** topics to be covered during technical or in-school training in order to meet the learning outcomes for the sub-task

**Range of Variables:** elements and examples (not all inclusive) that provide a more indepth description of a term used in the learning outcomes and learning objectives

Appendix A – Acronyms: a list of acronyms used in the standard with their full name

Appendix B – Tools and Equipment / Outils et équipement: a bilingual non-exhaustive list of tools and equipment used in this trade

Appendix C – Glossary / Glossaire: bilingual definitions or explanations of selected technical terms used in the standard

# Methodology

#### **Development of the Standard**

A draft standard is developed by a broad group of trade representatives, including tradespeople, instructors and employers at a National Workshop led by a team of facilitators. This draft standard breaks down all the tasks performed in the occupation and describes the knowledge and abilities required for a tradesperson to demonstrate competence in the trade.

#### **Online Survey**

Stakeholders are asked to review and validate the activities described in the new standard via an online survey. These stakeholders are invited to participate in this consultation through apprenticeship authorities, as well as national stakeholder groups.

#### **Draft Review**

The RSOS development team forwards a copy of the standard to provincial and territorial authorities who consult with industry representatives to review it. Their recommendations are assessed and incorporated into the standard.

#### Validation and Weighting

Participating provinces and territories also consult with industry to validate and weight the document for the purpose of planning the makeup of the Red Seal Interprovincial Examination for the trade. They validate and weight the major work activities (MWA), tasks and sub-tasks, of the standard as follows:

- MWA Each jurisdiction assigns a percentage of questions to each MWA for an examination that would cover the entire trade.Tasks Each jurisdiction assigns a percentage of exam questions to each task within a MWA.
- **Sub-tasks** Each jurisdiction indicates, with a "yes" or "no", whether or not each sub-task is performed by skilled workers within the occupation in its jurisdiction.

The results of this exercise are submitted to the RSOS development team who then analyzes the data and incorporates it into the document. The RSOS provides the individual jurisdictional validation results as well as the national averages of all responses. The national averages for MWA and task weighting guide the Interprovincial Red Seal Examination plan for the trade.

The validation of the RSOS is used to identify common core sub-tasks across Canada for the occupation. If at least 70% of the responding jurisdictions' industry performs a sub-task, it shall be considered common core. Interprovincial Red Seal Examination questions are limited to the common core sub-tasks identified through this validation process.

### **Definitions for Validation and Weighting**

yes	sub-task performed by qualified workers in the occupation in that province or territory
no	sub-task not performed by qualified workers in the occupation in that province or territory
NV	standard <u>N</u> ot <u>V</u> alidated by that province or territory
ND	trade <u>N</u> ot <u>D</u> esignated in a province or territory
Not Common Core (NCC)	sub-task, task or MWA performed less than 70% of responding jurisdictions; these will not be tested by the Interprovincial Red Seal Examination for the trade
National Average %	average percentage of questions assigned to each MWA and task in Interprovincial Red Seal Examination for the trade

### **Provincial/Territorial Abbreviations**

NL	Newfoundland and Labrador
NS	Nova Scotia
PE	Prince Edward Island
NB	New Brunswick
QC	Quebec
ON	Ontario
MB	Manitoba
SK	Saskatchewan
AB	Alberta
BC	British Columbia
NT	Northwest Territories
YT	Yukon Territory
NU	Nunavut

# Description of the Refrigeration and Air Conditioning Mechanic Trade

"Refrigeration and Air Conditioning Mechanic" is this trade's official Red Seal occupational title approved by the CCDA. This standard covers tasks performed by refrigeration and air conditioning mechanics.

Refrigeration and air conditioning mechanics install, maintain, service and retrofit residential, commercial, industrial and institutional heating, ventilation, air conditioning and refrigeration units and systems. They also connect to and service air delivery systems, install and service hydronic and secondary refrigerant systems and associated controls. They install, repair and maintain systems for climate control and air quality. Their duties include laying out reference points for installation, assembling and installing components, installing wiring and cabling, to connect components and equipment to an electric power supply and calibrating related controls. They also measure, cut, bend, thread and connect piping and tubing to functional components and utilities.

Refrigeration and air conditioning mechanics maintain and service systems by inspecting and testing system and electrical components, and brazing, soldering and connecting mechanical fittings during installation or repairs. As part of service and commissioning, refrigeration and air conditioning mechanics start up, test, charge, adjust, calibrate, balance, measure, verify, maintain and document systems. They retrofit equipment with new energy efficient heating, ventilation, air conditioning and refrigeration (HVAC/R) systems using advanced electronic controls. They also retrofit HVAC/R systems with newer refrigerant oils.

In addition to their regular duties, some refrigeration and air conditioning mechanics may also prepare work estimates, source and order parts and materials, and design systems for clients.

Refrigeration and air conditioning mechanics work with a range of tools and equipment including hand, power, measuring, hoisting and rigging, charging, recovery, electrical and diagnostic.

They may be employed by HVAC/R contractors and manufacturers, property owners, retail establishments, and institutional and public sector employers. They also may be self -employed. Refrigeration and air conditioning mechanics may work on systems and units in housing, office buildings, restaurants, food and beverage, processing plants, ice rinks and arenas, supermarkets, hospitals, marine, aviation and mining sectors as well as bio-medical, scientific, research and development fields. They may also work on refrigerated transport trucks and trailers, automotive air conditioning systems, railcars and appliances.

In some jurisdictions, refrigeration and air conditioning mechanics may be required to work on fuel-fired equipment and therefore may require additional licencing.

Refrigeration and air conditioning mechanics work in various locations such as residential, industrial, commercial and institutional spaces, rooftops, mechanical rooms, computer rooms and laboratories. The work may be performed indoors or outdoors year-round and may require extensive travelling. Much of the work is performed independently.

Inherent risks in this trade include working at heights and in confined spaces, working with compressed gases, flammable and hazardous materials, chemicals and electricity. Hazardous work environments and weather conditions are also factors. Refrigeration and air conditioning mechanics must be aware of the physical demands and potential for personal injury when performing tasks.

People entering this trade should have key attributes such as strong client service, writing, communication and problem-solving skills, attention to detail, and the ability to be independent and self-directed. Coordination and manual dexterity are also important, as are mechanical and mathematical abilities. Good physical condition and the strength to lift heavy components are also valuable.

This standard recognizes some similarities with the work of steamfitters/pipefitters, plumbers, gasfitters, oil heat system technicians, sheet metal workers, industrial mechanics (millwrights), electricians, instrumentation and control technicians, riggers and stationary engineers.

With experience, refrigeration and air conditioning mechanics may act as mentors and trainers of apprentices in the trade. They may also become specialized in one area of the trade, advance to supervisory positions or become trainers.

# Trends in the Refrigeration and Air Conditioning Mechanic Trade

#### Technology

With the push for electrification and decarbonization, and the need for equipment to meet current industry and environmental standards, manufacturers are developing equipment with variable speed drives, controls and other technologies to meet requirements. Advancements in technology allow for more accurate monitoring and controlling of temperature, humidity, air quality, pressure, flow and occupancy.

Systems are more complicated than in the past and may require that refrigeration and air conditioning mechanics be trained directly by the manufacturer to access system controls. Design has become significantly more crucial than before to ensure correct, safe and efficient operation.

Some original equipment manufacturer (OEM) components and control systems are not compatible with generic components and cannot be retrofitted. Specialized manufacturer training may be required.

Although some technologies are pre-existing, high-energy efficiency is the catalyst to achieve future sustainability. There is a global mandate for sustainability and green technology resulting in improved control systems and heat transfer methods continuing to emerge and evolve. These include heat recovery systems, variable speed equipment and components, electronically commutated motors (ECM), advanced motor control systems, variable refrigerant flow (VRF), multi-zone equipment, solid-state control systems, electronic control valves, refrigerant control valves, flow control valves for hydronic heating, and oil free compressors. Remote assisted technologies, such as augmented reality, are evolving to aid technicians.

Heat pumps are becoming more common for climate control in buildings due to their significant environmental advantages and cost-efficiency. With the rapid evolution of heat pump technology, especially for air-to-air, air-to-liquid and liquid-to-liquid systems, it is imperative for refrigeration and air conditioning mechanics to remain at the forefront of this technology, especially as cold climate heat pumps are continually improving.

There is an increased use of solar panels being integrated into heating, ventilation and air conditioning/refrigeration (HVAC/R) equipment. This requires refrigeration and air conditioning mechanics to stay current with maintenance and service requirements of solar collectors and their associated equipment.

Cloud-based building management systems are becoming more commonplace to remotely monitor and control HVAC/R equipment and systems. Remote diagnostics and predictive maintenance using Internet of Things (IoT), or communication devices are becoming more widely incorporated in HVAC/R equipment.

Artificial intelligence (AI) is being used to optimize HVAC/R system performance and in assisting refrigeration and air conditioning mechanics with troubleshooting, service and training.

#### Health and Safety

As new refrigerants such as flammable/explosive, carbon dioxide (CO<sub>2</sub>), A1s, A2Ls, A3s are being introduced, it will be crucial for refrigeration and air conditioning mechanics to be knowledgeable of the codes and regulations, and servicing and handling procedures.

Personal protective equipment (PPE) is a crucial component of safety as jurisdictional and industry standards evolve for worker protection. Improved comfort and wearability allow PPE to be worn by an inclusive workforce when completing tasks.

#### **Tools and Equipment**

Smart tools that are now sometimes system-specific require manufacturer training to operate.

There are new tools and equipment for installing piping. Battery powered tools such as powered threaders and press connect fitting tools assist in installing piping in a safer and more efficient manner.

There is an increased functionality of Bluetooth or Wi-Fi wireless probes such as pressure gauges, thermometers, hygrometers, vacuum gauges, temperature sensors, manometers, anemometers, calibrators and combustion analyzers that allow better logging, tracking and reporting of the results. Computers, laptops, tablets, and smartphones are also being widely used to connect, analyze, troubleshoot, service, and display data.

As systems evolve, specific tools to maintain and service components have become necessary. Network cabling tools and equipment, nitrogen regulators capable of testing at higher pressure ranges for  $CO_2$  and VRF systems, digital manifold gauges, leak detectors for new refrigerants, service connection adapters, gauges capable of reading pressures in a  $CO_2$  system are all examples of tools that may be required by a refrigeration and air conditioning mechanic.

#### **Products/Materials**

CO<sub>2</sub> systems operate at higher pressures and therefore must use high pressure piping, fittings and components made of stainless steel, copper and copper-iron.

Refrigeration and air conditioning mechanics may have to install and terminate the network cables. In some instances, this may be done by another trade or company.

#### Environmental

Refrigerants with significant global warming potential (GWP) are being phased out in favor of lower GWP such as hydrofluoroolefins (HFOs), hydrocarbons, ammonia and CO<sub>2</sub>.

#### Legislative and Regulatory

There have been amendments to the Canadian Ozone-depleting Substances and Halocarbon Alternatives Regulations (ODSHAR) to reduce the supply of hydrofluorocarbons (HFC), which include refrigerants that enter Canada and the demand for HFCs in manufactured products, by phasing down HFC consumption allowances. These reductions will increase in the future. The level and pace of these HFC consumption allowance phasedowns are intended to reduce the GWP of HFCs. Refrigeration and air conditioning mechanics must stay current with legislative and regulatory amendments as they continue to evolve including reporting requirements.

### **Skills for Success Summary**

Skills for Success are needed in a quickly changing world for work, learning and life. They are foundational for building other skills and important for effective social interaction. Everyone benefits from having these skills as they help individuals get and sustain employment. They also help individuals become active members of their community and succeed in learning.

Through extensive research and consultations, the Government of Canada launched the new Skills for Success model renewing the previous Essential Skills framework to better reflect the needs of the current and future labour market.

The summary presented here is based on existing Essential Skills profiles and will be updated to align with the new <u>Skills for Success model</u> over time.

#### Reading

Refrigeration and air conditioning mechanics read a variety of materials including technical bulletins, manufacturers' specifications and manuals to obtain detailed information on equipment installation and troubleshooting procedures. They read maintenance and service logs to ensure that the correct piece of equipment is being installed or maintained according to client requirements, and to learn about the equipment history. They may also refer to wholesaler catalogues to assist in the selection and ordering of parts and equipment.

### **Document Use**

As part of document use, refrigeration and air conditioning mechanics consult company and work site procedures. They interpret information in tables, charts, graphs, codes and regulations, and apply that knowledge when performing a task. They also use drawings to understand job requirements. Refrigeration and air conditioning mechanics adhere to hazard signs and warning labels that are part of the Workplace Hazardous Materials Information System (WHMIS) to prevent injury to themselves and others.

### Writing

Refrigeration and air conditioning mechanics update logbooks and complete written documents such as service reports, work orders, warranty claim forms, permits, and legislated and company documents. They may prepare sketches and update as-built drawings.

### Numeracy

Refrigeration and air conditioning mechanics use numeracy in a range of tasks. For example, they measure lengths of ducting and piping. They calculate areas and volumes of ducting and piping assemblies to meet operating specifications. When designing and sizing HVAC/R systems, they perform heat load and heat loss calculations. They use diagnostic and measurement tools to troubleshoot and verify the proper operation of equipment. They compare equipment temperature and pressure trend graphs to equipment specifications and operating parameters to monitor systems. They also estimate time and material costs.

### Communication

Refrigeration and air conditioning mechanics communicate with other tradespeople to coordinate the installation, maintenance and service of HVAC/R systems. They interact with clients to identify system requirements and to obtain problem descriptions. They may also contact suppliers to order parts, communicate with manufacturers' representatives to obtain technical information and engineers to examine design specifications. They may also interact with jurisdictional officials to consider compliance with regulations.

### Thinking

Refrigeration and air conditioning mechanics use problem-solving skills to troubleshoot equipment problems and resolve client issues. They determine the most efficient and economical equipment for a job and repair options available. Refrigeration and air conditioning mechanics plan their work schedule considering factors such as priority, safety, time to complete and travelling time for a job. They schedule maintenance work to minimize down time.

### **Working With Others**

Refrigeration and air conditioning mechanics providing installation, maintenance and service can work independently or as part of a team alongside co-workers, subcontractors and other trades. They interact with clients and others in a professional, respectful and inclusive manner. Refrigeration and air conditioning mechanics mentor apprentices.

### **Digital Skills**

Refrigeration and air conditioning mechanics adjust parameters on automated control systems. They use remote access and on-board functions to monitor and diagnose problems. Refrigeration and air conditioning mechanics use electronic instruments for diagnosis. They may use software, electronic devices and the Internet during the course of their work.

### **Continuous Learning**

Continuous learning is important for refrigeration and air conditioning mechanics due to ongoing changes in technology and an increased emphasis on the environment and energy efficiency. They need to keep informed about new types of equipment, energy sources, materials, computer controls and available client options. They must also stay current on code and regulation changes that govern their work. Refrigeration and air conditioning mechanics learn through reading manufacturers' literature and trade journals, and by visiting manufacturers' websites. They can also take advantage of seminars and information sessions put on by equipment manufacturers, suppliers, unions and their employers.

## Roles and Opportunities for Skilled Trades in a Sustainable Future

Climate change affects all of us. Trades play a large role in implementing solutions and adjusting to changes in the world.

Throughout this standard, there may be specific references to tasks, skills and knowledge that clearly show this trade's role in a more sustainable future. Each trade has different roles to play and contributions to make in their own way.

For example:

- Construction tradespeople need to consider the materials they are using, building methods, and improvements to mechanical and electrical installations. There are important changes to codes and standards to help meet the climate change goals and commitments set for 2030 and 2050. Retrofits and new construction of low-energy buildings provide enormous opportunities for workers in this sector. Concepts, such as energy efficiency and regarding buildings as systems are foundational.
- Automotive and mechanical trades are seeing a shift towards the electrification of vehicles and equipment. As a result, new skills and knowledge will be required for tradespeople working in this sector. There are mandates for sales of new light-duty zero-emission vehicles (ZEV) in Canada, with the goal of achieving 100% ZEV sales by 2035. Due to this mandate, the demand for these vehicles is growing quickly among consumers and fleets. With this escalating demand, the need for skilled workers to maintain and repair these vehicles is also increasing.
- In industrial and resource sectors, there is pressure to move towards increased electrification of industrial processes. Many industrial and commercial facilities are also being upgraded to improve energy efficiency in areas such as lighting systems, and new production processes and technologies. There are also opportunities in carbon capture, utilization and storage (CCUS), as well as the production and export of low-carbon hydrogen.
- Trades in the service sector may also need to be aware of responsible sourcing, as well as efficient use of products and materials. New ways of working better are always a part of the job.

There are fast-moving changes in guidelines, codes, regulations and specifications. Many are being implemented for the purpose of energy efficiency and climate change. Those that affect specific trades may be mentioned within the standard. Examples of these guidelines and legislation include:

- the National Energy Code of Canada for Buildings (NECB).
- the Canadian Net-Zero Emissions Accountability Act (CNZEAA).
- programs that encourage sustainable building design and construction such as Leadership in Energy and Environmental Design (LEED) and the Zero Carbon Building (ZCB) standards.
- the Montreal Protocol for phasing out R22 refrigerants.
- energy efficiency programs such as ENERGY STAR.
- principles of the United Nations Declaration for the Rights of Indigenous Peoples pertaining to energy sector development.

Apprentices and tradespeople need to increase their climate literacy and reinforce their own understanding of energy issues and environmental practices. It is important for them to understand why these changes are happening and their effect on trades' work. While individual tradespeople and apprentices may not be able to choose certain elements like; the architectural design of buildings, building material selection, regulatory requirements, use of electric vehicles and technologies, they must understand the impact of using these elements in their work. Impacts include using environmentally friendly products and following requirements related to the disposal and recycling of materials.

In apprenticeship, as well as in ongoing professional development, employers and instructors should encourage learning about these concepts, why they are important, how they are implemented, and the overarching targets they are aiming to achieve.

All in all, it's about doing the work better and building a better world.

### **Industry Expected Performance**

All tasks must be performed according to the applicable jurisdictional codes, standards and regulations. All health and safety standards must be respected and observed. Work should be performed efficiently and to a high quality without material waste or environmental damage. All requirements of employers, engineers, designers, manufacturers, provincial/territorial regulators, customers, and quality assurance and control policies must be met. At a journeyperson level of performance, all tasks must be done with minimal direction and supervision. As a journeyperson progresses in their career, there is an expectation they continue to upgrade their skills and knowledge to maintain pace with industry and promote continuous learning in their trade through mentoring of apprentices.

# Language Requirements

It is expected that journeypersons are able to understand and communicate in either English or French, which are Canada's official languages. English or French are the common languages of business, codes, regulations and standards as well as languages of instruction in apprenticeship programs.

# Pie Chart of Red Seal Examination and Weightings



MWA A	Performs common occupational skills	8%
MWA B	Performs routine trade activities	16%
MWA C	Plans installation	13%
MWA D	Performs installation	21%
MWA E	Performs commissioning	17%
MWA F	Performs maintenance and service	25%

This pie chart represents a breakdown of the interprovincial Red Seal examination. Percentages are based on the collective input from workers from the trade from across Canada. The Task Matrix on the next pages indicates the breakdown of tasks and sub-tasks within each Major Work Activity and the breakdown of questions assigned to the Tasks. The Interprovincial examination for this trade has 125 questions.

# Refrigeration and Air Conditioning Mechanic Task Matrix

### A – Performs common occupational skills

Task A-1 A-1.01 Maintains safe work A-1.02 Performs lock-out, tag-A-1.03 Uses personal environment out and isolation procedures protective equipment (PPE) Maintains safe and healthy workplace and safety equipment 81% A-1.04 Participates in healthy and respectful work environment Task A-2 A-2.01 Upskills in new trade A-2.02 Upskills in emerging practices and procedures technologies Maintains continuous learning 13% Task A-3 A-3.01 Uses communication A-3.02 Uses mentoring techniques techniques Uses communication and mentoring techniques 6%

al skills

### **B** – Performs routine trade activities

B-4.01 Uses hand tools Task B-4 B-4.02 Uses portable and B-4.03 Uses piping and tubing stationary power tools Uses tools and equipment connecting tools and equipment 24% B-4.05 Uses evacuation tools B-4.06 Uses diagnostic and B-4.04 Uses recovery, recycling and charging tools and equipment measuring tools and and equipment equipment B-4.09 Uses rigging, hoisting **B-4.07 Uses electrical tools** B-4.08 Uses access and lifting equipment and equipment equipment B-4.10 Uses digital technology B-5.03 Plans job tasks and Task B-5 B-5.02 Uses reference **B-5.01 Interprets drawings** and specifications material and documentation procedures **Organizes work** 21% Task B-6 B-6.01 Prepares work site B-6.02 Handles materials and supplies Performs work site preparation 19% Task B-7 B-7.02 Performs leak and B-7.01 Connects piping and **B-7.03 Evacuates systems** tubing pressure tests on systems Performs trade-specific activities 36% B-7.04 Uses refrigerants, B-7.05 Performs field wiring B-7.06 Applies sealants, adhesives and insulation gases and oils of systems

### **C** – Plans installation

Task C-8 Plans installation of standard and high efficiency HVAC/R systems 34%	C-8.01 Performs HVAC/R system design	C-8.02 Selects HVAC/R equipment, components and accessories	C-8.03 Determines placement of HVAC/R equipment, components and accessories
	C-8.04 Performs HVAC/R material take-off		
Task C-9 Plans installation of control systems 28%	C-9.01 Performs control system design	C-9.02 Selects control system components and accessories	C-9.03 Determines placement of control system components and accessories
	C-9.04 Performs control system material take-off		
Task C-10 Plans retrofits 38%	C-10.01 Analyzes energy efficiency of current system	C-10.02 Determines requirements for retrofits	C-10.03 Analyzes distribution requirements for retrofits
	C-10.04 Performs design and sizing of retrofit equipment and components	C-10.05 Plans retrofit of control systems	

### **D** – Performs installation

### **21%**

Task D-11 Installs HVAC/R systems 63%	D-11.01 Confirms system layout	D-11.02 Assembles HVAC/R equipment, components and accessories	D-11.03 Places HVAC/R equipment, components and accessories
	D-11.04 Retrofits HVAC/R equipment refrigerants and refrigerant oils	D-11.05 Retrofits HVAC/R equipment, components and accessories	D-11.06 Installs fasteners, brackets and hangers
	D-11.07 Installs HVAC/R piping and tubing	D-11.08 Applies HVAC/R holding charge	
Task D-12 Installs control systems 37%	D-12.01 Places control system components	D-12.02 Connects control systems	D-12.03 Retrofits control systems

### **E – Performs commissioning**



Task E-13 Commissions new and retrofitted HVAC/R and control system components 54%	E-13.01 Performs pre-start-up checks for HVAC/R systems	E-13.02 Performs start-up of HVAC/R systems	E-13.03 Performs start-up checks for control systems
	E-13.04 Completes HVAC/R system charge	E-13.05 Sets up primary and secondary HVAC/R system components	
Task E-14 Verifies system performance 46%	E-14.01 Verifies/sets operating parameters	E-14.02 Verifies system integration	E-14.03 Performs system optimization
	E-14.04 Completes commissioning documentation		

### **F** – Performs maintenance and service

#### Task F-15 F-15.01 Inspects HVAC/R F-15.02 Performs predictive F-15.03 Tests HVAC/R system systems and scheduled maintenance components and accessories Maintains HVAC/R systems on HVAC/R systems 30% F-15.04 Optimizes integrated system performance Task F-16 F-16.02 Repairs HVAC/R F-16.01 Troubleshoots Services HVAC/R systems HVAC/R systems systems 43% Task F-17 F-17.01 Performs F-17.02 Troubleshoots control F-17.03 Calibrates operating Maintains and services control systems maintenance and inspection systems and safety controls on control systems 27% F-17.04 Repairs control systems

# **Harmonization of Apprenticeship Training**

Provincial and territorial apprenticeship authorities are each responsible for their respective apprenticeship programs. In the spirit of continual improvement, and to facilitate mobility among apprentices in Canada, participating authorities have agreed to work towards harmonizing certain aspects of their programs where possible. After consulting with their stakeholders in the trade, they have reached consensus on the following elements. Note that implementation of these elements may vary from jurisdiction to jurisdiction, depending on their own circumstances. For more information on the implementation in any province and territory, please contact that jurisdiction's apprenticeship authority.

### 1. Trade Name

The official Red Seal name for this trade is Refrigeration and Air Conditioning Mechanic.

### 2. Number of Levels of Apprenticeship

The number of levels of technical training recommended for this trade is four (4).

### **3. Total Training Hours**

The total hours of training, including both on-the-job and in-school training for this trade is 7200.

### 4. Sequencing Topics and Related Sub-tasks

The topic titles in the table below are placed in a column for each apprenticeship level for technical training. Each topic is accompanied by the sub-tasks and their reference number.

Level 1	Level 2	Level 3	Level 4
	In Context	In Context	In Context
	Safe and Healthy Workplace	Safe and Healthy Workplace	Safe and Healthy Workplace
	Communication Techniques	Communication Techniques	
	Tools and Equipment	Tools and Equipment	Tools and Equipment
Safe and Healthy Workplace 1.01 Maintains safe work environment 1.02 Performs lock-out, tag-out and isolation procedures 1.03 Uses personal protective equipment (PPE) and safety equipment 1.04 Participate in healthy and respectful work environment			
		<b>Continuous Learning</b> 2.01 Upskills in new trade practices and procedures 2.02 Upskills in emerging technologies	<b>Continuous Learning</b> 2.01 Upskills in new trade practices and procedures 2.02 Upskills in emerging technologies
Communication 3.01 Uses communication techniques			Mentoring 3.02 Uses mentoring techniques
<b>Tools and Equipment</b> 4.01 Uses hand tools 4.02 Uses portable and stationary power tools 4.03 Uses piping and tubing connecting tools and equipment 4.04 Uses recovery, recycling and charging tools and equipment 4.05 Uses evacuation tools and equipment 4.06 Uses diagnostic and measuring tools and equipment 4.07 Uses electrical tools and equipment 4.08 Uses access equipment 4.09 Uses rigging, hoisting and lifting equipment 4.10 Uses digital technology			

Level 1	Level 2	Level 3	Level 4
<b>Organizes Work</b> 5.02 Uses reference material and documentation 5.03 Plans job tasks and procedures	<b>Organizes Work</b> 5.01 Interprets drawings and specifications 5.02 Uses reference material and documentation 5.03 Plans job tasks and procedures	<b>Organizes Work</b> 5.01 Interprets drawings and specifications 5.02 Uses reference material and documentation 5.03 Plans job tasks and procedures	Organizes Work 5.01 Interprets drawings and specifications 5.02 Uses reference material and documentation 5.03 Plans job tasks and procedures
Work Site Preparation 6.01 Prepares work site 6.02 Handles materials and supplies			
Trade-Specific Activities 7.01 Connects piping and tubing 7.02 Performs leak and pressure tests on systems 7.03 Evacuates systems 7.04 Uses refrigerants, gases and oils 7.05 Performs field wiring of systems 7.06 Applies sealants, adhesives and insulation	<b>Trade-Specific Activities</b> 7.04 Uses refrigerants, gases and oils 7.05 Performs field wiring of systems		
Basic HVAC/R Systems (Plans Installation) 8.03 Determines placement of HVAC/R equipment, components and accessories	HVAC/R Systems (Plans Installation) 8.02 Selects HVAC/R equipment, components and accessories 8.03 Determines placement of HVAC/R equipment, components and accessories 8.04 Performs HVAC/R material take-off	HVAC/R Systems (Plans Installation) 8.01 Performs HVAC/R system design 8.02 Selects HVAC/R equipment, components and accessories 8.03 Determines placement of HVAC/R equipment, components and accessories 8.04 Performs HVAC/R material take-off	HVAC/R Systems (Plans Installation) 8.01 Performs HVAC/R system design 8.02 Selects HVAC/R equipment, components and accessories 8.03 Determines placement of HVAC/R equipment, components and accessories 8.04 Performs HVAC/R material take-off

Level 1	Level 2	Level 3	Level 4
Basic Control Systems (Plans Installation) 9.03 Determines placement of control system components and accessories	Control Systems (Plans Installation) 9.02 Selects control system components and accessories 9.03 Determines placement of control system components and accessories 9.04 Performs control system material take-off	Control Systems (Plans Installation) 9.01 Performs control system design 9.02 Selects control system components and accessories 9.03 Determines placement of control system components and accessories 9.04 Performs control system material take-off	Control Systems (Plans Installation) 9.01 Performs control system design 9.02 Selects control system components and accessories 9.03 Determines placement of control system components and accessories 9.04 Performs control system material take-off
	Retrofits (Planning) 10.02 Determines requirements for retrofits 10.03 Analyzes distribution requirements for retrofits	Retrofits (Planning) 10.01 Analyzes energy efficiency of current system 10.02 Determines requirements for retrofits 10.03 Analyzes distribution requirements for retrofits 10.04 Performs design and sizing of retrofit equipment and components 10.05 Plans retrofit of control systems	Retrofits (Planning) 10.01 Analyzes energy efficiency of current system 10.02 Determines requirements for retrofits 10.03 Analyzes distribution requirements for retrofits 10.04 Performs design and sizing of retrofit equipment and components 10.05 Plans retrofit of control systems
Basic HVAC/R Systems (Installation) 11.03 Places HVAC/R equipment, components and accessories 11.06 Installs fasteners, brackets and hangers 11.07 Installs HVAC/R piping and tubing 11.08 Applies HVAC/R holding charge	HVAC/R Systems (Installation) 11.02 Assembles HVAC/R equipment, components and accessories 11.03 Places HVAC/R equipment, components and accessories 11.04 Retrofits HVAC/R equipment refrigerants and refrigerant oils 11.05 Retrofits HVAC/R equipment, components and accessories 11.07 Installs HVAC/R piping and tubing	HVAC/R Systems (Installation) 11.01 Confirms system layout 11.02 Assembles HVAC/R equipment, components and accessories 11.03 Places HVAC/R equipment, components and accessories 11.04 Retrofits HVAC/R equipment refrigerants and refrigerant oils 11.05 Retrofits HVAC/R equipment, components and accessories 11.07 Installs HVAC/R piping and tubing	
Basic Control Systems (Installation) 12.01 Places control system components 12.02 Connects control systems	Control Systems (Installation) 12.01 Places control system components 12.02 Connects control systems 12.03 Retrofits control systems	Control Systems (Installation) 12.01 Places control system components 12.02 Connects control systems 12.03 Retrofits control systems	

Level 1	Level 2	Level 3	Level 4
		New and Retrofitted HVAC/R and Control System Components (Commissions) 13.01 Performs pre-start-up checks for HVAC/R systems 13.02 Performs start-up of HVAC/R systems 13.03 Performs start-up checks for control systems 13.04 Completes HVAC/R system charge 13.05 Sets up primary and secondary HVAC/R system components	New and Retrofitted HVAC/R and Control System Components (Commissions) 13.01 Performs pre-start-up checks for HVAC/R systems 13.02 Performs start-up of HVAC/R systems 13.03 Performs start-up checks for control systems 13.04 Completes HVAC/R system charge 13.05 Sets up primary and secondary HVAC/R system components
	System Performance (Introduction) 14.01 Verifies/sets operating parameters 14.02 Verifies system integration 14.03 Performs system optimization 14.04 Completes commissioning documentation	System Performance 14.01 Verifies/sets operating parameters 14.02 Verifies system integration 14.03 Performs system optimization 14.04 Completes commissioning documentation	System Performance 14.01 Verifies/sets operating parameters 14.02 Verifies system integration 14.03 Performs system optimization 14.04 Completes commissioning documentation
HVAC/R Systems (Basic Maintenance) 15.01 Inspects HVAC/R systems 15.02 Performs predictive and scheduled maintenance on HVAC/R systems 15.03 Tests HVAC/R system components and accessories	HVAC/R Systems (Maintain) 15.01 Inspects HVAC/R systems 15.02 Performs predictive and scheduled maintenance on HVAC/R systems 15.03 Tests HVAC/R system components and accessories	HVAC/R Systems (Maintain) 15.01 Inspects HVAC/R systems 15.02 Performs predictive and scheduled maintenance on HVAC/R systems 15.03 Tests HVAC/R system components and accessories 15.04 Optimizes integrated system performance	HVAC/R Systems (Maintain) 15.01 Inspects HVAC/R systems 15.02 Performs predictive and scheduled maintenance on HVAC/R systems 15.03 Tests HVAC/R system components and accessories 15.04 Optimizes integrated system performance
	HVAC/R Systems (Basic Service) 16.01 Troubleshoots HVAC/R systems 16.02 Repairs HVAC/R systems	HVAC/R Systems (Service) 16.01 Troubleshoots HVAC/R systems 16.02 Repairs HVAC/R systems	HVAC/R Systems (Service) 16.01 Troubleshoots HVAC/R systems 16.02 Repairs HVAC/R systems

	Level 4
trol Systems ntain and Service) 1 Performs tenance and inspection ontrol systems 2 Troubleshoots control ems 3 Calibrates operating safety controls 4 Repairs control ems	Control Systems (Maintain and Service) 17.01 Performs maintenance and inspection on control systems 17.02 Troubleshoots control systems 17.03 Calibrates operating and safety controls 17.04 Repairs control systems
n 1 2 2 3 3 4 er	ol Systems tain and Service) Performs enance and inspection ntrol systems Troubleshoots control ms Calibrates operating afety controls Repairs control ms

# Major Work Activity A Performs common occupational skills

### Task A-1 Maintains safe and healthy workplace

### **Task Descriptor**

Refrigeration and air conditioning mechanics must be able to recognize hazards and protect themselves and others. They must also protect property and the environment. They must participate in ensuring a healthy and inclusive workplace.

### A-1.01 Maintains safe work environment

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Skills							
	Performance Criteria	Evidence of Attainment						
A-1.01.01P	recognize <b>hazards</b>	<i>hazards</i> are recognized according to safety risk assessment						
A-1.01.02P	follow safe operating procedures (SOP)	SOP are followed according to tasks to be performed						
A-1.01.03P	maintain clean and tidy work site	clean and tidy work site is maintained to avoid injuries to self and others						
A-1.01.04P	coordinate tasks with other workers	tasks with other workers are coordinated to avoid injury to self and others						
A-1.01.05P	use flagging, traffic and parking controls, pylons and signage when working	flagging, traffic and parking controls, pylons and signage are used according to site requirements when working						
A-1.01.06P	manage <b>hazardous materials</b>	hazardous materials are managed according to Workplace Hazardous Materials Information System (WHMIS) and Transportation of Dangerous Goods (TDG) procedures and safe work practices						
A-1.01.07P	participate in safety meetings and discussions	safety meetings and discussions are participated in to ensure that information is understood, shared and demonstrated						
A-1.01.08P	recognize and report unsafe conditions	unsafe conditions are recognized and reported according to jurisdictional regulations so that they may be rectified						

### **Range of Variables**

*hazards* include: lifting, eye injury, cuts, high voltage electrocution, corrosive chemicals, toxic gases, liquids and materials, combustive reactions, fire, rotating equipment, working at heights, confined spaces, noisy locations, pressure hazards, refrigerants, compressed gases, weather, overhead obstacles, explosive, components and spaces with extreme temperatures (e.g., steam pipes, gas-fired equipment) *hazardous materials* include: combustible materials, biological contaminants (e.g., mould, bacteria), carcinogenic products, toxic products, refrigerants (flammable, non-flammable), corrosive chemicals *WHMIS and TDG procedures* include: disposal, labelling, handling, transportation, using personal protective equipment (PPE)

	Knowledge							
	Learning Outcomes	Learning Objectives						
A-1.01.01L	demonstrate knowledge of maintaining safe work environment	identify workplace <i>hazards</i>						
		describe procedures to maintain safe work environment						
		describe procedures to label, handle, store, transport and dispose of <i>hazardous materials</i>						
		describe procedures to recognize and rectify potential dangers related to workplace <b>hazards</b>						
A-1.01.02L	demonstrate knowledge of codes and <i>regulations</i> pertaining to safe work environment	interpret codes and <i>regulations</i> pertaining to workplace <i>hazards</i> and safe work practices						

### **Range of Variables**

*hazards* include: lifting, eye injury, cuts, high voltage electrocution, corrosive chemicals, toxic gases, liquids and materials, combustive reactions, fire, rotating equipment, working at heights, confined spaces, noisy locations, pressure hazards, refrigerants, compressed gases, weather, overhead obstacles, explosive, components and spaces with extreme temperatures (e.g., steam pipes, gas-fired equipment) *hazardous materials* include: combustible materials, biological contaminants (e.g., mould, bacteria), carcinogenic products, toxic products, refrigerants (flammable, non-flammable), corrosive chemicals *regulations* include: Occupational Health and Safety (OHS), jurisdictional, TDG, WHMIS

#### A-1.02

Performs lock-out, tag-out and isolation procedures

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Skills							
	Performance Criteria	Evidence of Attainment						
A-1.02.01P	notify building authorities of maintenance and repairs, and obtain required permits	building authorities are notified of maintenance and repairs prior to and after completion, and required permits are obtained						
A-1.02.02P	identify <i>hazards</i> associated with equipment and components	<i>hazards</i> associated with <i>equipment</i> and <i>components</i> are identified according to safety and procedural checklists						
A-1.02.03P	establish and confirm zero-energy state of equipment and components	zero-energy state of <i>equipment</i> and <i>components</i> is established using isolating devices and confirmed according to company and client policies						
A-1.02.04P	apply <i>lock-out device</i>	<i>lock-out device</i> is applied to secure isolation and prevent accidental start-up according to company and client policies						
A-1.02.05P	record lock-out information on tag attached to <i>lock-out devices</i>	lock-out information is recorded on tag attached to <i>lock-out devices</i> according to company and client policies						
A-1.02.06P	verify isolation of <i>equipment</i>	isolation of <i>equipment</i> is verified to ensure that equipment can be worked on safely according to company and client policies						
A-1.02.07P	remove tags and <i>lock-out devices</i> from <i>equipment</i> after completion of repair	tags and <i>lock-out devices</i> are removed from <i>equipment</i> after completion of repair according to company and client policies						

### **Range of Variables**

*hazards* include: pressure, voltage, thermal, explosive, fluids, toxicity, corrosiveness, oxygen displacement/deprivation, asphyxiation, environmental, rotating devices, pinch hazards, trip hazards, components and spaces with extreme temperatures (e.g., steam pipes, gas-fired equipment) *equipment* includes: capacitors, rotating fans and equipment, motors, conveyor belts, hydraulics, pneumatics, pressurized tanks, heat exchangers, thermal equipment

*components* include: disconnect switches, isolation valves, locking clasps, motors, rotating devices, blocking and restraint devices

lock-out devices include: locks, blocks, chains, hasps, plugs, caps, blank-off plates

	Knowledge						
	Learning Outcomes	Learning Objectives					
A-1.02.01L	demonstrate knowledge of <i>lock-out</i> <i>devices</i>	determine <i>equipment</i> and <i>components</i> requiring lock-out, tag-out and isolation					
		identify <i>lock-out devices</i> , and describe their characteristics and applications					
		identify energy sources to be locked out					
		identify potential of stored energy					
		describe characteristics of zero-energy state					
A-1.02.02L	demonstrate knowledge of procedures to lock-out, tag-out and isolate <b>equipment</b> and <b>components</b>	describe procedures to lock-out, tag-out and isolate <b>equipment</b> and <b>components</b> , and confirm zero-energy					
		determine when lock-out procedure is required for individual or group					
		identify <i>hazards</i> associated with isolating, tagging and locking out <i>equipment</i> and <i>components</i>					
		identify required permits and procedures to obtain them					

### **Range of Variables**

*lock-out devices* include: locks, blocks, chains, hasps, plugs, caps, blank-off plates *equipment* includes: capacitors, rotating fans and equipment, motors, conveyor belts, hydraulics, pneumatics, pressurized tanks, heat exchangers, thermal equipment

*components* include: disconnect switches, isolation valves, locking clasps, motors, rotating devices, blocking and restraint devices

energy sources include: electric, natural gas, propane, fossil fuels, solar, pneumatics, alternative fuels, steam, water

*hazards* include: pressure, voltage, thermal, explosive, fluids, toxicity, corrosiveness, oxygen displacement/deprivation, asphyxiation, environmental, rotating devices, pinch hazards, trip hazards, components and spaces with extreme temperatures (e.g., steam pipes, gas-fired equipment)

### A-1.03

### Uses personal protective equipment (PPE) and safety equipment

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Skills							
	Performance Criteria	Evidence of Attainment						
A-1.03.01P	select, wear and ensure proper fit of <b>PPE</b>	<b>PPE</b> is selected, worn and fitted according to task, site and company policies, manufacturers' specifications and jurisdictional regulations						
A-1.03.02P	inspect and identify expired, <i>defective or damaged PPE</i>	expired, <i>defective or damaged PPE</i> is inspected, identified, removed from service, repaired, replaced and recertified according to company policies and jurisdictional regulations						
A-1.03.03P	locate and use <b>safety equipment</b>	<i>safety equipment</i> is located and used according to job requirements, risk assessments, manufacturers' specifications and jurisdictional regulations						
A-1.03.04P	clean and store <b>PPE</b> and <b>safety</b> equipment	<b>PPE</b> and <b>safety equipment</b> are cleaned and stored according to manufacturers' recommendations						
A-1.03.05P	inspect <b>safety equipment</b> and verify it is certified	<i>safety equipment</i> is inspected, and certification is verified according to jurisdictional regulations and manufacturers' recommendations						

### **Range of Variables**

**PPE** includes: ear protection, hard hats, safety glasses and goggles, face shields, respirators, safety boots, gloves, safety vests, harnesses, lanyards, arc-rated clothing and gloves, arc flash shield, arc flash hood, arc flash suit

*defective or damaged PPE* includes: excessively worn boots, cracked safety glasses, expired or uncertified PPE, damaged harnesses and lanyards

*safety equipment* includes: fire extinguishers, fall protection, eye wash stations, emergency showers, first aid kits, spill kits, tool guards
	Knowledge							
	Learning Outcomes	Learning Objectives						
A-1.03.01L demonstrate knowledge of <b>PPE</b> and <b>safety equipment</b> , their characteristics, applications, maintenance and procedures for use		identify types of <i>PPE</i> and <i>safety</i> <i>equipment</i> , their characteristics, applications and procedures for use						
		describe procedures to maintain and store <i>PPE</i> and <i>safety equipment</i>						
A-1.03.02L	demonstrate knowledge of standards and regulations pertaining to <i>PPE</i> and <i>safety equipment</i>	identify standards and regulations pertaining to <b>PPE</b> and <b>safety equipment</b>						

**PPE** includes: ear protection, hard hats, safety glasses and goggles, face shields, respirators, safety boots, gloves, safety vests, harnesses, lanyards, arc-rated clothing and gloves, arc flash shield, arc flash hood, arc flash suit

*safety equipment* includes: fire extinguishers, fall protection, eye wash stations, emergency showers, first aid kits, spill kits, tool guards

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Sk	ills
	Performance Criteria	Evidence of Attainment
A-1.04.01P	perform self-assessment of physical and mental health	self-assessment of physical and mental health is performed, and signs and symptoms of fatigue and stress are identified
A-1.04.02P	identify <b>supports and resources</b> for personal mental health	<i>supports and resources</i> for personal mental health are identified
A-1.04.03P	identify <b>techniques to manage health</b> and wellness	techniques to manage health and wellness are identified
A-1.04.04P	assess personal job satisfaction	<i>personal job satisfaction</i> is assessed, and concerns are discussed with management
A-1.04.05P	create plan to manage work-life balance	plan is created to manage work-life balance and discussed with supervisors
A-1.04.06P	support and promote anti- <b>harassment</b> and anti- <b>discrimination</b> practices in workplace	workplace is <i>harassment-</i> and <i>discrimination-</i> free

*supports and resources* include: professional networks and associations, collaboration with colleagues and community members, counselling, mentoring, peer support groups

**techniques to manage health and wellness** include: practicing techniques for remaining physically, mentally and emotionally "fit for work"; managing personal and work life; recognizing effects and consequences of alcohol, over-the-counter drugs, prescription drugs or illegal drugs before, during and after work; maintaining good personal hygiene

*personal job satisfaction* includes: financial, work hours, flexibility, supports, working conditions *harassment*: as defined by the Canadian and jurisdictional Human Rights Commissions *discrimination*: as defined by the Canadian Human Rights Act and jurisdictional human rights laws

	Know	ledge
	Learning Outcomes	Learning Objectives
A-1.04.01L	demonstrate knowledge of personal health and well-being	describe how personal health and well- being impacts professional practice and healthy work environments
		identify and describe physical and emotional requirements of trade
		identify workplace stressors
		describe elements of healthy organizational cultures and importance of sense of collaboration and community
		identify <b>behaviours</b> that affect physical and mental health
A-1.04.02L	demonstrate knowledge of techniques to manage personal health and well-being	describe stress and time management techniques
		describe <b>techniques to manage health</b> and wellness
A-1.04.03L	demonstrate knowledge of professional ethics	identify characteristics and purpose of professionalism and professional ethics
		describe <b>factors</b> that impact professionalism
		identify <i>elements of codes of ethics,</i> <i>codes of conduct and other</i> <i>professional standards</i> , and describe their characteristics and applications
A-1.04.04L	demonstrate knowledge of value of diversity, equity, inclusion and belonging in workplace	define diversity and differences between individuals
		define equity and importance of individual's access to same opportunities and resources
		define inclusion and creation of respectful work environments
		identify communication that constitutes <i>harassment</i> and <i>discrimination</i>

behaviours include: diet, fitness, sleep, managing stress and emotions

**techniques to manage health and wellness** include: practicing techniques for remaining physically, mentally and emotionally "fit for work"; managing personal and work life; recognizing effects and consequences of alcohol, over-the-counter drugs, prescription drugs or illegal drugs before, during and after work; maintaining good personal hygiene

*factors* include: presentation of self (appearance, hygiene), communication (verbal, written, body language, social media presence), conduct

*elements of codes of ethics, codes of conduct and other professional standards* include: professional obligations, how to engage in the practice in professional way, signals accountability to the public, maintain public trust and credibility of the profession, defines misconduct

harassment: as defined by the Canadian and jurisdictional Human Rights Commissions

discrimination: as defined by the Canadian Human Rights Act and jurisdictional human rights laws

## Task A-2 Maintains continuous learning

#### **Task Descriptor**

Refrigeration and air conditioning mechanics must stay current on building science principles, sustainable practices and learn about new emerging technologies being introduced in the trade. They need to keep informed about new types of equipment, energy sources, materials and computer controls to inform clients on available options.

#### **A-2.01** Upskills in new trade practices and procedures

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Skills						
	Performance Criteria	Evidence of Attainment					
A-2.01.01P	apply <b>continuous learning methods</b>	continuous learning methods are applied					
A-2.01.02P	develop and maintain personal and professional development plan	personal and professional development plan is developed and maintained with established learning goals (short and long term) and time frames					
A-2.01.03P	identify available <i>supports and</i> <i>resources</i> for learning	available <i>supports and resources</i> for learning are identified					
A-2.01.04P	identify gaps in knowledge and implement independent learning techniques	gaps in knowledge are identified and independent learning techniques are implemented					

**continuous learning methods** include: actively engaging in performance review processes and taking action to address feedback, seeking out and actively participating in and embracing learning opportunities (seminars, webinars, trainings, podcasts, independent research), maintaining all required certifications and training, upgrading and maintaining computer and technology skills, sharing learning outcomes and concepts with others, transferring knowledge into practice

*supports and resources* include: professional networks and associations, manufacturers' seminars, collaboration with colleagues and community members, counselling, mentoring, peer support groups, online resources, trade shows

	Know	ledge
	Learning Outcomes	Learning Objectives
A-2.01.01L	demonstrate knowledge of procedures to upskill in new trade practices and procedures	identify <b>continuous learning methods</b>
		explain importance of staying current on new trade practices and procedures
		identify <b>supports and resources</b> for learning
A-2.01.02L	demonstrate knowledge of personal and professional development plan	identify <b>elements of a professional</b> <b>portfolio</b>
		identify link between professionalism and continuous learning
		describe how to assess personal learning needs
		identify <i>factors</i> that may impact learning needs and goals

#### **Range of Variables**

continuous learning methods include: actively engaging in performance review processes and taking action to address feedback, seeking out and actively participating in and embracing learning opportunities (seminars, webinars, trainings, podcasts, independent research), maintaining all required certifications and training, upgrading and maintaining computer and technology skills, sharing learning outcomes and concepts with others, transferring knowledge into practice

*supports and resources* include: professional networks and associations, manufacturers' seminars, collaboration with colleagues and community members, counselling, mentoring, peer support groups, online resources, trade shows

*elements of a professional portfolio* include: résumé, certificates, licenses, diplomas, degrees, transcripts, marketable skills, professional accomplishments, work samples, awards, references *factors* include: new technology, sector trends and practices, skills updating, legislative and regulatory changes

### A-2.02 Upskills in emerging technologies

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Sk	ills
	Performance Criteria	Evidence of Attainment
A-2.02.01P	read <i>information</i> about latest advancements and emerging technologies	<i>information</i> about latest advancements and emerging technologies is read to stay informed
A-2.02.02P	attend seminars, webinars, trade shows and information sessions	seminars, webinars, trade shows and information sessions organized by equipment manufacturers, suppliers, unions and employers are attended
A-2.02.03P	share information with colleagues, management and clients on new energy- efficient equipment and explain their advantages	information on new energy-efficient equipment is shared with colleagues, management and clients, and advantages are explained

#### **Range of Variables**

information includes: manufacturers' literature, online resources, trade journals, magazines

	Knowledge						
	Learning Outcomes	Learning Objectives					
A-2.02.01L	demonstrate knowledge of procedures to upskill in emerging technologies	identify types of <i>information</i> on emerging technologies					
		explain importance of staying current on emerging technologies					

#### **Range of Variables**

information includes: manufacturers' literature, online resources, trade journals, magazines

# **Task A-3 Uses communication and mentoring techniques**

#### **Task Descriptor**

Learning in the trades is done primarily in the workplace with tradespeople passing on their skills and knowledge to apprentices, as well as sharing knowledge among themselves. Apprenticeship is, and always has been about mentoring – learning workplace skills and passing them on. Because of the importance of this to the trade, this task covers activities related to communication in the workplace and mentoring skills.

#### **A-3.01** Uses communication techniques

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Skills						
	Performance Criteria	Evidence of Attainment					
A-3.01.01P	demonstrate communication practices with individuals or in a group	instructions and messages are interpreted by all parties involved in communication					
A-3.01.02P	listen using active listening practices	active listening practices are utilized					
A-3.01.03P	communicate using correct industry terminology to ensure understanding	understanding of message is confirmed by both parties					
A-3.01.04P	receive and respond to instructions	response to instructions indicates understanding					
A-3.01.05P	receive and respond to feedback on work completed or performed	response to feedback indicates understanding and corrective measures are taken					
A-3.01.06P	explain and provide feedback	explanation and feedback are provided, and task is carried out as directed					
A-3.01.07P	communicate understanding and comfort level in performing trade tasks	opportunities for practice and gradual exposure to new tasks is offered and understanding is confirmed					
A-3.01.08P	use questions to improve communication	questions are used to enhance understanding, on-the-job training and goal setting					

A-3.01.09P	send and receive <i>electronic messages</i>	<i>electronic messages</i> are sent and received using professionalism, plain language and clear expressions according to company policies and procedures
A-3.01.10P	coordinate communication with other trades while performing HVAC/R system <i>activities</i>	communication between trades is coordinated while performing HVAC/R system <b>activities</b> to avoid interference with other trades
A-3.01.11P	communicate with clients to analyze needs and recommend HVAC/R system energy efficient upgrades, maintenance or repairs	clients' needs are analyzed, and HVAC/R system recommendations are provided

*active listening* includes: hearing, interpreting, reflecting, responding, paraphrasing *electronic messages* include: email, text messages, online documentation, mobile apps, collaboration apps

activities include: designing, site planning, installing, commissioning, retrofitting, servicing, repairing

	Know	vledge
	Learning Outcomes	Learning Objectives
A-3.01.01L	demonstrate knowledge of trade terminology	define terminology used in trade
A-3.01.02L	demonstrate knowledge of effective communication practices	describe importance of using effective verbal and non-verbal communication with <b>people in workplace</b>
		describe importance of teamwork
		identify <b>sources of information</b> to effectively communicate
		identify communication and <i>learning</i> styles
		identify effective communication skills, and describe their applications
		relay and receive information and confirm understanding
		describe how to receive and give instructions effectively
		identify <b>personal responsibilities and</b> <b>attitudes</b> that contribute to on-the-job success
		identify communication that constitutes <i>harassment</i> and <i>discrimination</i>
		identify communication styles appropriate to different systems and applications of <i>electronic messages</i>

*people in workplace* include: other tradespeople, colleagues, apprentices, supervisors, clients, jurisdictional representatives, manufacturers, office administrators

*sources of information* include: regulations, codes, occupational health and safety requirements, jurisdictional requirements, prints, drawings, specifications, company and client documentation *learning styles* include: visual, auditory, kinesthetic

*personal responsibilities and attitudes* include: asking questions, working safely, accepting constructive feedback, time management and punctuality, respect for authority, good stewardship of materials, tools and property, efficient work practice

*harassment*: as defined by the Canadian and jurisdictional Human Rights Commissions *discrimination*: as defined by the Canadian Human Rights Act and jurisdictional human rights laws *electronic messages* include: email, text messages, online documentation, mobile apps, collaboration apps

#### A-3.02

#### Uses mentoring techniques

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Skills						
	Performance Criteria	Evidence of Attainment					
A-3.02.01P	identify and communicate learning objective and purpose of lesson	apprentice or learner can explain objective and purpose of lesson					
A-3.02.02P	link lesson to other lessons and project	lesson order and unplanned learning opportunities are defined					
A-3.02.03P	demonstrate performance of skill to an apprentice or learner	steps required to demonstrate skill are performed					
A-3.02.04P	set up conditions required for an apprentice or learner to practice skill	<i>practice conditions</i> are set up so that skill can be practiced safely by apprentice or learner					
A-3.02.05P	set up conditions where apprentice or learner feels comfortable communicating and asking questions	conditions are such that apprentice or learner feels comfortable communicating and asking questions					
A-3.02.06P	recognize and discuss multiple possible techniques for performing trade tasks and options that may be best for apprentice or learner	multiple possible techniques for performing trade tasks and options that may be best for apprentice or learner are recognized and discussed					
A-3.02.07P	assess apprentice or learner's ability to perform tasks with increasing independence	performance of apprentice or learner improves with practice to point where task can be done with less supervision					
A-3.02.08P	give supportive and constructive feedback	apprentice or learner adopts best practice after having been given supportive or constructive feedback					

A-3.02.09P	support apprentices or learners in pursuing technical training opportunities	technical training is completed within timeframe prescribed by apprenticeship authority
A-3.02.10P	support accommodations and alternate work practices that are appropriate for apprentice or learner	accommodations and alternate work practices that are appropriate for apprentice or learner are supported
A-3.02.11P	assess apprentice or learner suitability to trade during probationary period	apprentice or learner is given constructive feedback that helps them identify their own strengths and weaknesses and suitability for trade
A-3.02.12P	keep apprentice or learner informed about new procedures, practices and emerging technologies	apprentice or learner is kept informed about new procedures, practices and emerging technologies

*steps required to demonstrate skill* include: understanding who, what, where, when, why, and how; explaining; showing; giving encouragement; following up to ensure skill is performed correctly *practice conditions* mean: guided, limited independence, full independence

	Knowledge						
	Learning Outcomes	Learning Objectives					
A-3.02.01L	demonstrate knowledge of strategies for learning skills in workplace	describe importance of individual experience					
		describe shared responsibilities for workplace learning					
		determine one's own learning preferences and explain how these relate to learning new skills					
		describe importance of different types of skills in workplace					
		describe importance of <i>skills for success</i> (essential skills) in workplace					
		identify different learning styles					
		identify different <i>learning needs</i> and strategies to meet them					
		identify <b>strategies to assist in learning a</b> skill					

A-3.02.02L	demonstrate knowledge of strategies for teaching workplace skills	identify different roles played by workplace mentor			
		explain importance of identifying purpose of lesson			
		identify how to choose a suitable time to present lessons			
		explain importance of linking lessons			
		identify context for learning skills			
		describe considerations in setting up opportunities for skill practice			
		explain importance of providing feedback			
		identify techniques for giving effective feedback			
		describe a skills assessment			
		identify methods of assessing progress			
		explain how to adjust lesson to different situations			

*skills for success (essential skills)* are: adaptability, collaboration, communication, creativity and innovation, digital, numeracy, problem solving, reading, writing

learning styles include: visual, auditory, kinesthetic

learning needs include: learning disabilities, learning preferences, language proficiency

*strategies to assist in learning a skill* include: understanding basic principles of instruction, developing coaching skills, being mature and patient, providing feedback

# Major Work Activity B Performs routine trade activities

# Task B-4 Uses tools and equipment

### **Task Descriptor**

Refrigeration and air conditioning mechanics use and maintain tools and equipment to allow them to perform the tasks of their trade safely and efficiently. Use of tools and equipment includes activities such as inspecting, lubricating, storing and performing repairs. Certification may be required in some jurisdictions to use tools and equipment.

### B-4.01 Uses hand tools

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Skills						
	Performance Criteria	Evidence of Attainment					
B-4.01.01P	select <i>hand tools</i>	<i>hand tools</i> are selected according to job requirements					
B-4.01.02P	inspect <b>hand tools</b> for <b>damage</b> and wear	<i>hand tools</i> are inspected for <i>damage</i> and wear					
B-4.01.03P	maintain hand tools	<i>hand tools</i> are <i>maintained</i> to ensure proper operation					
B-4.01.04P	clean <i>hand tools</i> after use	<i>hand tools</i> are cleaned, and debris is removed after use to ensure they are clean and rust-free					
B-4.01.05P	replace <b>hand tool parts</b>	hand tool parts are replaced if required					
B-4.01.06P	tag and remove defective <i>hand tools</i> from service	defective <b>hand tools</b> are tagged and removed from service according to job requirements					
B-4.01.07P	store <i>hand tools</i> in a clean and dry location	<i>hand tools</i> are stored in a clean and dry location to ensure they are in operating condition					

*hand tools* include: screwdrivers, wrenches, nut drivers, pliers, hex keys, levels, pipe and tube cutters, pipe and tube benders, flaring tools, pipe and tube reamers, hand oil pumps

damage includes: dull blades and wheels, cracks, excessive wear

maintain includes: lubricate, sharpen, tighten, drain

hand tool parts include: cutting blades, hacksaw blades, O-rings

	Knowledge						
	Learning Outcomes	Learning Objectives					
B-4.01.01L	demonstrate knowledge of <i>hand tools</i> , their applications, maintenance and procedures for use	identify hazards and describe safe work practices pertaining to use of <b>hand tools</b>					
		identify types of <i>hand tools</i> and describe their applications and procedures for use					
		describe procedures to store and <i>maintain hand tools</i>					

#### **Range of Variables**

*hand tools* include: screwdrivers, wrenches, nut drivers, pliers, hex keys, levels, pipe and tube cutters, pipe and tube benders, flaring tools, pipe and tube reamers, hand oil pumps *maintain* includes: lubricate, sharpen, tighten, drain

#### **B-4.02** Uses portable and stationary power tools

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Skills							
	Performance Criteria	Evidence of Attainment						
B-4.02.01P	check batteries, chargers, and oil and fuel levels	batteries, chargers, and oil and fuel levels are checked to ensure they are in good condition, and batteries are fully charged						
B-4.02.02P	inspect <b>portable and stationary power</b> tools for unsafe conditions	<i>portable and stationary power tools</i> are inspected, and <i>unsafe conditions</i> are identified						
B-4.02.03P	inspect <b>portable and stationary power</b> tool parts	<i>portable and stationary power tool</i> <i>parts</i> are inspected to identify defects, faults and wear						
B-4.02.04P	maintain portable and stationary power tools	<i>portable and stationary power tools</i> are <i>maintained</i> to ensure they are ready for use						
B-4.02.05P	replace portable and stationary power tool components	portable and stationary power tool components are replaced if required						

B-4.02.06P	store <b>portable and stationary power</b> <b>tools</b> in clean and dry location	<b>portable and stationary power tools</b> are stored in clean and dry location to ensure they are in operating condition
B-4.02.07P	tag and remove defective <b>portable and</b> stationary power tools from service	defective <b>portable and stationary power</b> <b>tools</b> are tagged and removed from service according to manufacturers' recommendations and company policies

*portable and stationary power tools* include: pneumatic, electric, hydraulic, gas, generators *unsafe conditions* include: missing parts, defective or missing guards, unsafe power cords *portable and stationary power tool parts* include: cutting blades, bits, dies, drill chucks *maintain* includes: lubricate, sharpen, tighten, drain

*portable and stationary power tool components* include: drill bits, batteries and chargers, electric motor brushes, cutting discs

	Knowledge						
	Learning Outcomes	Learning Objectives					
B-4.02.01L	demonstrate knowledge of <i>portable and</i> <i>stationary power tools</i> , their applications, maintenance and procedures for use	identify hazards and describe safe work practices pertaining to use of <i>portable</i> and stationary power tools					
		identify types of <b>portable and stationary</b> <b>power tools</b> and describe their applications and procedures for use					
		describe procedures to store and <i>maintain portable and stationary power tools</i>					

#### **Range of Variables**

*portable and stationary power tools* include: pneumatic, electric, hydraulic, gas, generators *maintain* includes: lubricate, sharpen, tighten, drain

#### B-4.03 Us

#### Uses piping and tubing connecting tools and equipment

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Skills							
	Performance Criteria	Evidence of Attainment						
B-4.03.01P	select piping and tubing connecting tools and equipment	<i>piping and tubing connecting tools and</i> <i>equipment</i> are selected according to job requirements						
B-4.03.02P	inspect regulators, valves and flashback arresters hoses, torch tips and O-rings for <i>defects</i>	regulators, valves, flashback arresters, hoses, torch tips and O-rings are inspected for <b>defects</b>						
B-4.03.03P	inspect cylinders	cylinders are inspected for capacity, thread and valve damage to prevent leakage and fire						
B-4.03.04P	verify certification of cylinders	certification of cylinders is verified according to Transport Canada						
B-4.03.05P	store cylinders in secure, upright position, within rated temperatures	cylinders are stored in secure, upright and vented position, within rated temperatures, and according to <i>regulations</i>						
B-4.03.06P	tag and remove defective <i>piping and tubing connecting tools and equipment</i> from service	defective <i>piping and tubing connecting</i> <i>tools and equipment</i> are tagged and removed from service						
B-4.03.07P	purge nitrogen to prevent contamination using flowmeter	flowmeter is used to purge nitrogen and prevent contamination						
B-4.03.08P	select <i>mechanical fittings</i>	<i>mechanical fittings</i> are selected according to job requirements						
B-4.03.09P	inspect <i>mechanical fittings</i>	<i>mechanical fittings</i> are checked for <i>defects</i>						

#### **Range of Variables**

*piping and tubing connecting tools and equipment* include: brazing equipment, mechanical connections, mechanical press and dyes, threading tools, welding equipment

*defects* include: cracks, loose connections, discolouration, excessive wear, leakage, damaged components

*regulations* include: WHMIS procedures, OHS, TDG, Mechanical Refrigeration Code (CSA B52) *mechanical fittings* include: press, compression, threaded, flared, grooved, flanged

	Knowledge							
	Learning Outcomes	Learning Objectives						
B-4.03.01L	demonstrate knowledge of <i>piping and</i> <i>tubing connecting tools and</i> <i>equipment</i> , their applications, maintenance and procedures for use	identify hazards and describe safe work practices pertaining to use of <i>piping and</i> <i>tubing connecting tools and equipment</i>						
		identify types of <i>piping and tubing</i> <i>connecting tools and equipment</i> and describe their applications and procedures for use						
		describe procedures to store and maintain piping and tubing connecting tools and equipment						
B-4.03.02L	demonstrate knowledge of <i>mechanical fittings</i> , their applications and procedures for use	identify hazards and describe safe work practices pertaining to use of <i>mechanical fittings</i>						
		identify types of <i>mechanical fittings</i> and describe their applications and procedures for use						
		describe procedures to store <i>mechanical fittings</i>						

*piping and tubing connecting tools and equipment* include: brazing equipment, mechanical connections, mechanical press and dyes, threading tools, welding equipment *mechanical fittings* include: press, compression, threaded, flared, grooved, flanged

**B-4.04** Uses recovery, recycling and charging tools and equipment

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Skills						
	Performance Criteria	Evidence of Attainment					
B-4.04.01P	select and inspect <b>recovery, recycling</b> <b>and charging tools and equipment</b> for damage	<i>recovery, recycling and charging tools</i> <i>and equipment</i> are selected and inspected for damage from transport and use					
B-4.04.02P	clean, test and calibrate <b>recovery,</b> recycling and charging tools and equipment	<i>recovery, recycling and charging tools</i> <i>and equipment</i> are cleaned, tested and calibrated					
B-4.04.03P	check, clean or replace screens and filters	screens and filters are checked, cleaned or replaced to prevent blockage and ensure filtration of refrigerant					

B-4.04.04P	store refrigerant cylinders in a secure and upright position within rated temperatures	refrigerant cylinders are stored in a secure and upright position within rated temperatures, and according to <i>regulations</i>
B-4.04.05P	verify certification of cylinders	certification of cylinders is verified according to jurisdictional regulations
B-4.04.06P	connect <b>recovery, recycling and</b> <b>charging tools and equipment</b> to system	<i>recovery, recycling and charging tools</i> <i>and equipment</i> are connected to system according to manufacturers' specifications and industry standards
B-4.04.07P	recover refrigerant from system	refrigerant is recovered from system according to manufacturers' instructions, tank specifications and jurisdictional regulations
B-4.04.08P	label recovered refrigerants, their type and condition	recovered refrigerants, their type and condition are labelled according to jurisdictional regulations
B-4.04.09P	clean, isolate and store tools and equipment	tools and equipment are cleaned, isolated and stored according to company policies
B-4.04.10P	tag and remove defective <b>recovery,</b> <b>recycling and charging tools and</b> <b>equipment</b> from service	defective <i>recovery, recycling and</i> <i>charging tools and equipment</i> are tagged and removed from service according to company policies
B-4.04.11P	prepare system for recovering, recycling and charging	system is prepared for recovering, recycling and charging

**recovery, recycling and charging tools and equipment** include: air- and water-cooled refrigerant recovery and recycle units, refrigerant hoses, refrigerant cylinders, gauge manifolds, weigh scales, precision charging kits, filter driers, valve core removal tools, valve core depressors, A1, A2L and A3 rated equipment, tube piercing tools, access fitting adapters, smart probes, cylinder heaters, portable ventilation equipment, liquid refrigerant pumps

*regulations* include: WHMIS procedures, OHS, TDG, Environmental Code of Practice for the Elimination of Fluorocarbon Emissions from Refrigeration and Air Conditioning Systems, Authority Having Jurisdiction (AHJ), Mechanical Refrigeration Code (CSA B52)

	Knowledge							
	Learning Outcomes	Learning Objectives						
B-4.04.01L	demonstrate knowledge of <i>recovery,</i> <i>recycling and charging tools and</i> <i>equipment</i> , their applications, maintenance and procedures for use	identify hazards and describe safe work practices pertaining to use of <i>recovery,</i> <i>recycling and charging tools and</i> <i>equipment</i>						
		identify types of <i>recovery, recycling and</i> <i>charging tools and equipment</i> and describe their applications and procedures for use						
		identify method of recovering, recycling and charging						
		identify capacity of recovery systems						
		describe procedures to store and maintain <i>recovery, recycling and charging tools and equipment</i>						

*recovery, recycling and charging tools and equipment* include: air- and water-cooled refrigerant recovery and recycle units, refrigerant hoses, refrigerant cylinders, gauge manifolds, weigh scales, precision charging kits, filter driers, valve core removal tools, valve core depressors, A1, A2L and A3 rated equipment, tube piercing tools, access fitting adapters, smart probes, cylinder heaters, portable ventilation equipment, liquid refrigerant pumps

#### B-4.05 Uses evacuation tools and equipment

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Skills							
	Performance Criteria	Evidence of Attainment						
B-4.05.01P	change oil in vacuum pumps	oil in vacuum pumps is changed to ensure operation of pump according to manufacturers' instructions						
B-4.05.02P	clean and flush vacuum pumps	vacuum pumps are cleaned and flushed regularly according to manufacturers' recommendations						
B-4.05.03P	store equipment in secure position	equipment is stored in secure position to prevent oil spillage						
B-4.05.04P	maintain adequate oil level	adequate oil level is maintained to enable evacuation						
B-4.05.05P	inspect and replace <i>components</i>	<i>components</i> are inspected and replaced if required						

B-4.05.06P	test vacuum pumps using <i>tools</i>	vacuum pumps are tested using <i>tools</i> to ensure operation according to manufacturers' instructions
B-4.05.07P	tag and remove defective evacuation tools and equipment from service	defective evacuation tools and equipment are tagged and removed from service
B-4.05.08P	prepare system for evacuation	system is prepared for evacuation

*components* include: gauges, O-rings, seals, gas ballast valves, vacuum-rated hoses *tools* include: vacuum gauges, micron gauges, vacuum pumps, cold traps, core removal tools, special connectors, fittings, vacuum manifolds

	Knowledge					
	Learning Outcomes	Learning Objectives				
B-4.05.01L	demonstrate knowledge of evacuation tools and equipment, their applications, maintenance and procedures for use	identify hazards and describe safe work practices pertaining to use of evacuation tools and equipment				
		identify types of evacuation tools and equipment and describe their applications and procedures for use				
		describe procedures to store and maintain evacuation tools and equipment				

**B-4.06** Uses diagnostic and measuring tools and equipment

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Skills					
	Performance Criteria	Evidence of Attainment				
B-4.06.01P	inspect leads, probes, sensors and batteries for damage and wear, and verify ratings	leads, probes, sensors and batteries are inspected for damage and wear and replaced as necessary, and ratings are verified according to job requirements and manufacturers' specifications				
B-4.06.02P	verify calibration of <i>diagnostic and</i> <i>measuring tools and equipment</i>	calibration of <i>diagnostic and measuring</i> <i>tools and equipment</i> is verified according to manufacturers' specifications				
B-4.06.03P	interpret data, readings and results obtained	data, readings and results are interpreted according to established parameters				

B-4.06.04P	store <i>diagnostic and measuring tools</i> and equipment in a dry, secure location	diagnostic and measuring tools and equipment are stored in a dry, secure location according to manufacturers' recommendations
B-4.06.05P	tag and remove defective <i>diagnostic and measuring tools and equipment</i> from service	defective <i>diagnostic and measuring</i> <i>tools and equipment</i> are tagged and removed from service according to company policies

*diagnostic and measuring tools and equipment* include: multimeters, thermometers, calibrators, scales, leak detectors, meters, calipers, micrometers, gauge manifolds, airflow measurement tools, manometers, anemometers, hygrometers, hydrometers, refractometers, decibel meters, manufacturers' specific tools, software tools

	Knowledge					
	Learning Outcomes	Learning Objectives				
B-4.06.01L	demonstrate knowledge of <i>diagnostic</i> <i>and measuring tools and equipment</i> , their applications, maintenance and procedures for use	identify hazards and describe safe work practices pertaining to use of <i>diagnostic</i> and measuring tools and equipment				
		identify types of <i>diagnostic and</i> <i>measuring tools and equipment</i> and describe their applications and procedures for use				
		describe procedures to store and maintain <i>diagnostic and measuring tools and</i> <i>equipment</i>				

#### **Range of Variables**

*diagnostic and measuring tools and equipment* include: multimeters, thermometers, calibrators, scales, leak detectors, meters, calipers, micrometers, gauge manifolds, airflow measurement tools, manometers, anemometers, hygrometers, hydrometers, refractometers, decibel meters, manufacturers' specific tools, software tools

#### **B-4.07** Uses electrical tools and equipment

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Skills					
	Performance Criteria	Evidence of Attainment				
B-4.07.01P	select and inspect <b>electrical tools and</b> <b>equipment</b> for <b>damage</b>	electrical tools and equipment are selected and inspected for damage				
B-4.07.02P	clean, isolate and store <i>electrical tools</i> and equipment	<i>electrical tools and equipment</i> are cleaned, isolated and stored according to company policies and manufacturers' specifications				
B-4.07.03P	tag and remove defective <i>electrical tools</i> and equipment from service	defective <i>electrical tools and equipment</i> are tagged and removed from service according to company policies				

#### **Range of Variables**

*electrical tools and equipment* include: knockout tools, conduit benders, wire strippers, connectors, meters, fish tape, megohmmeters, torque wrenches, electrically insulated hand tools *damage* includes: compromised insulation, rust, compromised body, excessive wear, chips, cracks

	Knowledge						
	Learning Outcomes	Learning Objectives					
B-4.07.01L	demonstrate knowledge of <i>electrical tools and equipment</i> , their applications, maintenance and procedures for use	identify hazards and describe safe work practices pertaining to use of <b>electrical</b> tools and equipment					
		identify types of <i>electrical tools and</i> <i>equipment</i> and describe their applications and procedures for use					
		describe procedures to store and maintain electrical tools and equipment					
B-4.07.02L	demonstrate knowledge of regulations pertaining to electricity	describe role of jurisdictional regulations and associated work restrictions					

#### **Range of Variables**

*electrical tools and equipment* include: knockout tools, conduit benders, wire strippers, connectors, meters, fish tape, megohmmeters, torque wrenches, electrically insulated hand tools

### **B-4.08** Uses access equipment

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Skills					
	Performance Criteria	Evidence of Attainment				
B-4.08.01P	select ladders and work platforms	ladders and work platforms are selected according to site conditions and task being performed				
B-4.08.02P	inspect ladders and scaffolding for wear, damage, defects, certification date and missing components	ladders and scaffolding are inspected for wear, damage, defects, certification date and missing components according to jurisdictional regulations and manufacturers' specifications				
B-4.08.03P	identify <b>hazards</b> when erecting ladders and scaffolding	<i>hazards</i> are identified when erecting ladders and scaffolding according to jurisdictional regulations and manufacturers' specifications				
B-4.08.04P	inspect and document pre-use condition of <i>access equipment</i>	<i>access equipment</i> is inspected, and pre- use condition documentation is completed according to jurisdictional regulations, company policies and manufacturers' specifications				
B-4.08.05P	erect, secure, level and dismantle <i>access</i> equipment	<i>access equipment</i> is erected, secured, levelled and dismantled according to jurisdictional regulations, company policies and manufacturers' specifications				
B-4.08.06P	use equipment within operating limitations	equipment is used within operating limitations according to jurisdictional regulations, manufacturers' instructions and certification requirements				
B-4.08.07P	tag and remove defective <b>access</b> <b>equipment</b> from service	defective <i>access equipment</i> is tagged and removed from service				

#### **Range of Variables**

*hazards* include: power lines, excess loads, equipment damage, uneven ground, weather, slippery surfaces

access equipment includes: ladders, scaffolding, lifts, staging

	Knowledge						
	Learning Outcomes	Learning Objectives					
B-4.08.01L	demonstrate knowledge of <i>access</i> <i>equipment</i> , their applications, maintenance and procedures for use	identify <i>hazards</i> and describe safe work practices pertaining to use of <i>access equipment</i>					
		identify types of <b>access equipment</b> and describe their applications, limitations and procedures for use					
		interpret information pertaining to using <i>access equipment</i> found on drawings and specifications					
		identify <i>factors</i> to consider when selecting <i>access equipment</i>					
		describe procedures to inspect, store and maintain <i>access equipment</i>					
B-4.08.02L	demonstrate knowledge of regulations pertaining to <i>access equipment</i>	interpret codes and regulations pertaining to <i>access equipment</i>					

access equipment includes: ladders, scaffolding, lifts, staging

*hazards* include: power lines, excess loads, equipment damage, uneven ground, weather, slippery surfaces

factors include: safety, load characteristics, environment, application

### B-4.09 Uses rigging, hoisting and lifting equipment

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Skills					
	Performance Criteria	Evidence of Attainment				
B-4.09.01P	select and use <b>rigging, hoisting and</b> <i>lifting equipment</i>	<i>rigging, hoisting and lifting equipment</i> is selected and used according to task and <i>factors</i>				
B-4.09.02P	inspect <i>rigging, hoisting and lifting</i> <i>equipment</i> for wear, damage, defects, certification date and application	<i>rigging, hoisting and lifting equipment</i> is inspected for wear, damage, defects, certification date and application, and replaced if required				
B-4.09.03P	identify <b>hazards</b>	<i>hazards</i> are identified according to hazard risk assessment				
B-4.09.04P	verify load size and parameters	load size and parameters are verified according to job and manufacturers' specifications				

B-4.09.05P	rig loads	loads are rigged according to rigging procedures, manufacturers' specifications and jurisdictional regulations to ensure safety
B-4.09.06P	communicate with equipment operators	equipment operators are communicated with using approved <i>communication methods</i>
B-4.09.07P	guide and position loads	loads are guided and positioned using tag lines
B-4.09.08P	store <b>rigging, hoisting and lifting</b> equipment	<i>rigging, hoisting and lifting equipment</i> is stored in clean and dry locations according to manufacturers' recommendations
B-4.09.09P	tag and remove defective <i>rigging,</i> <i>hoisting and lifting equipment</i> from service	defective <i>rigging, hoisting and lifting</i> <i>equipment</i> is tagged and removed from service according to company policies and jurisdictional regulations

*rigging, hoisting and lifting equipment* includes: slings, come-alongs/chain falls, shackles, jacks, hoists, belts, ropes, cables, spreader bars, pry bars, gantry, trolleys

factors include: weight, distance to be travelled, size, obstacles

hazards include: power lines, excavations, excessive loads, weather

*communication methods* include: standard crane and hoist hand signals, two-way radios, video, radio, mobile phones

	Knowledge						
	Learning Outcomes	Learning Objectives					
B-4.09.01L	demonstrate knowledge of <i>rigging,</i> <i>hoisting and lifting equipment</i> , their applications, maintenance and procedures for use	identify types of <i>rigging, hoisting and</i> <i>lifting equipment</i> and describe their applications, limitations and procedures for use					
		identify <i>hazards</i> and describe safe work practices pertaining to use of <i>rigging,</i> <i>hoisting and lifting equipment</i>					
		interpret information pertaining to using <i>rigging, hoisting and lifting equipment</i> found on drawings and specifications					
		identify factors to consider when selecting rigging, hoisting and lifting equipment					
		identify <i>factors to consider when</i> <i>rigging a load</i> (material and equipment) for hoisting and lifting					
		describe procedures to rig and secure a load (material and equipment) for lifting and hoisting					

		describe procedures to inspect, store and maintain <i>rigging, hoisting and lifting</i> equipment
		describe procedures to perform lift
		identify types of knots, hitches and bends, and describe their applications and associated procedures
B-4.09.02L	demonstrate knowledge of codes and regulations pertaining to <i>rigging, hoisting and lifting equipment</i>	interpret codes and regulations pertaining to using <i>rigging, hoisting and lifting equipment</i>
B-4.09.03L	demonstrate knowledge of <i>communication methods</i> used during rigging, hoisting and lifting	identify and interpret <i>communication</i> <i>methods</i> used during rigging, hoisting and lifting, and describe their associated procedures

*rigging, hoisting and lifting equipment* includes: slings, come-alongs/chain falls, shackles, jacks, hoists, belts, ropes, cables, spreader bars, pry bars, gantry, trolleys

hazards include: power lines, excavations, excessive loads, weather

*factors to consider when selecting rigging, hoisting and lifting equipment* include: safety, load characteristics, environment, application

*factors to consider when rigging a load* include: load characteristics, equipment and accessories, environment, anchor points/attachment locations, sling angles, machine capacity/load chart

*communication methods* include: standard crane and hoist hand signals, two-way radios, video, radio, mobile phones

#### B-4.10 Uses digital technology

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Skills					
	Performance Criteria	Evidence of Attainment				
B-4.10.01P	identify and apply hardware and software requirements to connect to control systems and equipment	hardware and software requirements necessary to achieve connection are applied according to manufacturers' specifications				
B-4.10.02P	connect <i>electronic devices</i> to control systems and equipment	<i>electronic devices</i> are connected to control systems and equipment according to manufacturers' specifications				
B-4.10.03P	use <b>electronic devices</b> to configure parameters	<i>electronic devices</i> are used to configure parameters to set up operation of system according to manufacturers' instructions				

B-4.10.04P	monitor and diagnose problems and retrieve data and trend logs	problems are monitored and diagnosed using on-board and remote functions, and data and trend logs are retrieved
B-4.10.05P	back up program files	program files are backed up for easy retrieval

*electronic devices* include: computers, laptops, smart phones, user interface modules, tablets, thermal imagers, manufacturers' instruments

	Knowledge				
	Learning Outcomes	Learning Objectives			
B-4.10.01L	demonstrate knowledge of <i>digital</i> <i>technology</i> , their applications, maintenance and procedures for use	identify types of <i>digital technology</i> used to set up operation of systems			
		describe procedures to set up operation of systems			
		describe procedures to diagnose problems			

#### **Range of Variables**

*digital technology* includes: direct digital control (DDC), programmable logic controller (PLC), microprocessor, communication protocols, software, internet/web-based

# Task B-5 Organizes work

#### **Task Descriptor**

Refrigeration and air conditioning mechanics organize their work to complete their tasks safely, efficiently and productively.

#### **B-5.01** Interprets drawings and specifications

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Skills					
	Performance Criteria	Evidence of Attainment				
B-5.01.01P	determine equipment specifications	equipment specifications are determined according to manufacturers' specifications and drawings				
B-5.01.02P	determine equipment required	equipment required is determined according to design specifications				
B-5.01.03P	identify electrical, mechanical and communication equipment	electrical, mechanical and communication equipment is identified according to <i>specifications</i> and <i>drawings</i>				
B-5.01.04P	scale <b>drawings</b>	<i>drawings</i> are scaled for placement of equipment and accessories, coring of holes and location of utilities				
B-5.01.05P	interpret <b>drawings</b> , schematics and pictorial diagrams	<i>drawings</i> , schematics and pictorial diagrams are interpreted to provide information on electrical equipment, piping components and air distribution systems				
B-5.01.06P	interpret codes and regulations	<b>codes and regulations</b> are interpreted to install, maintain and service HVAC/R systems				

#### **Range of Variables**

equipment specifications include: weight, size, service access locations

*drawings* include: engineered, isometric, elevation, plan views, shop drawings, as-built, sketches, flow charts

specifications include: site, manufacturers', engineers', contractors', clients'

**codes and regulations** include: Canadian Standards Association (CSA) codes, Environmental Code of Practice for the Elimination of Fluorocarbon Emissions from Refrigeration and Air Conditioning Systems, National Building Code of Canada (NBC), Canadian Electrical Code (CEC), jurisdictional regulations, OHS, refrigerant regulations

	Knowledge					
	Learning Outcomes	Learning Objectives				
B-5.01.01L	demonstrate knowledge of <b>drawings</b> and <b>specifications</b> and their applications	define terminology associated with drawings and specifications				
		identify <b>specifications</b> and describe their applications				
		identify <b>drawings</b> and describe their applications				
		identify <b>codes and regulations</b> and describe their applications				
		identify <b>views used on drawings</b>				
		identify <i>information found on drawings</i>				
		explain use of <b>drawings</b> and measurement scales				
		describe procedures to convert between metric and imperial units of measurement				
		describe procedures to interpret and extract information from <i>drawings</i> and <i>specifications</i>				

*drawings* include: engineered, isometric, elevation, plan views, shop drawings, as-built, sketches, flow charts

specifications include: site, manufacturers', engineers', contractors', clients'

**codes and regulations** include: Canadian Standards Association (CSA) codes, Environmental Code of Practice for the Elimination of Fluorocarbon Emissions from Refrigeration and Air Conditioning Systems, National Building Code of Canada (NBC), Canadian Electrical Code (CEC), jurisdictional regulations, OHS, refrigerant regulations

views used on drawings include: elevation, plan, section, detail, 3-D

*information found on drawings* includes: lines, legend, symbols and abbreviations, title block, notes and specifications, schedules, units of measurement (metric/imperial), seismic, detail

#### **B-5.02** Uses reference material and documentation

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Sk	ills
	Performance Criteria	Evidence of Attainment
B-5.02.01P	determine installation procedures and requirements	installation procedures and requirements are determined according to manufacturers' specifications
B-5.02.02P	determine pipe and duct sizes, pressure/temperature (P/T) relationships and pressure/enthalpy relationships	pipe and duct sizes, P/T relationships and pressure/enthalpy relationships are determined according to tables and charts
B-5.02.03P	verify detailed equipment information	detailed equipment information is verified by referring to technical bulletins and manuals
B-5.02.04P	verify warranties	warranties are verified to assist in submitting required documentation
B-5.02.05P	submit <i>information</i> to activate and claim warranties	<i>information</i> is submitted to activate and claim warranties
B-5.02.06P	select and order parts and equipment	parts and equipment are selected and ordered by referring to <i>documentation</i>
B-5.02.07P	maintain <i>log sheets</i>	<i>log sheets</i> are maintained according to jurisdictional regulations, and client and company policies
B-5.02.08P	complete <b>written and electronic</b> documents	<i>written and electronic documents</i> are completed according to jurisdictional regulations, and client and company policies

#### **Range of Variables**

*information* includes: start-up, warranty claim forms, maintenance forms *documentation* includes: manufacturers' specifications, manufacturers' and wholesaler catalogues, drawings, employer-specific forms and reports, material take-offs

log sheets include: refrigerant, repairs, maintenance, equipment, operating

*written and electronic documents* include: work reports, work orders, incident reports, permits, time sheets, estimates, inspection test plans (ITP)

	Know	ledge
	Learning Outcomes	Learning Objectives
B-5.02.01L	demonstrate knowledge of reference material, <i>documentation</i> and <i>written</i> <i>and electronic documents</i> , their purpose, application and use	identify types and sources of reference material, <i>documentation</i> and <i>written</i> <i>and electronic documents</i> , and describe their applications
		describe procedures to access, interpret and apply information found in reference material and <i>documentation</i>
B-5.02.02L	demonstrate knowledge of procedures to complete and interpret <i>documentation</i> and <i>written and electronic documents</i>	describe procedures to complete documentation and written and electronic documents

*documentation* includes: manufacturers' specifications, manufacturers' and wholesaler catalogues, drawings, employer-specific forms and reports, material take-offs

*written and electronic documents* include: work reports, work orders, incident reports, permits, time sheets, estimates, inspection test plans (ITP)

B-5.03	Plans	job tasks	and	procedures

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Sk	ills
	Performance Criteria	Evidence of Attainment
B-5.03.01P	prepare material list, confirm availability and order materials	material list is prepared, availability is confirmed, and materials are ordered according to task
B-5.03.02P	apply for and obtain permits	permits are obtained according to jurisdictional regulations
B-5.03.03P	schedule delivery of equipment and materials	delivery of equipment and materials is scheduled
B-5.03.04P	arrange time to access work site	time to access work site is arranged according to client requirements to avoid downtime and delays
B-5.03.05P	transport equipment and materials	equipment and materials are transported safely and according to jurisdictional regulations, TDG and company policies
B-5.03.06P	arrange for storage of materials in safe and secure location	storage of materials in safe and secure location is arranged according to site conditions, manufacturers' specifications and company policies

B-5.03.07P	schedule tasks with other trades, sectors and professionals	tasks with <b>other trades, sectors and</b> professionals are scheduled
B-5.03.08P	select and assign personnel	personnel are selected and assigned according to specific tasks, equipment and certifications
B-5.03.09P	arrange for use of <i>major tools and</i> <i>equipment</i>	use of <i>major tools and equipment</i> is arranged
B-5.03.10P	organize tools and equipment for availability	tools and equipment are available when required

other trades, sectors and professionals include: gasfitters, sheet metal workers, plumbers, electricians, roofers, cutting and coring workers, well drillers, steamfitters/pipefitters, excavators, utility workers, sprinkler fitters, engineers, welders

*major tools and equipment* include: cranes, threaders, personnel lifts, press fit tools, core drills, rigging equipment, lever dollies, carts, welding and cutting equipment

	Know	ledge
	Learning Outcomes	Learning Objectives
B-5.03.01L	demonstrate knowledge of planning job tasks and procedures	define terminology associated with job tasks and procedures
		identify <b>sources of information</b> relevant to job planning and execution
		identify information gathering and communication techniques, and describe their associated procedures
		describe procedures to coordinate job tasks and procedures
		describe procedures to estimate work requirements

#### **Range of Variables**

*sources of information* include: work permits as applicable (hot, enclosed vessel), drawings, specifications, manufacturers' literature, code books, company policy manual for job requirements, Safety Data Sheets (SDS), asbestos/lead/workplace hazards assessment report, on-site logbooks

# Task B-6 Performs work site preparation

#### **Task Descriptor**

Refrigeration and air conditioning mechanics prepare the work site to accomplish their tasks. They ensure the availability and storage of material and supplies on site to be used for the job at hand.

### **B-6.01** Prepares work site

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Sk	ills
	Performance Criteria	Evidence of Attainment
B-6.01.01P	identify on-site <b>hazards</b>	on-site <i>hazards</i> are identified
B-6.01.02P	locate safety equipment, muster sites and emergency exits, and interpret rescue plans	safety equipment, muster sites and emergency exits are located, and rescue plans are interpreted
B-6.01.03P	perform <b>job hazard assessment</b>	<b>job hazard assessment</b> is performed according to job specifications, site conditions, company policies and jurisdictional regulations
B-6.01.04P	eliminate or mitigate <i>hazards</i> in work area	work area <b>hazards</b> are eliminated or mitigated
B-6.01.05P	identify <b>PPE</b> required	PPE required for task is identified
B-6.01.06P	erect barricades and signage	barricades and signage are erected according to site and client safety requirements, and jurisdictional regulations
B-6.01.07P	locate <i>isolation points</i>	<i>isolation points</i> are located according to site conditions
B-6.01.08P	coordinate site access for <i>equipment</i>	site access for <i>equipment</i> is coordinated
B-6.01.09P	identify area for storage of tools, equipment and supplies	area for storage of tools, equipment and supplies is identified according to site condition and job location
B-6.01.10P	determine location and layout of equipment and systems	location and layout of equipment and systems are determined according to site conditions and design specifications

*hazards* include: utility distribution, other construction activities, other trade activities, lack of lighting, components and spaces with extreme temperatures (e.g., steam pipes, gas-fired equipment) *job hazard assessment* includes: evaluate job tasks, identify hazards, identify controls, identify PPE *PPE* includes: safety glasses, head protection, high-visibility apparel, foot protection, hand protection, appropriate clothing, personal monitors, respiratory protection

*isolation points* include: water, gas, electrical shut-offs, fuels, compressed gases, steam, utility services *equipment* includes: cranes, personnel lifts, delivery trucks, dollies, carts, hoists, lifts

	Know	ledge
	Learning Outcomes	Learning Objectives
B-6.01.01L	demonstrate knowledge of procedures to prepare work site	define terminology associated with job coordination
		describe procedures to coordinate work requirements
B-6.01.02L	demonstrate knowledge of safe work practices	identify workplace <i>hazards</i> and describe safe work practices and equipment
		describe procedures to conduct <i>job</i> hazard assessment
		describe procedures to maintain safe work environment and to remediate potential dangers related to workplace <i>hazards</i>
B-6.01.03L	demonstrate knowledge of codes and regulations pertaining to work site safety	interpret codes and regulations pertaining to workplace <b>hazards</b> and safe work practices

#### **Range of Variables**

*hazards* include: utility distribution, other construction activities, other trade activities, lack of lighting, components and spaces with extreme temperatures (e.g., steam pipes, gas-fired equipment) *job hazard assessment* includes: evaluate job tasks, identify hazards, identify controls, identify PPE

### **B-6.02** Handles materials and supplies

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Skills					
	Performance Criteria	Evidence of Attainment				
B-6.02.01P	receive and verify delivered materials	delivered materials are received and verified to ensure they conform to order				
B-6.02.02P	inspect delivered materials	delivered materials are inspected to detect shipping damage				
B-6.02.03P	label materials and supplies	materials and supplies are labelled for project according to company policies				
B-6.02.04P	secure materials and supplies	materials and supplies are secured by using <b>equipment</b> when being stored or shipped according to jurisdictional regulations, manufacturers' specifications and site conditions				
B-6.02.05P	manually lift materials, supplies and equipment	materials, supplies and equipment are manually lifted according to OHS regulations and industry standards to avoid personal injury, and damage to materials, supplies and equipment				
B-6.02.06P	mechanically lift materials, supplies and equipment	materials, supplies and equipment are mechanically lifted using <i>rigging,</i> <i>hoisting and lifting equipment</i> according to manufacturers' specifications and jurisdictional regulations				
B-6.02.07P	store materials and supplies	materials and supplies are stored to prevent damage, deterioration, discharge or theft according to jurisdictional regulations, manufacturers' specifications and site conditions				
B-6.02.08P	dispose of waste materials	waste materials are disposed of according to jurisdictional regulations and site conditions				

#### **Range of Variables**

*equipment* includes: chains, straps, slings, blocks, rollers, pallet jacks, dollies, winches, hoists, casters *rigging, hoisting and lifting equipment* includes: slings, come-alongs/chain falls, shackles, jacks, hoists, belts, ropes, cables, spreader bars, pry bars, gantries, trolleys

	Knowledge						
	Learning Outcomes	Learning Objectives					
B-6.02.01L	demonstrate knowledge of procedures to handle materials and supplies	identify sources of information relevant to handling materials and supplies					
		describe considerations for handling materials and supplies					
B-6.02.02L	demonstrate knowledge of regulations pertaining to handling of materials and supplies	identify and interpret regulatory requirements and responsibilities for handling materials and supplies					
		identify and interpret regulatory requirements and responsibilities for disposing of waste materials					

# Task B-7 Performs trade-specific activities

#### **Task Descriptor**

Refrigeration and air conditioning mechanics perform routine trade activities to enable them to complete the tasks of their trade. The activities are performed at various stages of the work.

### **B-7.01** Connects piping and tubing

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Skills					
	Performance Criteria	Evidence of Attainment				
B-7.01.01P	<i>prepare</i> piping and tubing	piping and tubing are <b>prepared</b> according to manufacturers' specifications and industry standards				
B-7.01.02P	select <b>brazing equipment</b>	<i>brazing equipment</i> is selected according to pipe size, job location and industry standards				
B-7.01.03P	select safety procedures	<i>safety procedures</i> are selected according to task at hand				
B-7.01.04P	select <b>brazing, soldering and welding</b> materials	<i>brazing, soldering and welding</i> <i>materials</i> are selected according to <i>job</i> <i>requirements</i> and jurisdictional regulations				
B-7.01.05P	select and place <i>heat protection materials</i>	<i>heat protection materials</i> are selected and placed to protect surrounding area or <i>components</i> according to manufacturers' recommendations and safety procedures				

B-7.01.06P	purge piping and tubing with inert gases	piping and tubing are purged with inert gases to prevent oxidization during soldering and brazing
B-7.01.07P	solder and braze <i>components</i>	<b>components</b> are soldered and brazed using <b>compressed gases</b> and according to jurisdictional regulations and safety procedures
B-7.01.08P	select and use <i>mechanical fittings</i>	<i>mechanical fittings</i> are selected and used according to size of piping and tubing, and manufacturers' specifications
B-7.01.09P	<i>join</i> piping and tubing	piping and tubing are <b>joined</b> according to job specifications, materials used and jurisdictional regulations
B-7.01.10P	inspect connections	connections are inspected to identify potential leaks

preparing includes: cutting, cleaning, sanding, reaming

brazing equipment includes: air-fuel, oxy-fuel, electric induction

safety procedures include: identify hot work permit, identify fire watch requirements

*brazing, soldering and welding materials* include: flux, brazing alloy copper phosphorous (BCuP), brazing alloy silver (BAg), solder, welding consumables (sticks, gases and tips)

job requirements include: metal compatibility, pressure requirements, type of material

heat protection materials include: heat blankets, heat sinks

*components* include: fittings, accessories, compressors, evaporators, metering devices, condensers *compressed gases* are oxy-fuel and air-fuel

mechanical fittings include: crimp, flare, push, compression

*joining* includes: welding, crimping, pressing, fusion, adhesion, flanges, grooving, threading, flaring, compression fitting connection

	Knowledge							
	Learning Outcomes	Learning Objectives						
B-7.01.01L	demonstrate knowledge of procedures to connect piping and tubing	identify <b>types of piping and tubing</b> , and describe their characteristics and applications						
		identify types of <i>fittings</i> , and describe their characteristics and applications						
		identify types of <i>mechanical fittings</i> , and describe their characteristics and applications						
		identify types of <i>brazing, soldering and</i> <i>welding materials</i> and fillers, and describe their characteristics and applications						

		identify hazards and describe safe work practices when connecting piping and tubing
		describe procedures to connect piping and tubing
B-7.01.02L	demonstrate knowledge of codes and regulations pertaining to piping and tubing	interpret codes and regulations pertaining to piping and tubing

*types of piping and tubing* include: copper, stainless steel, steel, copper-iron alloy, brass, aluminum *fittings* include: elbows, tees, reducers, couplings, unions

mechanical fittings include: crimp, flare, push, compression

*brazing, soldering and welding materials* include: flux, brazing alloy copper phosphorous (BCuP), brazing alloy silver (BAg), solder, welding consumables (sticks, gases and tips)

#### **B-7.02** Performs leak and pressure tests on systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Skills						
	Performance Criteria	Evidence of Attainment					
B-7.02.01P	select and use <i>tools and equipment</i>	<i>tools and equipment</i> are selected and used according to task and manufacturers' specifications					
B-7.02.02P	prepare system for leak and pressure test	system is prepared for leak and pressure test according to manufacturers' specifications, industry standards and jurisdictional regulations					
B-7.02.03P	remove or isolate devices or sections of system that could be damaged during pressure test	devices or sections of system that could be damaged during pressure test are removed or isolated					
B-7.02.04P	pressurize system with system-compatible <i>liquids</i> and/or <i>gases</i> to perform pressure test	system is pressurized with system- compatible <i>liquids</i> and/or <i>gases</i> to perform pressure test to ensure system integrity according to jurisdictional regulations and job requirements					
B-7.02.05P	interpret and record leak and pressure test results	leak and pressure test results are interpreted and recorded to verify system integrity within a given period					
*tools and equipment* include: electronic leak detectors, ultrasonic leak detectors, dye leak detectors, certified gauges, regulators, leak detection solutions, litmus paper, digital data logger, micron gauges *liquids* include: water, glycol, brine

gases include: nitrogen, air (for secondary system), helium, argon, carbon dioxide (CO<sub>2</sub>), inert gases

	Know	ledge
	Learning Outcomes	Learning Objectives
B-7.02.01L	demonstrate knowledge of procedures to perform leak and pressure tests on HVAC/R systems	define terminology associated with leak and pressure testing
		identify hazards and describe safe work practices pertaining to leak and pressure testing
		identify <b>tools and equipment</b> used to leak and pressure test an HVAC/R system, and describe their applications and procedures for use
		describe procedures to leak and pressure test an HVAC/R system
		determine approved and compatible <i>liquids</i> or <i>gases</i> required for HVAC/R system pressure test
		calculate volumes of <i>liquids</i> and <i>gases</i> required to pressure test an HVAC/R system
B-7.02.02L	demonstrate knowledge of codes and regulations pertaining to leak and pressure testing	interpret codes and regulations pertaining to leak and pressure testing

#### **Range of Variables**

*tools and equipment* include: electronic leak detectors, ultrasonic leak detectors, dye leak detectors, certified gauges, regulators, leak detection solutions, litmus paper, digital data logger, micron gauges *liquids* include: water, glycol, brine

gases include: nitrogen, air (for secondary system), helium, argon, carbon dioxide (CO<sub>2</sub>), inert gases

## **B-7.03** Evacuates systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Sk	ills
	Performance Criteria	Evidence of Attainment
B-7.03.01P	select and use <i>tools and equipment</i>	<i>tools and equipment</i> are selected and used according to task, manufacturers' specifications and job requirements
B-7.03.02P	check integrity of vacuum pump	integrity of vacuum pump is checked to meet <b>evacuation</b> requirements
B-7.03.03P	ensure system is at atmospheric pressure	system is at atmospheric pressure
B-7.03.04P	connect vacuum pump to system	vacuum pump is connected to system according to manufacturers' specifications
B-7.03.05P	perform <b>evacuation(s)</b> until system has acceptable micron reading	<b>evacuation(s)</b> are performed according to test results, manufacturers' and clients' specifications, industry standards and jurisdictional regulations
B-7.03.06P	perform standing vacuum test	standing vacuum test is performed according to manufacturers' specifications and jurisdictional regulations
B-7.03.07P	interpret and record evacuation test results	evacuation test results are interpreted and recorded to verify system integrity

#### **Range of Variables**

*tools and equipment* include: compound gauges, micron gauges, vacuum pumps (A1, A2L and A3 rated), vacuum-rated hoses, smart probes, recording mobile apps

evacuation is: removal of air, non-condensables and water vapour to accepted levels

	Know	ledge
	Learning Outcomes	Learning Objectives
B-7.03.01L	demonstrate knowledge of <i>procedures</i> to <i>evacuate</i> HVAC/R systems	define terminology associated with evacuation of HVAC/R systems
		identify hazards and describe safe work practices pertaining to <b>evacuation</b> of HVAC/R systems
		identify <b>tools and equipment</b> used to <b>evacuate</b> HVAC/R systems, and describe their applications and procedures for use
		describe <b>procedures</b> to <b>evacuate</b> and dehydrate HVAC/R systems

*procedures* include: single evacuation, multiple evacuation, use of multiple vacuum pumps, use of cold traps

evacuation is: removal of air, non-condensables and water vapour to accepted levels

*tools and equipment* include: compound gauges, micron gauges, vacuum pumps (A1, A2L and A3 rated), vacuum-rated hoses, smart probes, recording mobile apps

## **B-7.04** Uses refrigerants, gases and oils

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Sk	ills
	Performance Criteria	Evidence of Attainment
B-7.04.01P	select and use <i>tools and equipment</i>	<i>tools and equipment</i> are selected and used according to task
B-7.04.02P	select <b>refrigerants</b>	<i>refrigerants</i> are selected according to system, manufacturers' specifications and jurisdictional regulations
B-7.04.03P	select <b>refrigerant oils</b>	<i>refrigerant oils</i> are selected according to type of <i>refrigerant</i> , temperature range of system and manufacturers' specifications
B-7.04.04P	recover <b>refrigerant</b> and drain <b>refrigerant</b> oil	<i>refrigerant</i> is recovered and <i>refrigerant</i> <i>oil</i> is drained when repairing, relocating, troubleshooting and decommissioning systems according to manufacturers' specifications, codes and jurisdictional regulations
B-7.04.05P	select gases	gases are selected according to task
B-7.04.06P	dispose of <b>refrigerants</b> and <b>refrigerant</b> oils	<i>refrigerants</i> and <i>refrigerant oils</i> are disposed of according to environmental protocols and jurisdictional regulations
B-7.04.07P	transport and store <b>refrigerants</b> , <b>gases</b> and <b>refrigerant oils</b>	<i>refrigerants, gases</i> and <i>refrigerant oils</i> are transported and stored according to TDG, jurisdictional regulations and manufacturers' specifications
B-7.04.08P	charge system with <b>refrigerants</b> and <b>refrigerant oil</b>	system is charged with <i>refrigerants</i> and <i>refrigerant oil</i> according to manufacturers' specifications and job-specific requirements

tools and equipment include: gauge manifolds, weigh scales, pumps, refrigerant recovery units, regulators

*refrigerants* include: primary (chlorofluorocarbon [CFC], hydrofluorocarbon [HFC], hydrofluoroolefin [HFO], hydrofluorocarbon [HCFC], hydrocarbons [HC]), natural (R-744, R-717), secondary (water, glycol solutions, brine solutions)

refrigerant oils include: mineral, alkylbenzene (AB), polyolester (POE), polyvinyl ether (PVE), polyalkylene glycol (PAG), polyalphaolefin (PAO)

gases include: nitrogen, acetylene, oxygen, CO<sub>2</sub>, argon, helium

	Know	ledge
	Learning Outcomes	Learning Objectives
B-7.04.01L	demonstrate knowledge of <i>refrigerants,</i> <i>gases</i> and <i>refrigerant oils</i> , their characteristics, applications and procedures for use	define terminology associated with <b>refrigerant oils</b>
		identify hazards and safe work practices pertaining to <i>refrigerants, gases</i> and <i>refrigerant oils</i>
		identify types of <i>refrigerants</i> and describe their <i>characteristics</i> , applications and phase-out schedules
		identify safety classifications of refrigerants
		identify types of refrigerant containers and colour coding classifications
		identify types of <i>refrigerant oils</i> and describe their characteristics and applications
		identify types of <b>gases</b> and describe their characteristics and applications
		explain <b>effects of refrigerants, gases</b> and refrigerant oils on environment
		describe procedures to perform <b>refrigerant</b> and <b>refrigerant oil</b> conversions
		describe procedures to store and transport <b>refrigerants, gases</b> and <b>refrigerant oils</b>
B-7.04.02L	demonstrate knowledge of regulations, standards and codes pertaining to refrigerants, gases and refrigerant oils	interpret regulations, <i>standards and codes</i> pertaining to <i>refrigerants, gases</i> and <i>refrigerant oils</i>
B-7.04.03L	demonstrate knowledge of procedures to recover, recycle and dispose of <b>refrigerants</b> and <b>refrigerant oils</b>	describe procedures to recover, recycle and dispose of <i>refrigerants</i> and <i>refrigerant oils</i>

*refrigerants* include: primary (chlorofluorocarbon [CFC], hydrofluorocarbon [HFC], hydrofluoroolefin [HFO], hydrochlorofluorocarbon [HCFC], hydrocarbons [HC]), natural (R-744, R-717), secondary (water, glycol solutions, brine solutions)

gases include: nitrogen, acetylene, oxygen, CO2, argon, helium

*refrigerant oils* include: mineral, alkylbenzene (AB), polyolester (POE), polyvinyl ether (PVE), polyalkylene glycol (PAG), polyalphaolefin (PAO)

*characteristics* include: glide, fractionation, saturation, dew point, bubble point, flammability, subcooled, superheated, triple point (R-744)

safety classifications of refrigerants are: toxicity and flammability (e.g., A1, A2L, A3, B2L)

effects of refrigerants, gases and refrigerant oils on environment include: ozone depletion potential, global warming potential (GWP), pollution, contamination

**standards and codes** include: American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) Standard 34; Boiler, Pressure Vessel, and Pressure Piping Code (CSA B51); Mechanical Refrigeration Code (CSA B52); Environmental Code of Practice for the Elimination of Fluorocarbon Emissions from Refrigeration and Air Conditioning Systems; NBC; CEC; Natural Gas and Propane Installation Code (CSA B149)

**B-7.05** Performs field wiring of systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Sk	kills
	Performance Criteria	Evidence of Attainment
B-7.05.01P	select and use <i>tools and equipment</i>	<i>tools and equipment</i> are selected and used according to task and manufacturers' specifications
B-7.05.02P	verify circuit is de-energized	circuit is de-energized to avoid personal injury or damage to equipment by following lock-out and tag-out procedures
B-7.05.03P	verify power requirements, <i>HVAC</i> and <i>refrigeration system</i> equipment wiring configuration and phasing	power requirements, <b>HVAC</b> and <b>refrigeration system</b> equipment wiring configuration and phasing are verified to ensure correct component selection according to manufacturers' requirements
B-7.05.04P	identify correctly sized fusing and overloads	correctly sized fusing and overloads are identified according to jurisdictional regulations and manufacturers' specifications
B-7.05.05P	interpret electrical schematics and termination points	electrical schematics and termination points are interpreted according to manufacturers' and design specifications, and jurisdictional regulations

B-7.05.06P	select wire size and type	wire size and type are selected according to amperage, insulation rating, compatibility with other components, codes and jurisdictional regulations
B-7.05.07P	select <i>components</i>	<i>components</i> are selected according to locations where they will be used and jurisdictional regulations
B-7.05.08P	route and secure wiring	wiring is routed and secured according to codes, jurisdictional regulations and site requirements
B-7.05.09P	terminate wiring to <i>HVAC</i> and <i>refrigeration system</i> equipment	wiring to <b>HVAC</b> and <b>refrigeration system</b> equipment is terminated
B-7.05.10P	label or tag wiring with wire markers	wiring is labelled or tagged with wire markers for identification and service purposes according to jurisdictional regulations and design specifications
B-7.05.11P	update wiring diagrams	wiring diagrams are updated to record changes and modifications

*tools and equipment* include: crimpers, cutters, pliers, strippers, screwdrivers, hex keys, multimeters, lock-out devices

*HVAC systems* include: air conditioning systems, heat pump systems, packaged units, split systems, ductless split systems, variable refrigerant flow (VRF), chillers, geothermal systems, computer room air conditioning (CRAC) units, field built-up systems, inverter driven systems, humidification systems, dehumidification systems, heat reclaim equipment, heat recovery ventilators (HRVs), energy recovery ventilators (ERVs), district heating and cooling systems, evaporative coolers, hydronic systems **refrigeration systems**, include: coolers, freezers, food/beverage equipment, ice machines, supermarket and warehouse systems, plate freezers, blast coolers and freezers, compound systems, process refrigeration systems, cascade systems, cryogenic systems, adsorption and absorption systems **components** include: connectors, junction boxes, enclosures, terminal strips, conduits, disconnects

	Know	ledge
	Learning Outcomes	Learning Objectives
B-7.05.01L	demonstrate knowledge of fundamental concepts of electricity	define terminology associated with electrical fundamentals
		identify hazards and describe safe work practices pertaining to electricity
B-7.05.02L	demonstrate knowledge of procedures to field wire systems	describe procedures to field wire systems
		identify <b>tools and equipment</b> used to field wire systems, and describe their applications and procedures for use
		identify types of wiring termination
		identify types and gauges of wire
		identify types of <i>components</i>
B-7.05.03L	demonstrate knowledge of <i>codes and</i> <i>regulations</i> pertaining to field wiring of <i>HVAC</i> and <i>refrigeration systems</i>	interpret <i>codes and regulations</i> pertaining to field wiring of <i>HVAC</i> and <i>refrigeration systems</i>

*tools and equipment* include: crimpers, cutters, pliers, strippers, screwdrivers, hex keys, multimeters, lock-out devices

*components* include: connectors, junction boxes, enclosures, terminal strips, conduits, disconnects *codes and regulations* include: CEC, jurisdictional regulations

*HVAC systems* include: air conditioning systems, heat pump systems, packaged units, split systems, ductless split systems, variable refrigerant flow (VRF), chillers, geothermal systems, computer room air conditioning (CRAC) units, field built-up systems, inverter driven systems, humidification systems, dehumidification systems, heat reclaim equipment, heat recovery ventilators (HRVs), energy recovery ventilators (ERVs), district heating and cooling systems, evaporative coolers, hydronic systems

*refrigeration systems* include: coolers, freezers, food/beverage equipment, ice machines, supermarket and warehouse systems, plate freezers, blast coolers and freezers, compound systems, process refrigeration systems, chillers, cooling towers, ice rinks, refrigerated containers, marine refrigeration systems, ultra-low systems, cascade systems, cryogenic systems, adsorption and absorption systems

## **B-7.06** Applies sealants, adhesives and insulation

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Skills						
	Performance Criteria	Evidence of Attainment					
B-7.06.01P	select <b>sealants</b> , <b>adhesives</b> and <b>insulation</b>	<i>sealants</i> , <i>adhesives</i> and <i>insulation</i> are selected according to manufacturers' recommendations, engineers' specifications and compatibility with other materials					
B-7.06.02P	select and use <i>tools and equipment</i>	<i>tools and equipment</i> are selected and used according to manufacturers' specifications					
B-7.06.03P	ensure adequate ventilation during application of <i>sealants</i> , <i>adhesives</i> and <i>insulation</i>	ventilation is adequate during application of <i>sealants, adhesives</i> and <i>insulation</i> according to manufacturers' specifications and jurisdictional regulations					
B-7.06.04P	inspect and prepare sealing surfaces	sealing surfaces are inspected and prepared before <i>sealants, adhesives</i> and <i>insulation</i> are applied according to manufacturers' specifications					
B-7.06.05P	use <b>sealants</b> , <b>adhesives</b> and <b>insulation</b>	<i>sealants</i> , <i>adhesives</i> and <i>insulation</i> are used according to codes, regulations, manufacturers' specifications and job requirements					

#### **Range of Variables**

*sealants* include: silicone, spray foam, spray adhesives, thread seal, fire stop, duct seal, mastic *adhesives* include: insulation glues, primers, pipe adhesives, epoxies

*insulation* includes: closed-cell elastomeric, polyethylene, polystyrene, fiberglass, rigid foam insulation with vinyl covering, tape, corrosion-inhibiting gel, acoustic

tools and equipment include: brushes, caulking guns, paint scrapers, rollers, PPE

	Know	vledge
	Learning Outcomes	Learning Objectives
B-7.06.01L	demonstrate knowledge of <i>sealants</i> , <i>adhesives</i> and <i>insulation</i> , their applications and procedures for use	identify types of <b>sealants</b> , <b>adhesives</b> and <b>insulation</b> and describe their characteristics and applications
		describe procedures to apply <b>sealants</b> , <b>adhesives</b> and <b>insulation</b>
		identify <b>tools and equipment</b> used to apply <b>sealants</b> , <b>adhesives</b> and <b>insulation</b> , and describe their applications and procedures for use
B-7.06.02L	demonstrate knowledge of codes and regulations pertaining to <i>sealants</i> , <i>adhesives</i> and <i>insulation</i>	interpret codes and regulations pertaining to <b>sealants</b> , <b>adhesives</b> and <b>insulation</b>

*sealants* include: silicone, spray foam, spray adhesives, thread seal, fire stop, duct seal, mastic *adhesives* include: insulation glues, primers, pipe adhesives, epoxies

*insulation* includes: closed-cell elastomeric, polyethylene, polystyrene, fiberglass, rigid foam insulation with vinyl covering, tape, corrosion-inhibiting gel, acoustic

tools and equipment include: brushes, caulking guns, paint scrapers, rollers, PPE

# Major Work Activity C Plans installation

# Task C-8 Plans installation of standard and high efficiency HVAC/R systems

#### **Task Descriptor**

Refrigeration and air conditioning mechanics plan the installation of standard and high efficiency HVAC/R systems to facilitate the smooth installation of the equipment and to ensure the desired result. Proper planning ensures system longevity and reliability and reduces operating costs. HVAC/R systems include residential, commercial, industrial and institutional applications.

#### C-8.01

Performs HVAC/R system design

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Skills							
	Performance Criteria	Evidence of Attainment						
C-8.01.01P	obtain data required for system design	data in engineering and design-build specifications are obtained						
C-8.01.02P	calculate system loads for <b>refrigeration</b> <b>systems</b>	load calculations for refrigeration systems are performed and verified						
C-8.01.03P	calculate system loads for HVAC systems	<i>load calculations for HVAC systems</i> are performed and verified						
C-8.01.04P	evaluate <i>capacity control requirements</i>	<i>capacity control requirements</i> are evaluated according to budget, equipment protection and engineering specifications						
C-8.01.05P	evaluate backup, supplemental and auxiliary heating requirements	backup, supplemental and auxiliary heating requirements are evaluated according to thermal and economic balance points, load calculations and design conditions						
C-8.01.06P	assess <b>utility requirements</b> for new equipment installation	<i>utility requirements</i> for new equipment installation are assessed according to equipment requirements, site conditions and electrical code						
C-8.01.07P	evaluate equipment choices	equipment choices are evaluated according to <i>factors</i>						

C-8.01.08P	assess distribution and ventilation requirements	<i>distribution and ventilation</i> <i>requirements</i> are assessed according to site conditions and manufacturers' specifications
C-8.01.09P	assess requirements for <b>energy-efficient</b> equipment	energy-efficient equipment requirements are assessed according to planned design and local regulations
C-8.01.10P	consult available energy assessment	energy assessments are consulted to ensure energy efficiency program and capacity requirements are met

**refrigeration systems** include: coolers, freezers, food/beverage equipment, ice machines, supermarket and warehouse systems, plate freezers, blast coolers and freezers, compound systems, process refrigeration systems, chillers, cooling towers, ice rinks, refrigerated containers, marine refrigeration systems, ultra-low systems, cascade systems, cryogenic systems, adsorption and absorption systems

**load calculations for refrigeration systems** include: heat loss, heat gain (HLHG) (e.g., solar load), operating capacity ranges, air changes per hour (ACH), ventilation, indoor and outdoor locations, design conditions (indoor and outdoor temperature and humidity ranges), building envelope, duct heat gain and loss, product being refrigerated or frozen, CO<sub>2</sub> levels, equipment loads, lighting loads, exhaust systems, occupancy rates and schedules, building pressurization, evaporation rates, psychrometric properties

*HVAC systems* include: air conditioning systems, heat pump systems, packaged units, split systems, ductless split systems, VRF, chillers, geothermal systems, CRAC units, field built-up systems, inverter driven systems, humidification systems, dehumidification systems, heat reclaim equipment, HRVs, ERVs, district heating and cooling systems, evaporative coolers, hydronic systems

*load calculations for HVAC systems* include: HLHG (e.g., solar load), operating capacity ranges, ACH, ventilation, design conditions (indoor and outdoor temperature and humidity ranges), building envelope, duct heat gain and loss, CO<sub>2</sub> levels, equipment loads, lighting loads, exhaust systems, occupancy rates and schedules, building pressurization, evaporation rates, psychrometric properties

*capacity control requirements* include: variable speed, variable capacity, staging, modulation, load variances, redundancy

*utility requirements* include: panel sizing, grid capacity, building distribution, condensate drainage, fossil fuel supply, water supply, neighbourhood energy unit supply

**factors** include: inspection authority's equipment standards, fuel sources, refrigerant selection, installation location, climate zone, seismic requirements, snow clearance, drainage requirements, size of building, building envelope, manufacturers' specifications, Leadership in Energy and Environmental Design (LEED) criteria, SEER, SEER2 and HSPF criteria, annual walk-in energy factor (AWEF) criteria

*distribution and ventilation requirements* include: static pressure, airflow, velocity, volume, insulation, pump/head pressure, duct size, diffusers, grilles, zoning, equipment access and serviceability

*energy-efficient equipment* includes: heat reclaim equipment, economizers, controls, building automation systems (BAS)

	Know	rledge
	Learning Outcomes	Learning Objectives
C-8.01.01L	demonstrate knowledge of <i>HVAC</i> and <i>refrigeration systems</i> , their <i>components</i> , <i>accessories</i> , characteristics and applications	identify types of <i>HVAC</i> and <i>refrigeration systems</i> and describe their characteristics and applications
		identify types of <i>HVAC/R components</i> and describe their characteristics and applications
		identify capacity ratings of <i>HVAC</i> and <i>refrigeration systems</i> , their <i>components</i> and <i>accessories</i>
		identify <b>safety classifications of</b> <b>refrigerants</b>
		interpret information pertaining to <b>HVAC</b> and <b>refrigeration systems</b> found on drawings, specifications, graphs and tables
		identify types of <i>electrical components</i> and describe their characteristics and applications
		identify types of <b>energy-efficient</b> <b>equipment</b> and describe their characteristics and applications
		define seasonal energy efficiency ratio (SEER), SEER2, heating seasonal performance factor (HSPF) and coefficient of performance (COP)
		describe backup, supplemental and auxiliary heating requirements for <i>HVAC</i> systems
C-8.01.02L	demonstrate knowledge of <i>heat pump</i> <i>systems</i> , their components, accessories, characteristics and applications	identify types of <i>heat pump systems</i> and describe their components, accessories, characteristics and applications
		describe heat pump design and configuration for heating and cooling cycle
		identify types of service valves
		describe <i>types of compressors</i> and their components, accessories, <i>characteristics</i> , applications and operation
		describe <i>types of fans</i> and describe their components, accessories, characteristics, applications and operation

		explain minimum and maximum system capacity in variable speed systems
		explain variable system capacity capabilities and their impact on humidity
		explain differences between heat pumps and fossil fuel heating systems
C-8.01.03L	demonstrate knowledge of HVAC/R system design	describe procedures to perform HVAC/R system design
		explain air quality, air circulation and ventilation
		identify <i>factors</i> to consider in evaluating equipment choices
		describe <b>distribution and ventilation</b> requirements
		describe design requirements for <b>energy</b> efficient equipment
C-8.01.04L	demonstrate knowledge of load calculations	describe procedures to perform <i>load</i> calculations for refrigeration systems
		describe procedures to perform <i>load</i> calculations for HVAC systems
C-8.01.05L	demonstrate knowledge of <i>capacity</i> <i>control requirements</i>	describe capacity control options and applications for HVAC/R systems
		identify procedure to select equipment options that meet <i>capacity control requirements</i>
C-8.01.06L	demonstrate knowledge of sizing heat pumps	describe procedures for sizing heat pumps for different applications (cooling, partial heating, full heating)
		explain impact of climate zones and outdoor temperature on approach for sizing heat pumps
C-8.01.07L	demonstrate knowledge of hydronic systems	identify types of hydronic systems and describe their components and accessories
C-8.01.08L	demonstrate knowledge of <b>standards</b> <b>and codes</b> pertaining to HVAC/R systems and equipment, their <b>components</b> and <b>accessories</b>	interpret <b>standards and codes</b> pertaining to HVAC/R systems and equipment, their <b>components</b> and <b>accessories</b>

*HVAC systems* include: air conditioning systems, heat pump systems, packaged units, split systems, ductless split systems, VRF, chillers, geothermal systems, CRAC units, field built-up systems, inverter driven systems, humidification systems, dehumidification systems, heat reclaim equipment, HRVs, ERVs, district heating and cooling systems, evaporative coolers, hydronic systems

*refrigeration systems* include: coolers, freezers, food/beverage equipment, ice machines, supermarket and warehouse systems, plate freezers, blast coolers and freezers, compound systems, process refrigeration systems, chillers, cooling towers, ice rinks, refrigerated containers, marine refrigeration systems, ultra-low systems, cascade systems, cryogenic systems, adsorption and absorption systems

*HVAC/R components* include: compressors, condensers, metering devices, evaporators, remote aircooled condensers, filter driers, sight glasses, valves, regulators, receivers, pressure vessels, heat exchangers, vibration eliminators, liquid pumps, temperature sensors, pressure transducers, fans, blowers, air filters, economizers, controllers, oil management devices, insulation, condensate drains, supply diffusers, return grilles, dampers, flow switches

*accessories* include: pressure controls, temperature controls, safety controls, time clocks, defrost controls, crankcase heaters, pipe hangers and clamps, solenoid valves, regulating valves, check valves, oil separators, accumulators, stands and supports, condensate pumps, indoor air quality (IAQ) devices

safety classifications of refrigerants are: toxicity and flammability (e.g., A1, A2L, A3, B2L)

*electrical components* include: motors (single-phase, three-phase, electronically commutated motors [ECM]), transformers, contactors, relays, solid state relays, starters, variable speed drives (VSD), variable frequency drives (VFD), silicon-controlled rectifiers (SCR), capacitors, resistors, inverter drives, potentiometers, rheostats, disconnects

*energy-efficient equipment* includes: heat reclaim equipment, economizers, controls, building automation systems (BAS)

*heat pump systems* include: air-to-air, liquid-to-air, liquid-to-liquid, air-to-liquid, geothermal, solar, variable speed, VRF, dual fuel

*types of compressors* include: reciprocating, rotary, swing, scroll, screw, centrifugal, magnetic, linear *characteristics* (of compressors) include: single-stage, multi-stage, variable speed, tandem, parallel, compound, open drive, semi-hermetic, hermetic

types of fans include: constant speed, variable speed, axial (propeller), radial (centrifugal)

*factors* include: inspection authority's equipment standards, fuel sources, refrigerant selection, installation location, climate zone, seismic requirements, snow clearance, drainage requirements, size of building, building envelope, manufacturers' specifications, Leadership in Energy and Environmental Design (LEED) criteria, SEER, SEER2 and HSPF criteria, annual walk-in energy factor (AWEF) criteria

*distribution and ventilation requirements* include: static pressure, airflow, velocity, volume, insulation, pump/head pressure, duct size, diffusers, grilles, zoning, equipment access and serviceability

*load calculations for refrigeration systems* include: heat loss, heat gain (HLHG) (e.g., solar load), operating capacity ranges, air changes per hour (ACH), ventilation, indoor and outdoor locations, design conditions (indoor and outdoor temperature and humidity ranges), building envelope, duct heat gain and loss, product being refrigerated or frozen, CO<sub>2</sub> levels, equipment loads, lighting loads, exhaust systems, occupancy rates and schedules, building pressurization, evaporation rates, psychrometric properties

*load calculations for HVAC systems* include: HLHG (e.g., solar load), operating capacity ranges, ACH, ventilation, design conditions (indoor and outdoor temperature and humidity ranges), building envelope, duct heat gain and loss, CO<sub>2</sub> levels, equipment loads, lighting loads, exhaust systems, occupancy rates and schedules, building pressurization, evaporation rates, psychrometric properties

*capacity control requirements* include: variable speed, variable capacity, staging, modulation, load variances, redundancy

*standards and codes* include: ASHRAE Standard 34; Boiler, Pressure Vessel, and Pressure Piping Code (CSA B51); Mechanical Refrigeration Code (CSA B52); Environmental Code of Practice for the Elimination of Fluorocarbon Emissions from Refrigeration and Air Conditioning Systems; NBC; CEC; Natural Gas and Propane Installation Code (CSA B149)

#### C-8.02

#### Selects HVAC/R equipment, components and accessories

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Skills							
	Performance Criteria	Evidence of Attainment						
C-8.02.01P	select equipment, <i>HVAC/R components</i> , <i>accessories</i> and <i>electrical components</i>	equipment, <i>HVAC/R components</i> , <i>accessories</i> and <i>electrical components</i> are selected according to <i>factors</i>						
C-8.02.02P	select <b>energy-efficient equipment</b> and accessories	energy-efficient equipment and accessories are selected according to design specifications, code and operational requirements						
C-8.02.03P	select backup, supplemental and auxiliary heating requirements for <i>HVAC systems</i>	backup, supplemental and auxiliary heating requirements for <i>HVAC systems</i> are selected according to design specifications, code and operational requirements						
C-8.02.04P	verify <b>refrigeration component</b> specifications	<i>refrigeration component specifications</i> are verified according to design specifications, code and operational requirements						
C-8.02.05P	verify HVAC component specifications	<b>HVAC component specifications</b> are verified according to design specifications, code and operational requirements						

#### **Range of Variables**

*HVAC/R components* include: compressors, condensers, metering devices, evaporators, remote aircooled condensers, filter driers, sight glasses, valves, regulators, receivers, pressure vessels, heat exchangers, vibration eliminators, liquid pumps, temperature sensors, pressure transducers, fans, blowers, air filters, economizers, controllers, oil management devices, insulation, condensate drains, supply diffusers, return grilles, dampers, flow switches

*accessories* include: pressure controls, temperature controls, safety controls, time clocks, defrost controls, crankcase heaters, pipe hangers and clamps, solenoid valves, regulating valves, check valves, oil separators, accumulators, stands and supports, condensate pumps, IAQ devices

*electrical components* include: motors (single-phase, three-phase, ECM), transformers, contactors, relays, solid state relays, starters, VSDs, VFDs, SCRs, capacitors, resistors, inverter drives, potentiometers, rheostats, disconnects

*factors* include: code requirements, manufacturers' and engineering specifications, system and client requirements, appropriate refrigerant for application, drawings, site conditions, environmental conditions *energy-efficient equipment* includes: heat reclaim equipment, economizers, controls, BAS

*HVAC systems* include: air conditioning systems, heat pump systems, packaged units, split systems, ductless split systems, VRF, chillers, geothermal systems, CRAC units, field built-up systems, inverter driven systems, humidification systems, dehumidification systems, heat reclaim equipment, HRVs, ERVs, district heating and cooling systems, evaporative coolers, hydronic systems

*refrigeration component specifications* include: pressure drops, oil return, flow rate capacity, corrosion protection

*HVAC component specifications* include: blower capacity, pressure drops, size, fluid flow, heating/cooling capacity, sensible heating ratio

	Know	ledge
	Learning Outcomes	Learning Objectives
C-8.02.01L	demonstrate knowledge of <i>HVAC</i> systems and refrigeration systems, their components and accessories	identify types of <i>HVAC systems</i> and <i>refrigeration systems</i> and describe their characteristics and applications
		identify types of <i>HVAC/R components</i> and describe their characteristics and applications
		identify types of <i>accessories</i> and describe their characteristics and applications
		identify types of <i>electrical components</i> and describe their characteristics and applications
		identify capacity ratings of <i>HVAC</i> systems and refrigeration systems, their components and accessories
		identify HVAC/R component specifications
		identify <b>refrigeration component</b> specifications
		interpret information pertaining to <i>HVAC</i> <i>systems</i> and <i>refrigeration systems</i> found on drawings, specifications, graphs and tables
		identify types of <b>energy-efficient</b> <b>equipment</b> and their accessories, and describe their characteristics and applications
		identify backup, supplemental and auxiliary heating requirements for <i>HVAC</i> systems

C-8.02.02L	demonstrate knowledge of <i>heat pump</i> <i>systems</i> , their components, accessories, characteristics and applications	identify types of <b>heat pump systems</b> and describe their components, accessories, characteristics and applications
		describe heat pump design and configuration for heating and cooling cycle
		identify types of service valves
		describe <b>types of compressors</b> and their components, accessories, <b>characteristics</b> , applications and operation
		explain minimum and maximum system capacity in variable speed systems
		describe <b>types of fans</b> and describe their components, accessories, characteristics, applications and operation
		list and explain differences between heat pumps and fossil fuel heating systems
C-8.02.03L	demonstrate knowledge of selection of <i>HVAC systems</i> and <i>refrigeration</i> <i>systems</i> , their <i>components</i> and <i>accessories</i>	identify <i>factors</i> to consider when selecting <i>HVAC systems</i> and <i>refrigeration systems</i> , their <i>components</i> and <i>accessories</i>
C-8.02.04L	demonstrate knowledge of codes pertaining to HVAC/R systems and equipment, their <i>components</i> and <i>accessories</i>	interpret codes pertaining to HVAC/R systems and equipment, their <i>components</i> and <i>accessories</i>

*HVAC systems* include: air conditioning systems, heat pump systems, packaged units, split systems, ductless split systems, VRF, chillers, geothermal systems, CRAC units, field built-up systems, inverter driven systems, humidification systems, dehumidification systems, heat reclaim equipment, HRVs, ERVs, district heating and cooling systems, evaporative coolers, hydronic systems

*refrigeration systems* include: coolers, freezers, food/beverage equipment, ice machines, supermarket and warehouse systems, plate freezers, blast coolers and freezers, compound systems, process refrigeration systems, chillers, cooling towers, ice rinks, refrigerated containers, marine refrigeration systems, ultra-low systems, cascade systems, cryogenic systems, adsorption and absorption systems

**HVAC/R components** include: compressors, condensers, metering devices, evaporators, remote aircooled condensers, filter driers, sight glasses, valves, regulators, receivers, pressure vessels, heat exchangers, vibration eliminators, liquid pumps, temperature sensors, pressure transducers, fans, blowers, air filters, economizers, controllers, oil management devices, insulation, condensate drains, supply diffusers, return grilles, dampers, flow switches

*accessories* include: pressure controls, temperature controls, safety controls, time clocks, defrost controls, crankcase heaters, pipe hangers and clamps, solenoid valves, regulating valves, check valves, oil separators, accumulators, stands and supports, condensate pumps, IAQ devices

*electrical components* include: motors (single-phase, three-phase, ECM), transformers, contactors, relays, solid state relays, starters, VSDs, VFDs, SCRs, capacitors, resistors, inverter drives, potentiometers, rheostats, disconnects

*HVAC component specifications* include: blower capacity, pressure drops, size, fluid flow, heating/cooling capacity, sensible heating ratio

*refrigeration component specifications* include: pressure drops, oil return, flow rate capacity, corrosion protection

*energy-efficient equipment* includes: heat reclaim equipment, economizers, controls, BAS *heat pump systems* include: air-to-air, liquid-to-air, liquid-to-liquid, air-to-liquid, geothermal, solar, variable speed, VRF, dual fuel

*types of compressors* include: reciprocating, rotary, swing, scroll, screw, centrifugal, magnetic, linear *characteristics* (of compressors) include: single-stage, multi-stage, variable speed, tandem, parallel, compound, open drive, semi-hermetic, hermetic

*types of fans* include: constant speed, variable speed, axial (propeller), radial (centrifugal) *factors* include: code requirements, manufacturers' and engineering specifications, system and client requirements, appropriate refrigerant for application, drawings, site conditions, environmental conditions

# **C-8.03** Determines placement of HVAC/R equipment, components and accessories

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Skills					
	Performance Criteria	Evidence of Attainment				
C-8.03.01P	determine placement of <b>HVAC</b> and refrigeration system	placement of <b>HVAC</b> and <b>refrigeration</b> system is determined according to factors and surrounding <b>environmental</b> issues				
C-8.03.02P	determine placement of <i>HVAC/R</i> components	placement of <i>HVAC/R components</i> is determined according to <i>factors</i> and jurisdictional regulations				
C-8.03.03P	determine requirements and limitations for placement of <i>HVAC</i> and <i>refrigeration</i> <i>system</i> , <i>components</i> and <i>accessories</i>	requirements and limitations for placement of <i>HVAC</i> and <i>refrigeration</i> <i>system</i> , <i>components</i> and <i>accessories</i> are determined according to codes, jurisdictional and design specifications, system requirements and environmental conditions				
C-8.03.04P	take measurements	measurements are taken to ensure that equipment will fit in location				

#### **Range of Variables**

*HVAC systems* include: air conditioning systems, heat pump systems, packaged units, split systems, ductless split systems, VRF, chillers, geothermal systems, CRAC units, field built-up systems, inverter driven systems, humidification systems, dehumidification systems, heat reclaim equipment, HRVs, ERVs, district heating and cooling systems, evaporative coolers, hydronic systems

*refrigeration systems* include: coolers, freezers, food/beverage equipment, ice machines, supermarket and warehouse systems, plate freezers, blast coolers and freezers, compound systems, process refrigeration systems, chillers, cooling towers, ice rinks, refrigerated containers, marine refrigeration systems, ultra-low systems, cascade systems, cryogenic systems, adsorption and absorption systems *factors* include: sizing, manufacturers' clearances, serviceability, accessibility, scheduling and availability of utilities and services, structure, aesthetics, client

*environmental issues* include: noise, exhaust and intake vent locations, environmental conditions *HVAC/R components* include: compressors, condensers, metering devices, evaporators, remote air-cooled condensers, filter driers, sight glasses, valves, regulators, receivers, pressure vessels, heat exchangers, vibration eliminators, liquid pumps, temperature sensors, pressure transducers, fans, blowers, air filters, economizers, controllers, oil management devices, insulation, condensate drains, supply diffusers, return grilles, dampers, flow switches

*accessories* include: pressure controls, temperature controls, safety controls, time clocks, defrost controls, crankcase heaters, pipe hangers and clamps, solenoid valves, regulating valves, check valves, oil separators, accumulators, stands and supports, condensate pumps, IAQ devices

	Knowledge						
	Learning Outcomes	Learning Objectives					
C-8.03.01L	demonstrate knowledge of <i>HVAC</i> and <i>refrigeration systems</i> , their <i>components</i> , <i>accessories</i> , characteristics and applications	identify types of <i>HVAC</i> and <i>refrigeration</i> <i>systems</i> and their <i>components</i> and <i>accessories</i> , and describe their characteristics and applications					
C-8.03.02L	demonstrate knowledge of <i>heat pump</i> <i>systems</i> , their components, accessories, characteristics and applications	identify types of <i>heat pump systems</i> and their components and accessories, and describe their characteristics and applications					
C-8.03.03L	demonstrate knowledge of determining placement of <i>HVAC</i> and <i>refrigeration</i> <i>systems</i> , <i>components</i> and <i>accessories</i>	identify <i>factors</i> and <i>environmental</i> <i>issues</i> to consider for placement of <i>HVAC</i> and <i>refrigeration systems</i> , <i>components</i> and <i>accessories</i>					
		identify requirements and limitations for placement of <i>HVAC</i> and <i>refrigeration systems</i> , <i>components</i> and <i>accessories</i>					
		describe procedures to place <b>HVAC</b> and <b>refrigeration systems</b> , <b>components</b> and <b>accessories</b>					
		identify <i>methods of zoning</i> and describe their applications					
		explain importance of balancing system capacity with system load					
C-8.03.04L	demonstrate knowledge of codes and regulations pertaining to <i>HVAC</i> and <i>refrigeration systems</i> , their <i>components</i> and <i>accessories</i>	interpret codes and regulations pertaining to <b>HVAC</b> and <b>refrigeration systems</b> , their <b>components</b> and <b>accessories</b>					

#### **Range of Variables**

*HVAC systems* include: air conditioning systems, heat pump systems, packaged units, split systems, ductless split systems, VRF, chillers, geothermal systems, CRAC units, field built-up systems, inverter driven systems, humidification systems, dehumidification systems, heat reclaim equipment, HRVs, ERVs, district heating and cooling systems, evaporative coolers, hydronic systems

*refrigeration systems* include: coolers, freezers, food/beverage equipment, ice machines, supermarket and warehouse systems, plate freezers, blast coolers and freezers, compound systems, process refrigeration systems, chillers, cooling towers, ice rinks, refrigerated containers, marine refrigeration systems, ultra-low systems, cascade systems, cryogenic systems, adsorption and absorption systems

*HVAC/R components* include: compressors, condensers, metering devices, evaporators, remote aircooled condensers, filter driers, sight glasses, valves, regulators, receivers, pressure vessels, heat exchangers, vibration eliminators, liquid pumps, temperature sensors, pressure transducers, fans, blowers, air filters, economizers, controllers, oil management devices, insulation, condensate drains, supply diffusers, return grilles, dampers, flow switches

*accessories* include: pressure controls, temperature controls, safety controls, time clocks, defrost controls, crankcase heaters, pipe hangers and clamps, solenoid valves, regulating valves, check valves, oil separators, accumulators, stands and supports, condensate pumps, IAQ devices

*heat pump systems* include: air-to-air, liquid-to-air, liquid-to-liquid, air-to-liquid, geothermal, solar, variable speed, VRF, dual fuel

*factors* include: sizing, manufacturers' clearances, serviceability, accessibility, scheduling and availability of utilities and services, structure, aesthetics, client

*environmental issues* include: noise, exhaust and intake vent locations, environmental conditions *methods of zoning* include: dual duct system, terminal reheat (cool) system, variable air volume (VAV) system, variable volume and temperature (VVT) system, heat recovery VRF system, induction reheat system, hydronic system, multiple unitary/heat pump system, multi-zone system

#### **C-8.04** Performs HVAC/R material take-off

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Skills						
	Performance Criteria	Evidence of Attainment					
C-8.04.01P	determine quantity of materials required	quantity of materials required is determined according to <i>component</i> <i>interconnections</i> from working drawings and site visits					
C-8.04.02P	determine piping and tubing size and length needed	piping and tubing size and length needed are determined according to pipe run, refrigerant type, equipment capacity and manufacturers' specifications					
C-8.04.03P	determine insulation type and thickness	insulation type and thickness required are determined according to operating temperature and code					
C-8.04.04P	establish material order list for <i>components</i>	material order list for <i>components</i> is established according to HVAC/R system requirements					
C-8.04.05P	identify alternative options for materials and equipment	alternative options for materials and equipment are identified based on availability					

#### **Range of Variables**

*component interconnections* include: piping, ducting routes, electrical, condensate *components* include: hangers, stands, flow controls, piping, venting, ducting, drainage, hardware, associated accessories

	Knowledge					
	Learning Outcomes	Learning Objectives				
C-8.04.01L	demonstrate knowledge of performing HVAC/R material take-off	identify <i>factors</i> to consider when determining materials and pipe required				
		describe imperial and metric systems of measurement				
		describe procedures to perform an HVAC/R material take-off list				
		identify types of alternative materials that may be considered as options				

*factors* include: location, quantity, length, obstacles, core drilling, underground piping, supply chain issues, code requirements, manufacturers' and engineering specifications

# **Task C-9 Plans installation of control systems**

#### **Task Descriptor**

Planning of control systems ensures proper operation of the equipment. Control systems are used to operate the system effectively and efficiently.

#### C-9.01 Performs control system design

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Skills					
	Performance Criteria	Evidence of Attainment				
C-9.01.01P	determine <i>control system</i> requirements	<i>control system</i> requirements are determined according to clients' needs, efficiency considerations and <i>equipment</i> <i>specifications</i>				
C-9.01.02P	determine <i>location considerations</i>	<i>location considerations</i> are determined according to jurisdictional regulations and environmental conditions				
C-9.01.03P	determine operating ranges required	operating ranges required are determined to ensure safe control of equipment and safety of controlled space/product				

C-9.01.04P	determine wiring, cabling and connections used for <i>control systems</i>	wiring, cabling and connections used for <i>control systems</i> are determined according to manufacturers' specifications and design plan
C-9.01.05P	verify electrical requirements for <b>control</b> systems	electrical requirements for <b>control</b> <b>systems</b> are verified according to equipment requirements, site conditions and electrical code

*control systems* include: electrical, mechanical, electronic, app-based, wireless, predictive (artificial intelligence [Al]-capable), pneumatic, centralized, distributed, integrated control circuits

*equipment specifications* include: maximum allowable distances between components, number of component devices

location considerations include: humidity, elevation, fail-safe requirements, temperature, outdoor reset

	Knowledge						
	Learning Outcomes	Learning Objectives					
C-9.01.01L	demonstrate knowledge of <i>control</i> systems and their components	define terminology associated with control systems and their components					
		explain purpose and operation of <i>control systems</i> , devices and components					
		identify types of <i>control systems</i> and their components, and describe their characteristics and applications					
		identify specifications related to <i>control</i> systems					
C-9.01.02L	demonstrate knowledge of fundamental concepts of electricity	define terminology associated with electrical fundamentals					
		identify units of electrical measurement and symbols					
		identify hazards and describe safe work practices pertaining to electricity					
C-9.01.03L	demonstrate knowledge of performing control system design	describe procedures to perform <i>control</i> system design					
		identify component compatibility issues					

#### **Range of Variables**

*control systems* include: electrical, mechanical, electronic, app-based, wireless, predictive (artificial intelligence [AI]-capable), pneumatic, centralized, distributed, integrated control circuits

#### **C-9.02** Selects control system components and accessories

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Skills				
	Performance Criteria	Evidence of Attainment			
C-9.02.01P	determine <i>control system</i> components and accessories	<i>control system</i> components and accessories are determined according to <i>applications</i> , code requirements, and manufacturers' and engineering specifications			
C-9.02.02P	determine <i>control system</i> component <i>specifications</i>	<i>control system</i> component <i>specifications</i> are determined according to system design and application			

#### **Range of Variables**

*control systems* include: electrical, mechanical, electronic, app-based, wireless, predictive (Al-capable), pneumatic, centralized, distributed, integrated control circuits

*applications* include: humidity, temperature, pressure, flow, motion, infrared, energy consumption *specifications* include: effective connection distances, number of inputs/outputs able to be controlled, communication compatibility, electromagnetic interference, connection and wireless signal reliability

	Knowledge						
	Learning Outcomes	Learning Objectives					
C-9.02.01L	demonstrate knowledge of <i>control systems</i> and their components and accessories	identify types of <i>control systems</i> and their components and accessories, and describe their characteristics and applications					
		interpret information pertaining to <i>control systems</i> found on drawings and specifications					
		identify <b>specifications</b> to consider when selecting <b>control systems</b> and their components and accessories					
		explain how to incorporate various control strategies into control systems					
		explain purpose and operation of <i>control systems</i> and their components and accessories					
C-9.02.02L	demonstrate knowledge of codes and regulations pertaining to <i>control systems</i> and their components and accessories	interpret codes and regulations pertaining to <i>control systems</i> and their components and accessories					

control systems include: electrical, mechanical, electronic, app-based, wireless, predictive (Al-capable), pneumatic, centralized, distributed, integrated control circuits

specifications include: effective connection distances, number of inputs/outputs able to be controlled, communication compatibility, electromagnetic interference, connection and wireless signal reliability control strategies include: two position control, step control, modulating control, floating control, pulse width modulation (PWM), proportional (P), proportional integral (PI), proportional integral derivative (PID), Al, adaptive

C-9.03	Determines	placement of controls	system com	ponents and accessories	
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NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Skills			
	Performance Criteria	Evidence of Attainment		
C-9.03.01P	assess placement of <i>control systems</i>	placement of <i>control systems</i> is assessed according to serviceability, code requirements and <i>interference from</i> <i>external forces</i>		
C-9.03.02P	determine connection routing for <i>control system</i> components	connection routing for <b>control system</b> components is determined according to drawings and site visits		
C-9.03.03P	determine location of mechanical, electrical, electronic and digital control devices	location of mechanical, electrical, electronic and digital control devices is determined according to their intended function and operation		

#### **Range of Variables**

control systems include: electrical, mechanical, electronic, app-based, wireless, predictive (Al-capable), pneumatic, centralized, distributed, integrated control circuits

interference from external forces include: environment, electrical noise, pests

	Knowledge				
	Learning Outcomes	Learning Objectives			
C-9.03.01L	demonstrate knowledge of determining placement of <i>control systems</i> and their components	identify system <b>control strategies</b> and describe their characteristics and applications			
		interpret information pertaining to placement of <i>control systems</i> found on drawings and specifications			
		identify types of mechanical, electrical, electronic and digital control devices, and explain their purpose and operation			
C-9.03.02L	demonstrate knowledge of codes and regulations pertaining to <b>control system</b> components and accessories	interpret codes and regulations pertaining to <i>control system</i> components and accessories			

*control systems* include: electrical, mechanical, electronic, app-based, wireless, predictive (Al-capable), pneumatic, centralized, distributed, integrated control circuits

*control strategies* include: two position control, step control, modulating control, floating control, PWM, P, PI, PID, AI, adaptive

#### **C-9.04** Performs control system material take-off

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Skills			
	Performance Criteria	Evidence of Attainment		
C-9.04.01P	determine quantity of <i>materials</i> required	quantity of <i>materials</i> required is determined according to manufacturers' and engineering specifications, control requirements and location		
C-9.04.02P	identify alternative options for <i>materials</i>	alternative options for <i>materials</i> are identified according to availability, <i>environmental conditions</i> and <i>regulatory requirements</i>		

#### **Range of Variables**

*materials* include: control devices, wiring, tubing, hangers, fasteners, hardware, cables, connectors *environmental conditions* include: indoor/outdoor use of control components, operating temperature *regulatory requirements* include: electrical, restricted materials, food grade

	Knowledge			
	Learning Outcomes	Learning Objectives		
C-9.04.01L	demonstrate knowledge of performing control system take-off	identify <i>factors</i> to consider when determining <i>materials</i> required		
		describe procedures to perform control system take-off		
		identify types of alternative <i>materials</i> that may be considered as options		

*factors* include: location, quantity, length, obstacles, core drilling, saw cutting, underground wiring, supply chain issues

materials include: control devices, wiring, tubing, hangers, fasteners, hardware, cables, connectors

# **Task C-10 Plans retrofits**

#### **Task Descriptor**

Refrigeration and air conditioning mechanics plan the retrofit of HVAC/R systems to facilitate the seamless retrofiting of the equipment and to ensure the desired end result. Proper planning ensures system longevity and reliability and reduces operating costs. HVAC/R systems include residential, commercial, industrial and institutional applications. Retrofits may or may not have engineered drawings or supporting documentation, so it may be the responsibility of the refrigeration and air conditioning mechanic to perform design and analysis and complete the associated documentation.

#### **C-10.01** Analyzes energy efficiency of current system

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Skills			
	Performance Criteria	Evidence of Attainment		
C-10.01.01P	identify what equipment and components are eligible for retrofits	equipment and components' eligibility for retrofits is identified according to specifications		
C-10.01.02P	identify <b>efficiency data</b> on existing systems	<i>efficiency data</i> on existing systems is identified		
C-10.01.03P	evaluate changes to building load	changes to building load are evaluated		

C-10.01.04P	collect information on system performance history	information on system performance history is collected from occupants, visual inspection, service reports, trend logs and system tests
C-10.01.05P	inspect HVAC/R distribution system	HVAC/R distribution system are inspected to determine that compatibility, integrity and capacity are suitable for retrofit requirements

*efficiency data* includes: nameplate data, model numbers, SEER, SEER2, HSPF, COP, AWEF, cubic feet per minute (CFM), gallons per minute (GPM), maintenance logs, equipment modification records *changes to building load* include: building envelope (windows, doors, insulation), occupancy, ventilation, makeup air, humidity changes, occupant expectations, change in floor plans, new HVAC equipment in the environment, new heat-producing equipment (e.g., computers, lights, kitchen equipment)

*HVAC/R distribution systems* include: air distribution and components, hydronics, refrigerant piping, geothermal loops, zoning, VAV terminals, insulation

	Know	vledge
	Learning Outcomes	Learning Objectives
C-10.01.01L	demonstrate knowledge of <i>HVAC</i> and <i>refrigeration systems</i> , their <i>components</i> and <i>accessories</i>	identify types of <b>HVAC</b> and <b>refrigeration</b> <b>systems</b> and describe their characteristics and applications
		identify types of <i>HVAC/R components</i> and describe their characteristics and applications
		identify capacity ratings of <b>HVAC</b> and <i>refrigeration systems</i> , their <i>components</i> and <i>accessories</i>
		interpret information pertaining to <b>HVAC</b> and <b>refrigeration systems</b> found on drawings, specifications, graphs and tables
		identify types of <i>electrical components</i> and describe their characteristics and applications
		identify types of <b>energy-efficient</b> <b>equipment</b> and their accessories, and describe their characteristics and applications
		define SEER, SEER2, HSPF and COP
		describe backup, supplemental and auxiliary heating requirements for <b>HVAC</b> systems
		describe <b>HVAC</b> and <b>refrigeration system</b> equipment integration

C-10.01.02L	demonstrate knowledge of load calculations	describe procedures to perform <i>load</i> calculations for refrigeration systems
		describe procedures to perform <i>load</i> calculations for HVAC systems
C-10.01.03L	demonstrate knowledge of <i>capacity</i> control requirements	describe capacity control options and applications for <i>HVAC</i> and <i>refrigeration</i> systems
C-10.01.04L	demonstrate knowledge of analyzing energy efficiency of current system	identify tools and equipment used to analyze energy efficiency of current system, and describe their applications and procedures for use
		identify hazards and describe safe work practices to analyze energy efficiency of current system
		describe procedures to analyze energy efficiency of current system
		describe energy audits, <i>information</i> collected and their benefits
C-10.01.05L	demonstrate knowledge of codes and regulations pertaining to <b>HVAC</b> and <b>refrigeration systems</b> , their <b>components</b> and <b>accessories</b>	interpret codes and regulations pertaining to <b>HVAC</b> and <b>refrigeration systems</b> , their <b>components</b> and <b>accessories</b>

*HVAC systems* include: air conditioning systems, heat pump systems, packaged units, split systems, ductless split systems, VRF, chillers, geothermal systems, CRAC units, field built-up systems, inverter driven systems, humidification systems, dehumidification systems, heat reclaim equipment, HRVs, ERVs, district heating and cooling systems, evaporative coolers, hydronic systems

*refrigeration systems* include: coolers, freezers, food/beverage equipment, ice machines, supermarket and warehouse systems, plate freezers, blast coolers and freezers, compound systems, process refrigeration systems, chillers, cooling towers, ice rinks, refrigerated containers, marine refrigeration systems, ultra-low systems, cascade systems, cryogenic systems, adsorption and absorption systems

*HVAC/R components* include: compressors, condensers, metering devices, evaporators, remote aircooled condensers, filter driers, sight glasses, valves, regulators, receivers, pressure vessels, heat exchangers, vibration eliminators, liquid pumps, temperature sensors, pressure transducers, fans, blowers, air filters, economizers, controllers, oil management devices, insulation, condensate drains, supply diffusers, return grilles, dampers, flow switches

*accessories* include: pressure controls, temperature controls, safety controls, time clocks, defrost controls, crankcase heaters, pipe hangers and clamps, solenoid valves, regulating valves, check valves, oil separators, accumulators, stands and supports, condensate pumps, IAQ devices

*electrical components* include: motors (single-phase, three-phase, ECM), transformers, contactors, relays, solid state relays, starters, VSDs, VFDs, SCRs, capacitors, resistors, inverter drives, potentiometers, rheostats, disconnects

energy-efficient equipment includes: heat reclaim equipment, economizers, controls, BAS

*load calculations for refrigeration systems* include: HLHG (e.g., solar load), operating capacity ranges, ACH, ventilation, indoor and outdoor locations, design conditions (indoor and outdoor temperature and humidity ranges), building envelope, duct heat gain and loss, product being refrigerated or frozen, CO<sub>2</sub> levels, equipment loads, lighting loads, exhaust systems, occupancy rates and schedules, building pressurization, evaporation rates, psychrometric properties

**load calculations for HVAC systems** include: HLHG (e.g., solar load), operating capacity ranges, ACH, ventilation, design conditions (indoor and outdoor temperature and humidity ranges), building envelope, duct heat gain and loss, CO<sub>2</sub> levels, equipment loads, lighting loads, exhaust systems, occupancy rates and schedules, building pressurization, evaporation rates, psychrometric properties

*capacity control requirements* include: variable speed, variable capacity, staging, modulation, load variances, redundancies

*information collected* includes: building geometry (takeoffs), building materials (R-values), airtightness (blower door test), type of mechanical ventilation systems, climate conditions, duct loss/gain through unconditioned spaces

#### **C-10.02** Determines requirements for retrofits

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Sk	<b>kills</b>
	Performance Criteria	Evidence of Attainment
C-10.02.01P	perform revised <i>load calculations for</i> refrigeration systems	revised <i>load calculations for</i> <i>refrigeration systems</i> are performed according to assessment of current system
C-10.02.02P	perform revised <i>load calculations for</i> <i>HVAC systems</i>	revised <i>load calculations for HVAC</i> <i>systems</i> are performed according to assessment of current system
C-10.02.03P	assess <b>utility requirements</b> for new equipment installation	<i>utility requirements</i> for new equipment installation are assessed according to equipment requirements, site conditions and electrical code
C-10.02.04P	determine placement of system and components	placement of system and components is determined according to <i>factors</i> and surrounding <i>environmental issues</i>
C-10.02.05P	identify compatibility issues	compatibility issues between existing system and retrofit equipment are identified
C-10.02.06P	advise clients to determine their expectations and explain options and advantages of retrofit systems	clients are advised on equipment capabilities and technologies that are applicable

**load calculations for refrigeration systems** include: HLHG (e.g., solar load), operating capacity ranges, ACH, ventilation, indoor and outdoor locations, design conditions (indoor and outdoor temperature and humidity ranges), building envelope, duct heat gain and loss, product being refrigerated or frozen, CO<sub>2</sub> levels, equipment loads, lighting loads, exhaust systems, occupancy rates and schedules, building pressurization, evaporation rates, psychrometric properties

*load calculations for HVAC systems* include: HLHG (e.g., solar load), operating capacity ranges, ACH, ventilation, design conditions (indoor and outdoor temperature and humidity ranges), building envelope, duct heat gain and loss, CO<sub>2</sub> levels, equipment loads, lighting loads, exhaust systems, occupancy rates and schedules, building pressurization, evaporation rates, psychrometric properties

*utility requirements* include: panel sizing, grid capacity, building distribution, condensate drainage, fossil fuel supply, water supply, neighbourhood energy unit supply

*factors* (when placing system and components) include: sizing, manufacturers' clearances, serviceability, accessibility, scheduling and availability of utilities and services, structure, aesthetics, client, seismic, hazardous material abatement

environmental issues include: noise, exhaust and intake vent locations, environmental conditions

	Know	ledge
	Learning Outcomes	Learning Objectives
C-10.02.01L	demonstrate knowledge of determining requirements for retrofits	describe methods to perform <i>load</i> calculations for refrigeration systems
		describe methods to perform <i>load</i> calculations for HVAC systems
		describe <b>consequences of undersizing</b> an installation
		describe <b>consequences of oversizing</b> an installation
		describe <b>advantages of calculating load</b> for installations accurately
		identify <i>factors</i> to consider when sizing, selecting, and installing retrofit systems and components
		identify safety classifications of refrigerants
		determine compatibility of existing system and retrofit equipment
C-10.02.01L	demonstrate knowledge of <i>standards</i> <i>and codes</i> pertaining to HVAC/R systems, components and accessories	interpret <b>standards and codes</b> pertaining to HVAC/R systems, components and accessories

*load calculations for refrigeration systems* include: HLHG (e.g., solar load), operating capacity ranges, ACH, ventilation, indoor and outdoor locations, design conditions (indoor and outdoor temperature and humidity ranges), building envelope, duct heat gain and loss, product being refrigerated or frozen, CO<sub>2</sub> levels, equipment loads, lighting loads, exhaust systems, occupancy rates and schedules, building pressurization, evaporation rates, psychrometric properties

*load calculations for HVAC systems* include: HLHG (e.g., solar load), operating capacity ranges, ACH, ventilation, design conditions (indoor and outdoor temperature and humidity ranges), building envelope, duct heat gain and loss, CO<sub>2</sub> levels, equipment loads, lighting loads, exhaust systems, occupancy rates and schedules, building pressurization, evaporation rates, psychrometric properties

*consequences of undersizing an installation* include: not meeting heating and cooling loads, higher utility costs, poor thermal comfort

**consequences of oversizing an installation** include: higher capital costs, poor performance – short cycling and reduced overall efficiency, reduced equipment lifespan, thermal stratification (hot and cold spots), poor dehumidification performance, poor acoustic performance, other upgrades may be required (e.g., electrical panel)

advantages of calculating load for installations accurately include: right sized system that operates as designed, improved thermal comfort and dehumidification, lower utility bills, lower carbon emissions, reduced call backs, increased equipment life

*factors* (when sizing, selecting, and installing retrofit systems and components) include: local climate, environmental considerations, energy efficiency, source (well, loop, air), ambient conditions, physical location (total square footage, volume, room distribution, insulation quality)

safety classifications of refrigerants are: toxicity and flammability (e.g., A1, A2L, A3, B2L) standards and codes include: ASHRAE Standard 34; Boiler, Pressure Vessel, and Pressure Piping Code (CSA B51); Mechanical Refrigeration Code (CSA B52); Environmental Code of Practice for the Elimination of Fluorocarbon Emissions from Refrigeration and Air Conditioning Systems; NBC; CEC; Natural Gas and Propane Installation Code (CSA B149)

#### **C-10.03** Analyzes distribution requirements for retrofits

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Sk	ills
	Performance Criteria	Evidence of Attainment
C-10.03.01P	select and use <i>tools and equipment</i>	<i>tools and equipment</i> are selected and used according to task
C-10.03.02P	measure and record <i>distribution</i> capacity in current system	<i>distribution</i> capacity in current system is measured and recorded by performing <i>air</i> <i>flow tests</i> , <i>hydronic flow tests</i> and calculating refrigerant piping capacities
C-10.03.03P	analyze <b>options</b> for distribution system to accommodate retrofit equipment	options for distribution system to accommodate retrofit equipment are analyzed

*tools and equipment* include: pitot tubes and manometers, anemometers, velometers (electrical and mechanical), temperature measuring devices, air balancing hoods, air handler flow meters, digital gauges, airflow grids, electronic devices (apps), airflow charts and tables, duct calculator and design charts

*distribution* includes: airflow (static pressure, velocity, volume), insulation, pump/head pressure, duct size, diffusers, grilles, zoning, equipment access and serviceability

air flow tests include: pressure, velocity, volume

hydronic flow tests include: pressure, flow rate, velocity

*options* include: replacing, adding or removing ductwork; replacing, adding or removing piping; adapting power and fuel source; upgrading, removing or adjusting control systems

	Know	ledge
	Learning Outcomes	Learning Objectives
C-10.03.01L	demonstrate knowledge of distribution requirements for retrofits	interpret information pertaining to distribution requirements for equipment found on drawings and specifications
		describe air flow for HVAC/R systems
		describe hydronic flow for HVAC/R systems
		calculate refrigerant piping capabilities
C-10.03.02L	demonstrate knowledge of analyzing distribution requirements for retrofits	identify <b>tools and equipment</b> used to analyze distribution requirements, and describe their applications and procedures for use
		identify hazards and describe safe work practices to analyze distribution requirements
		describe procedures to analyze distribution requirements to ensure adequate distribution
		describe procedures to perform <b>air flow</b> <b>tests</b>
		describe procedures to perform <i>hydronic flow tests</i>
		describe consequences of undersizing or oversizing a distribution system
C-10.03.03L	demonstrate knowledge of codes and regulations pertaining to HVAC/R systems, components and accessories	interpret codes and regulations pertaining to HVAC/R systems, components and accessories

*tools and equipment* include: pitot tubes and manometers, anemometers, velometers (electrical and mechanical), temperature measuring devices, air balancing hoods, air handler flow meters, digital gauges, airflow grids, electronic devices (apps), airflow charts and tables, duct calculator and design charts

air flow tests include: pressure, velocity, volume

hydronic flow tests include: pressure, flow rate, velocity

consequences of undersizing or oversizing a distribution system include: noise complaints, underperformance, premature equipment failures, increased service costs and voiding warranty, loss of business reputation, reduced capacity and efficiency, greater reliance on supplemental or backup heating, incorrect airflow, poor humidity control, temperature imbalances/uneven distribution, excessive  $\Delta T$  (temperature change)

#### **C-10.04** Performs design and sizing of retrofit equipment and components

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Skills							
	Performance Criteria	Evidence of Attainment						
C-10.04.01P	evaluate <b>capacity control requirements</b>	<i>capacity control requirements</i> are evaluated according to load calculations, equipment protection and engineering specifications						
C-10.04.02P	evaluate backup, supplemental and auxiliary heating requirements	backup, supplemental and auxiliary heating requirements are evaluated according to thermal and economic balance points, load calculations and design conditions						
C-10.04.03P	assess <i>utility requirements</i> for retrofit equipment installation	<i>utility requirements</i> for retrofit equipment installation are assessed according to equipment requirements, site conditions and code requirements						
C-10.04.04P	evaluate equipment choices	equipment choices are evaluated according to <i>factors</i>						
C-10.04.05P	assess requirements for <b>energy-efficient</b> equipment	energy-efficient equipment requirements are assessed according to planned design and local regulations						
C-10.04.06P	reference available energy assessments	energy assessments are referenced to ensure energy efficiency program requirements are met						
C-10.04.07P	determine HVAC/R component limitations	HVAC/R component limitations are determined according to design specifications and operational requirements						

*capacity control requirements* include: variable speed, variable capacity, staging, modulation, load variances, redundancy

*utility requirements* include: panel sizing, grid capacity, building distribution, condensate drainage, fossil fuel supply, water supply, neighbourhood energy unit supply

*factors* include: inspection authority's equipment standards, fuel sources, refrigerant selection, installation location, climate zone, seismic requirements, snow clearance, drainage requirements, size of building, building envelope, manufacturers' specifications, LEED criteria, SEER and SEER2 criteria, HSPF criteria, AWEF criteria, distribution sizing

*energy-efficient equipment* includes: heat reclaim equipment, economizers, controls, BAS *HVAC/R component limitations* include: blower capacity, pressure drops, size, fluid flow, heating/cooling capacity, sensible heating ratio, outdoor ambient conditions (temperature and humidity), local code compliance

	Know	rledge
	Learning Outcomes	Learning Objectives
C-10.04.01L	demonstrate knowledge of performing design and sizing of retrofits	describe procedures to test airflow capacity for selecting retrofit equipment
		identify <b>possible issues</b> that may arise if testing of air flow capacity is not performed
		describe procedures to calculate energy performance
		describe procedures to calculate greenhouse gas (GHG) emissions performance
		describe pipe and duct sizing, P/T relationships and pressure/enthalpy relationships
		identify changes in climatic conditions and extreme temperature ranges that impact equipment design
		identify safety classifications of refrigerants
C-10.04.02L	demonstrate knowledge of <i>standards</i> <i>and codes</i> pertaining to HVAC/R systems, components and accessories	interpret <b>standards and codes</b> pertaining to HVAC/R systems, components and accessories

#### **Range of Variables**

*possible issues* include: noise complaints, underperformance, premature component failures, incorrect airflow, undersizing equipment so that it does not maximize energy and GHG reduction potential *safety classifications of refrigerants* are: toxicity and flammability (e.g., A1, A2L, A3, B2L) *standards and codes* include: ASHRAE Standard 34; Boiler, Pressure Vessel, and Pressure Piping Code (CSA B51); Mechanical Refrigeration Code (CSA B52); Environmental Code of Practice for the Elimination of Fluorocarbon Emissions from Refrigeration and Air Conditioning Systems; NBC; CEC; Natural Gas and Propane Installation Code (CSA B149)

# **C-10.05** Plans retrofit of control systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Skills							
	Performance Criteria	Evidence of Attainment						
C-10.05.01P	determine <i>control system</i> requirements	<i>control system</i> requirements are determined according to clients' needs, efficiency considerations and <i>equipment</i> <i>specifications</i>						
C-10.05.02P	determine ability to integrate new <i>control system</i> with existing <i>control system</i>	ability to integrate new <i>control system</i> with existing <i>control system</i> is determined according to <i>factors</i>						
C-10.05.03P	determine <i>location considerations</i>	<i>location considerations</i> are determined according to jurisdictional regulations and environmental conditions						
C-10.05.04P	determine operating ranges required	operating ranges required are determined to ensure safe control of equipment and safety of controlled space/product						
C-10.05.05P	determine wiring, cabling and connections used for <i>control systems</i>	wiring, cabling and connections used for <i>control systems</i> are determined according to manufacturers' specifications and design plan						
C-10.05.06P	verify electrical requirements for <i>control systems</i>	electrical requirements for <b>control</b> <b>systems</b> are verified according to equipment requirements, site conditions and electrical code						
C-10.05.07P	determine which <i>control approach</i> to use with new high efficiency system	<i>control approach</i> for new high efficiency system is determined						

#### **Range of Variables**

*control systems* include: electrical, mechanical, electronic, integrated control circuits, app-based, wireless, predictive (Al-capable), pneumatic, centralized, distributed

*equipment specifications* include: maximum allowable distances between components, number of component devices, design temperature

*factors* include: number of conductors required, compatibility of integrating system components, routing of wiring, wireless or hybrid components, communication protocols, code requirements

*location considerations* include: humidity, elevation, fail-safe requirements, temperature, outdoor reset, service access

*control approaches* include: design criteria, configuration, IAQ (CO<sub>2</sub>, contaminants), air changes, filtration, modulation of equipment, staging

	Know	ledge
	Learning Outcomes	Learning Objectives
C-10.05.01L	demonstrate knowledge of <i>control</i> systems and their components	define terminology associated with control systems and their components
		identify types of <i>control systems</i> and their components, and describe their characteristics and applications
		explain purpose and operation of <i>control systems</i> , devices and components
C-10.05.02L	demonstrate knowledge of planning retrofit of <i>control systems</i>	describe procedures to plan retrofit of control systems
		describe procedures to plan <b>control</b> <b>systems</b> for retrofits with dual energy sources
		identify <b>control approaches</b> , and describe their characteristics and applications
		perform <i>calculations</i> required for control system programming
C-10.05.03L	demonstrate knowledge of codes and regulations pertaining to <i>control systems</i> and their components	interpret codes and regulations pertaining to <i>control systems</i> and their components

*control systems* include: electrical, mechanical, electronic, integrated control circuits, app-based, wireless, predictive (Al-capable), pneumatic, centralized, distributed

*control approaches* include: design criteria, configuration, IAQ (CO<sub>2</sub>, contaminants), air changes, filtration, modulation of equipment, staging

calculations include: operating parameters, alarm threshold, air changes, energy performance
## Major Work Activity D Performs installation

## Task D-11 Installs HVAC/R systems

#### **Task Descriptor**

Refrigeration and air conditioning mechanics assemble, place, secure and connect components of HVAC/R systems for all types of applications such as residential, commercial, industrial and institutional. They also perform retrofits to replace old equipment and integrate high efficiency systems with existing systems.

#### **D-11.01** Confirms system layout

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Sk	ills
	Performance Criteria	Evidence of Attainment
D-11.01.01P	verify that equipment matches material take-offs	equipment is verified that it matches material take-offs to ensure correct components are installed
D-11.01.02P	determine modifications for <b>HVAC</b> and <b>refrigeration system</b> equipment, <b>components</b> and <b>accessories</b>	HVAC and refrigeration system equipment, components and accessories and their locations are modified to accommodate actual site conditions and equipment
D-11.01.03P	verify site measurements and clearance for <i>HVAC</i> and <i>refrigeration system</i> equipment, <i>components</i> and <i>accessories</i> and their location/orientation	site measurements and clearance for <i>HVAC</i> and <i>refrigeration system</i> equipment, <i>components</i> and <i>accessories</i> and their location/orientation are verified for serviceability and overall function
D-11.01.04P	verify <i>utilities</i>	required <i>utilities</i> are available

*HVAC systems* include: air conditioning systems, heat pump systems, packaged units, split systems, ductless split systems, VRF, chillers, geothermal systems, CRAC units, field built-up systems, inverter driven systems, humidification systems, dehumidification systems, heat reclaim equipment, HRVs, ERVs, district heating and cooling systems, evaporative coolers, hydronic systems

*refrigeration systems* include: coolers, freezers, food/beverage equipment, ice machines, supermarket and warehouse systems, plate freezers, blast coolers and freezers, compound systems, process refrigeration systems, chillers, cooling towers, ice rinks, refrigerated containers, marine refrigeration systems, ultra-low systems, cascade systems, cryogenic systems, adsorption and absorption systems

*HVAC/R components* include: compressors, condensers, metering devices, evaporators, remote aircooled condensers, filter driers, sight glasses, valves, regulators, receivers, pressure vessels, heat exchangers, vibration eliminators, liquid pumps, temperature sensors, pressure transducers, fans, blowers, air filters, economizers, controllers, oil management devices, insulation, condensate drains, supply diffusers, return grilles, dampers, flow switches

accessories include: pressure controls, temperature controls, safety controls, time clocks, defrost controls, crankcase heaters, pipe hangers and clamps, solenoid valves, regulating valves, check valves, oil separators, accumulators, stands and supports, condensate pumps, IAQ devices

utilities include: electrical, gas, water

	Know	ledge
	Learning Outcomes	Learning Objectives
D-11.01.01L	demonstrate knowledge of procedures to confirm HVAC/R system layout	interpret information found on material take-offs
		identify factors to consider when modifying <i>HVAC</i> and <i>refrigeration</i> <i>system components</i> and <i>accessories</i> or their location
		identify utilities required for <i>HVAC</i> and <i>refrigeration systems</i>
		identify types of <b>energy sources</b> and describe their application
		describe procedures to prepare for <b>HVAC</b> and <b>refrigeration system</b> installations

*HVAC systems* include: air conditioning systems, heat pump systems, packaged units, split systems, ductless split systems, VRF, chillers, geothermal systems, CRAC units, field built-up systems, inverter driven systems, humidification systems, dehumidification systems, heat reclaim equipment, HRVs, ERVs, district heating and cooling systems, evaporative coolers, hydronic systems

*refrigeration systems* include: coolers, freezers, food/beverage equipment, ice machines, supermarket and warehouse systems, plate freezers, blast coolers and freezers, compound systems, process refrigeration systems, chillers, cooling towers, ice rinks, refrigerated containers, marine refrigeration systems, ultra-low systems, cascade systems, cryogenic systems, adsorption and absorption systems

*HVAC/R components* include: compressors, condensers, metering devices, evaporators, remote aircooled condensers, filter driers, sight glasses, valves, regulators, receivers, pressure vessels, heat exchangers, vibration eliminators, liquid pumps, temperature sensors, pressure transducers, fans, blowers, air filters, economizers, controllers, oil management devices, insulation, condensate drains, supply diffusers, return grilles, dampers, flow switches

*accessories* include: pressure controls, temperature controls, safety controls, time clocks, defrost controls, crankcase heaters, pipe hangers and clamps, solenoid valves, regulating valves, check valves, oil separators, accumulators, stands and supports, condensate pumps, IAQ devices

energy sources include: electric, natural gas, propane, fossil fuels, solar, pneumatics, alternative fuels, steam, water

#### **D-11.02** Assembles HVAC/R equipment, components and accessories

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Sk	ills
	Performance Criteria	Evidence of Attainment
D-11.02.01P	select and use <i>tools and equipment</i>	<i>tools and equipment</i> are selected and used according to task
D-11.02.02P	unpack and perform pre-assembly check of <i>HVAC</i> and <i>refrigeration system</i> equipment, <i>components</i> and <i>accessories</i>	HVAC and refrigeration system equipment, components and accessories are unpacked to ensure quantity and type are correct, in good condition, and are compatible with utilities/energy sources, and installation and job specifications
D-11.02.03P	modify or adjust <b>HVAC</b> and <b>refrigeration</b> system equipment, <b>components</b> and <b>accessories</b> including orientation, flow direction, add-on kits and rotations	HVAC and refrigeration system equipment, components and accessories including orientation, flow direction, add-on kits and rotations are modified or adjusted to match system orientation and design
D-11.02.04P	confirm final assembly of <i>components</i> and <i>accessories</i>	final assembly of <i>components</i> and <i>accessories</i> is confirmed according to jurisdictional regulations and manufacturers' specifications

tools and equipment include: hand tools, power tools, rigging and hoisting equipment

*HVAC systems* include: air conditioning systems, heat pump systems, packaged units, split systems, ductless split systems, VRF, chillers, geothermal systems, CRAC units, field built-up systems, inverter driven systems, humidification systems, dehumidification systems, heat reclaim equipment, HRVs, ERVs, district heating and cooling systems, evaporative coolers, hydronic systems

*refrigeration systems* include: coolers, freezers, food/beverage equipment, ice machines, supermarket and warehouse systems, plate freezers, blast coolers and freezers, compound systems, process refrigeration systems, chillers, cooling towers, ice rinks, refrigerated containers, marine refrigeration systems, ultra-low systems, cascade systems, cryogenic systems, adsorption and absorption systems

*HVAC/R components* include: compressors, condensers, metering devices, evaporators, remote aircooled condensers, filter driers, sight glasses, valves, regulators, receivers, pressure vessels, heat exchangers, vibration eliminators, liquid pumps, temperature sensors, pressure transducers, fans, blowers, air filters, economizers, controllers, oil management devices, insulation, condensate drains, supply diffusers, return grilles, dampers, flow switches

*accessories* include: pressure controls, temperature controls, safety controls, time clocks, defrost controls, crankcase heaters, pipe hangers and clamps, solenoid valves, regulating valves, check valves, oil separators, accumulators, stands and supports, condensate pumps, IAQ devices

	Know	ledge
	Learning Outcomes	Learning Objectives
D-11.02.01L	demonstrate knowledge of assembling <i>HVAC</i> and <i>refrigeration system</i> equipment, <i>components</i> and <i>accessories</i>	identify <b>tools and equipment</b> used for assembling <b>HVAC</b> and <b>refrigeration</b> <b>system</b> equipment, <b>components</b> and <b>accessories</b> , and describe their applications and procedures for use
		interpret information pertaining to <b>HVAC</b> and <b>refrigeration system</b> equipment, <b>components</b> and <b>accessories</b> found on drawings and manufacturers' specifications
		identify <i>factors to consider</i> when assembling <i>HVAC</i> and <i>refrigeration</i> <i>system</i> equipment, <i>components</i> and <i>accessories</i>
		identify <i>components</i> and <i>accessories</i> used in assembly of <i>HVAC</i> and <i>refrigeration systems</i> , and describe their characteristics and applications
		identify hazards and describe safe work practices when assembling <i>HVAC</i> and <i>refrigeration systems</i>

*HVAC systems* include: air conditioning systems, heat pump systems, packaged units, split systems, ductless split systems, VRF, chillers, geothermal systems, CRAC units, field built-up systems, inverter driven systems, humidification systems, dehumidification systems, heat reclaim equipment, HRVs, ERVs, district heating and cooling systems, evaporative coolers, hydronic systems

*refrigeration systems* include: coolers, freezers, food/beverage equipment, ice machines, supermarket and warehouse systems, plate freezers, blast coolers and freezers, compound systems, process refrigeration systems, chillers, cooling towers, ice rinks, refrigerated containers, marine refrigeration systems, ultra-low systems, cascade systems, cryogenic systems, adsorption and absorption systems

*HVAC/R components* include: compressors, condensers, metering devices, evaporators, remote aircooled condensers, filter driers, sight glasses, valves, regulators, receivers, pressure vessels, heat exchangers, vibration eliminators, liquid pumps, temperature sensors, pressure transducers, fans, blowers, air filters, economizers, controllers, oil management devices, insulation, condensate drains, supply diffusers, return grilles, dampers, flow switches

*accessories* include: pressure controls, temperature controls, safety controls, time clocks, defrost controls, crankcase heaters, pipe hangers and clamps, solenoid valves, regulating valves, check valves, oil separators, accumulators, stands and supports, condensate pumps, IAQ devices

tools and equipment include: hand tools, power tools, rigging and hoisting equipment

factors to consider include: component placement, tool requirements, material list, scheduling

#### **D-11.03** Places HVAC/R equipment, components and accessories

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Skills							
	Performance Criteria	Evidence of Attainment						
D-11.03.01P	select and use <i>tools and equipment</i>	<i>tools and equipment</i> are selected and used according to task						
D-11.03.02P	install <b>anchors and supports</b>	<i>anchors and supports</i> are installed according to jurisdictional regulations and manufacturers' specifications						
D-11.03.03P	install <i>isolation components</i>	<i>isolation components</i> are installed to eliminate vibration transmission and noise						
D-11.03.04P	secure <b>HVAC</b> and <b>refrigeration system</b> equipment, <b>components</b> and <b>accessories</b>	HVAC and refrigeration system equipment, components and accessories are secured according to jurisdictional regulations and manufacturers' specifications						

*tools and equipment* include: chain falls, lifts, ladders, scaffolding, wrenches, measuring tapes, laser levels

*anchors and supports* include: hangers, straps, seismic restraints, fasteners, threaded rods, brackets, manufactured stands

*isolation components* include: spring isolators, cork/rubber pads, canvas connectors, vibration eliminators

*HVAC systems* include: air conditioning systems, heat pump systems, packaged units, split systems, ductless split systems, VRF, chillers, geothermal systems, CRAC units, field built-up systems, inverter driven systems, humidification systems, dehumidification systems, heat reclaim equipment, HRVs, ERVs, district heating and cooling systems, evaporative coolers, hydronic systems

*refrigeration systems* include: coolers, freezers, food/beverage equipment, ice machines, supermarket and warehouse systems, plate freezers, blast coolers and freezers, compound systems, process refrigeration systems, chillers, cooling towers, ice rinks, refrigerated containers, marine refrigeration systems, ultra-low systems, cascade systems, cryogenic systems, adsorption and absorption systems

*HVAC/R components* include: compressors, condensers, metering devices, evaporators, remote aircooled condensers, filter driers, sight glasses, valves, regulators, receivers, pressure vessels, heat exchangers, vibration eliminators, liquid pumps, temperature sensors, pressure transducers, fans, blowers, air filters, economizers, controllers, oil management devices, insulation, condensate drains, supply diffusers, return grilles, dampers, flow switches

*accessories* include: pressure controls, temperature controls, safety controls, time clocks, defrost controls, crankcase heaters, pipe hangers and clamps, solenoid valves, regulating valves, check valves, oil separators, accumulators, stands and supports, condensate pumps, IAQ devices

	Know	ledge
	Learning Outcomes	Learning Objectives
D-11.03.01L	demonstrate knowledge of <i>HVAC</i> and <i>refrigeration system</i> equipment, <i>components</i> and <i>accessories</i> , characteristics, applications and operation	identify types of <i>evaporators</i> and their <i>components</i> , and describe their characteristics, applications and operation
		identify types of <i>compressors</i> , and describe their characteristics, applications and operation
		identify types of <i>metering devices</i> and their components, and describe their characteristics, applications and operation
		identify types of <i>motors</i> and their components, and describe their characteristics, applications and operation
		identify types of <i>condensers/gas coolers</i> and their <i>components</i> , and describe their characteristics, applications and operation
		identify types of fluid coolers and their components, and describe their characteristics, applications and operation

D-11.03.02L	demonstrate knowledge of <i>HVAC</i> <i>systems</i> , their characteristics, applications and operation	identify types of <b>HVAC</b> systems and describe their characteristics, applications and operation
		identify types of <i>auxiliary heat rejection</i> <i>devices</i> and their components, and describe their characteristics, applications and operation
		identify <i>alternative heat transfer devices</i> and describe their <i>characteristics</i> , applications and operation
D-11.03.03L	demonstrate knowledge of <i>refrigeration systems</i> , their components, accessories, characteristics, applications and operation	identify types of <i>chillers</i> and their <i>components</i> , and describe their characteristics, applications and operation
		identify types of <i>industrial refrigeration systems</i> and describe their characteristics, applications and operation
		identify types of <i>refrigerant flow</i> <i>controls</i> , and describe their characteristics, applications and operation
		identify types of <i>refrigeration valves</i> and describe their characteristics, applications and operation
		identify types of <i>refrigeration accessory devices</i> and describe their characteristics, applications and operation
D-11.03.04L	demonstrate knowledge of <i>heat pump systems</i> , their components, accessories, characteristics, applications and operation	identify types of <i>heat pump systems</i> and their components and accessories, and describe their characteristics, applications and operation
		describe backup heating and supplemental heating for heat pumps
		describe operation of defrost cycle as it relates to heat pumps
		explain control sequences for heat pumps
		explain how variable speed and capacity affect heat pump performance and efficiency
		describe water/fluid quality as it relates to open and closed loop systems

D-11.03.05L	demonstrate knowledge of placing <i>HVAC</i> and <i>refrigeration system</i> equipment, <i>components</i> and <i>accessories</i>	identify <i>tools and equipment</i> used for placing <i>HVAC</i> and <i>refrigeration system</i> equipment, <i>components</i> and <i>accessories</i> , and describe their applications and procedures for use
		describe <b>anchors and supports</b> used to place <b>HVAC</b> and <b>refrigeration system</b> equipment
		identify types of <i>isolation components</i> used to eliminate vibration transmission and noise
		identify hazards and describe safe work practices pertaining to <i>HVAC</i> and <i>refrigeration system</i> equipment installations
		describe procedures to place <i>HVAC</i> and <i>refrigeration system</i> equipment
		interpret <i>documentation</i> for <i>HVAC</i> and <i>refrigeration system</i> installations
D-11.03.06L	demonstrate knowledge of <i>codes and regulations</i> pertaining to <i>HVAC</i> and <i>refrigeration systems</i>	interpret <b>codes and regulations</b> pertaining to <b>HVAC</b> and <b>refrigeration</b> systems

*HVAC systems* include: air conditioning systems, heat pump systems, packaged units, split systems, ductless split systems, VRF, chillers, geothermal systems, CRAC units, field built-up systems, inverter driven systems, humidification systems, dehumidification systems, heat reclaim equipment, HRVs, ERVs, district heating and cooling systems, evaporative coolers, hydronic systems

*refrigeration systems* include: coolers, freezers, food/beverage equipment, ice machines, supermarket and warehouse systems, plate freezers, blast coolers and freezers, compound systems, process refrigeration systems, chillers, cooling towers, ice rinks, refrigerated containers, marine refrigeration systems, ultra-low systems, cascade systems, cryogenic systems, adsorption and absorption systems

*HVAC/R components* include: compressors, condensers, metering devices, evaporators, remote aircooled condensers, filter driers, sight glasses, valves, regulators, receivers, pressure vessels, heat exchangers, vibration eliminators, liquid pumps, temperature sensors, pressure transducers, fans, blowers, air filters, economizers, controllers, oil management devices, insulation, condensate drains, supply diffusers, return grilles, dampers, flow switches

*accessories* include: pressure controls, temperature controls, safety controls, time clocks, defrost controls, crankcase heaters, pipe hangers and clamps, solenoid valves, regulating valves, check valves, oil separators, accumulators, stands and supports, condensate pumps, IAQ devices

*evaporators* include: direct expansion, flooded and liquid overfeed, forced and induced, brazed plate, primary and secondary surface, chiller barrel (fluid cooler)

**evaporator components** include: drain pan heaters, evaporator fans and controls, drain lines, flow switches, defrost heaters

compressors include: reciprocating, scroll, rotary, screw, centrifugal, swing, linear

*metering devices* include: hand expansion valve, piston, capillary tube, thermostatic expansion valve, automatic expansion valve, electronic expansion valve, electric expansion valve, high side and low side float control valve, orifice plate

motors include: multi-lead, dual-voltage, multi-speed, ECM, inverter, 3 phase

condensers/gas coolers include: air-cooled, water-cooled, evaporative, adiabatic

condenser/gas cooler components include: fans, centrifugal pumps, fill, eliminators

*auxiliary heat rejection devices* include: adiabatic heat exchanger, cooling towers (open and closed), evaporative coolers, internal and external sumps

alternative heat transfer devices include: eutectic plates, plate and frame

*characteristics* (of alternative heat transfer devices) include: counter flow, cross flow, parallel flow *chillers* include: direct expansion, flooded, absorption

*chiller components* include: compressors, oil pumps, condensers, purge units, chiller barrels, metering devices

industrial refrigeration systems include: parallel, compound, cascade, flooded, low-charge

*refrigerant flow controls* include: direct-acting, reverse-acting, pilot-operated, pressure regulators, reversing valves

refrigeration valves include: safety, metering, service/access, flow controls

*refrigeration accessory devices* include: regulators, filters and driers, liquid/moisture indicators, suction accumulators, oil separators, liquid receivers, pressure relief devices, heat exchangers

*heat pump systems* include: air-to-air, liquid-to-air, liquid-to-liquid, air-to-liquid, geothermal, solar, variable speed, VRF, dual fuel

*tools and equipment* include: chain falls, lifts, ladders, scaffolding, wrenches, measuring tapes, laser levels

*anchors and supports* include: hangers, straps, seismic restraints, fasteners, threaded rods, brackets, manufactured stands

*isolation components* include: spring isolators, cork/rubber pads, canvas connectors, vibration eliminators

*documentation* includes: start-up reports, commissioning reports, warranty documentation, environmental refrigeration documentation, record of pressure level, jurisdictional requirements, manufacturers' requirements, logbooks

*codes and regulations* include: CSA codes (B51, B52, B149), CEC, decibel noise level, seismic and hurricane restraints, jurisdictional

#### **D-11.04** Retrofits HVAC/R equipment refrigerants and refrigerant oils

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Skills							
	Performance Criteria	Evidence of Attainment						
D-11.04.01P	select and use <i>tools and equipment</i>	<i>tools and equipment</i> are selected and used according to task						
D-11.04.02P	identify <b>refrigerant oil</b> used in existing HVAC/R system	<i>refrigerant oil</i> being used in existing HVAC/R system is identified						
D-11.04.03P	drain <b>refrigerant oil</b>	refrigerant oil is drained						
D-11.04.04P	add recommended <i>refrigerant oil</i> to HVAC/R system prior to retrofitting	recommended <b>refrigerant oil</b> is added to HVAC/R system prior to retrofitting if existing <b>refrigerant oil</b> is different than retrofitted <b>refrigerant oil</b>						
D-11.04.05P	recover <b>refrigerant</b>	<i>refrigerant</i> is recovered according to best practices						

D-11.04.06P	replace <i>components</i>	components are replaced
D-11.04.07P	change or adjust metering device if required	metering device is changed or adjusted according to <i>refrigerant</i> manufacturers' specifications if required
D-11.04.08P	clean base screens	base screens are cleaned
D-11.04.09P	evacuate system	system is evacuated
D-11.04.10P	add new <b>refrigerant</b>	new <b>refrigerant</b> is added according to design specifications
D-11.04.11P	set up system operation with new <b>refrigerant</b>	system is operational with new <b>refrigerant</b>
D-11.04.12P	set up system super heat at compressor	system super heat at compressor is set up according to manufacturers' specifications
D-11.04.13P	check pressure drop on filters after adequate run time and replace if required	pressure drop on filters is checked after adequate run time, and filters are replaced if required
D-11.04.14P	check <i>refrigerant oil</i> quality after adequate run time and replace if required	<i>refrigerant oil</i> quality is checked after adequate run time and replaced if required

**tools and equipment** include: gauge manifolds, thermometers, refractometers, air and water cooled refrigerant recovery and recycle units, refrigerant hoses, refrigerant cylinders, weigh scales, valve core removal tools, valve core depressors, A1, A2L and A3 rated equipment, access fitting adapters, smart probes, cylinder heaters, portable ventilation equipment, fire extinguishers, liquid refrigerant pumps, PPE (e.g., masks, safety eyewear, personal monitors, gloves)

refrigerant oils include: mineral, AB, POE, PVE, PAG, PAO

*refrigerants* include: primary (CFC, HFC, HFO, HCFC, HC), natural (R-744, R-717), secondary (water, glycol solutions, brine solutions)

components include: gaskets, O-rings, filter driers, suction filters, oil filters

	Knowledge						
	Learning Outcomes	Learning Objectives					
D-11.04.01L	demonstrate knowledge of <i>refrigerants</i> and <i>refrigerant oils</i>	define terminology associated with HVAC/R <i>refrigerants</i> and <i>refrigerant</i> <i>oils</i>					
		identify types of <i>refrigerants</i> and <i>refrigerant oils</i> used to retrofit HVAC/R equipment, and describe their <i>characteristics</i> and applications					

D-11.04.02L	demonstrate knowledge of retrofitting HVAC/R equipment <i>refrigerants</i> and <i>refrigerant oils</i>	identify <b>tools and equipment</b> used to retrofit HVAC/R equipment <b>refrigerants</b> and <b>refrigerant oils</b> , and describe their applications and procedures for use
		describe procedures to retrofit HVAC/R equipment <b>refrigerants</b> and <b>refrigerant</b> oils
D-11.04.03L	demonstrate knowledge of training and certification requirements to retrofit HVAC/R equipment <i>refrigerants</i> and <i>refrigerant oils</i>	identify training and certification requirements to retrofit HVAC/R equipment <b>refrigerants</b> and <b>refrigerant</b> <b>oils</b>
D-11.04.04L	demonstrate knowledge of regulatory requirements pertaining to <i>refrigerants</i> and <i>refrigerant oils</i>	interpret standards, codes and regulations pertaining to <b>refrigerants</b> and <b>refrigerant oils</b>

*refrigerants* include: primary (CFC, HFC, HFO, HCFC, HC), natural (R-744, R-717), secondary (water, glycol solutions, brine solutions)

refrigerant oils include: mineral, AB, POE, PVE, PAG, PAO

*characteristics* include: glide, fractionation, saturation, dew point, bubble point, flammability, subcooled, superheated, triple point (R-744)

**tools and equipment** include: gauge manifolds, thermometers, refractometers, air and water cooled refrigerant recovery and recycle units, refrigerant hoses, refrigerant cylinders, weigh scales, valve core removal tools, valve core depressors, A1, A2L and A3 rated equipment, access fitting adapters, smart probes, cylinder heaters, portable ventilation equipment, fire extinguishers, liquid refrigerant pumps, PPE (e.g., masks, safety eyewear, personal monitors, gloves)

#### **D-11.05** Retrofits HVAC/R equipment, components and accessories

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Skills						
	Performance Criteria	Evidence of Attainment					
D-11.05.01P	select and use <i>tools and equipment</i>	<i>tools and equipment</i> are selected and used according to task					
D-11.05.02P	isolate energy sources	energy sources are isolated using lock-out and tag-out procedures					
D-11.05.03P	remove refrigerant and dispose of, store or reclaim	refrigerant is removed and disposed of, stored or reclaimed according to client's requirements, codes and jurisdictional regulations					
D-11.05.04P	disconnect existing <b>HVAC</b> and <b>refrigeration system</b> equipment from wiring, piping and ducting	existing <b>HVAC</b> and <b>refrigeration system</b> equipment is disconnected from wiring, piping and ducting					

D-11.05.05P	document disconnections for future reference	disconnections are documented for future reference
D-11.05.06P	take measurements	measurements are taken to ensure that <i>HVAC</i> and <i>refrigeration system</i> equipment will fit in location
D-11.05.07P	remove and dispose of existing <b>HVAC</b> and <b>refrigeration system</b> equipment	existing <i>HVAC</i> and <i>refrigeration system</i> equipment is removed according to client's requirements and jurisdictional regulations
D-11.05.08P	install <b>HVAC</b> and <b>refrigeration system</b> equipment, <b>components</b> and <b>accessories</b>	HVAC and refrigeration system equipment, components and accessories are installed according to manufacturers' specifications, codes and jurisdictional regulations
D-11.05.09P	integrate <b>HVAC</b> and <b>refrigeration</b> <b>system</b> equipment with supplemental systems	<b>HVAC</b> and <b>refrigeration system</b> equipment is integrated with supplemental systems
D-11.05.10P	update documentation	documentation is updated to reflect changes

*tools and equipment* include: chain falls, lifts, ladders, scaffolding, wrenches, measuring tapes, laser levels

*HVAC systems* include: air conditioning systems, heat pump systems, packaged units, split systems, ductless split systems, VRF, chillers, geothermal systems, CRAC units, field built-up systems, inverter driven systems, humidification systems, dehumidification systems, heat reclaim equipment, HRVs, ERVs, district heating and cooling systems, evaporative coolers, hydronic systems

*refrigeration systems* include: coolers, freezers, food/beverage equipment, ice machines, supermarket and warehouse systems, plate freezers, blast coolers and freezers, compound systems, process refrigeration systems, chillers, cooling towers, ice rinks, refrigerated containers, marine refrigeration systems, ultra-low systems, cascade systems, cryogenic systems, adsorption and absorption systems

*HVAC/R components* include: compressors, condensers, metering devices, evaporators, remote aircooled condensers, filter driers, sight glasses, valves, regulators, receivers, pressure vessels, heat exchangers, vibration eliminators, liquid pumps, temperature sensors, pressure transducers, fans, blowers, air filters, economizers, controllers, oil management devices, insulation, condensate drains, supply diffusers, return grilles, dampers, flow switches

*accessories* include: pressure controls, temperature controls, safety controls, time clocks, defrost controls, crankcase heaters, pipe hangers and clamps, solenoid valves, regulating valves, check valves, oil separators, accumulators, stands and supports, condensate pumps, IAQ devices

	Knowledge							
	Learning Outcomes	Learning Objectives						
D-11.05.01L	demonstrate knowledge of <i>HVAC</i> and <i>refrigeration systems</i> , their <i>components</i> , <i>accessories</i> , characteristics, applications and operation	identify types of <i>HVAC</i> and <i>refrigeration</i> <i>systems</i> and their <i>components</i> and <i>accessories</i> , and describe their characteristics and applications						
D-11.05.02L	demonstrate knowledge of retrofitting <i>HVAC</i> and <i>refrigeration system</i> equipment, <i>components</i> and <i>accessories</i>	identify types of <i>heating systems that</i> can be retrofitted with heat pump systems						
		identify <i>factors</i> to consider when retrofitting <i>HVAC</i> and <i>refrigeration systems</i>						
D-11.05.03L	demonstrate knowledge of procedures to retrofit <i>HVAC</i> and <i>refrigeration system</i> equipment, <i>components</i> and <i>accessories</i>	identify <b>tools and equipment</b> used to install <b>HVAC</b> and <b>refrigeration system</b> equipment, <b>components</b> and <b>accessories</b> , and describe their applications and procedures for use						
		identify hazards and describe safe work practices to retrofit <i>HVAC</i> and <i>refrigeration system</i> equipment, <i>components</i> and <i>accessories</i>						
		describe procedures to retrofit <i>HVAC</i> and <i>refrigeration system</i> equipment, <i>components</i> and <i>accessories</i>						
D-11.05.04L	demonstrate knowledge of training and certification requirements to retrofit <i>HVAC</i> and <i>refrigeration system</i> equipment, <i>components</i> and <i>accessories</i>	identify training and certification requirements to retrofit <i>HVAC</i> and <i>refrigeration system</i> equipment, <i>components</i> and <i>accessories</i>						
D-11.05.05L	demonstrate knowledge of standards, codes and regulations pertaining to <b>HVAC</b> and <b>refrigeration systems</b> , <b>components</b> and <b>accessories</b>	interpret standards, codes and regulations pertaining to <i>HVAC</i> and <i>refrigeration</i> <i>systems</i> , <i>components</i> and <i>accessories</i>						

*HVAC systems* include: air conditioning systems, heat pump systems, packaged units, split systems, ductless split systems, VRF, chillers, geothermal systems, CRAC units, field built-up systems, inverter driven systems, humidification systems, dehumidification systems, heat reclaim equipment, HRVs, ERVs, district heating and cooling systems, evaporative coolers, hydronic systems

*refrigeration systems* include: coolers, freezers, food/beverage equipment, ice machines, supermarket and warehouse systems, plate freezers, blast coolers and freezers, compound systems, process refrigeration systems, chillers, cooling towers, ice rinks, refrigerated containers, marine refrigeration systems, ultra-low systems, cascade systems, cryogenic systems, adsorption and absorption systems

*HVAC/R components* include: compressors, condensers, metering devices, evaporators, remote aircooled condensers, filter driers, sight glasses, valves, regulators, receivers, pressure vessels, heat exchangers, vibration eliminators, liquid pumps, temperature sensors, pressure transducers, fans, blowers, air filters, economizers, controllers, oil management devices, insulation, condensate drains, supply diffusers, return grilles, dampers, flow switches *accessories* include: pressure controls, temperature controls, safety controls, time clocks, defrost controls, crankcase heaters, pipe hangers and clamps, solenoid valves, regulating valves, check valves, oil separators, accumulators, stands and supports, condensate pumps, IAQ devices

*heating systems that can be retrofitted with heat pump systems* include: hydronic (air-to-liquid, liquid-to-air, liquid-to-liquid, air-to-air), forced-air

*factors* include: energy efficiency, compatibility issues, appropriate equipment, reusable components, space availability, electrical upgrades, emerging technologies

*tools and equipment* include: chain falls, lifts, ladders, scaffolding, wrenches, measuring tapes, laser levels

#### **D-11.06** Installs fasteners, brackets and hangers

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Skills						
	Performance Criteria	Evidence of Attainment					
D-11.06.01P	select and use <i>tools and equipment</i>	<i>tools and equipment</i> are selected and used according to task					
D-11.06.02P	select fasteners, brackets and hangers	fasteners, brackets and hangers are selected according to job specifications					
D-11.06.03P	lay out fasteners, brackets and hangers	fasteners, brackets and hangers are laid out according to drawings and site conditions					
D-11.06.04P	<i>construct and fabricate</i> hangers and brackets from raw material	hangers and brackets are <b>constructed</b> <b>and fabricated</b> from raw material for custom applications					
D-11.06.05P	assess <b>base material</b> dimensions, condition, and strength, and select appropriate fasteners and hardware	hangers and hardware are installed securely to <i>base material</i>					
D-11.06.06P	<i>mount</i> brackets and hangers	brackets and hangers are <i>mounted</i> according to codes, job specifications and environmental conditions					

#### **Range of Variables**

*tools and equipment* include: hand tools, power tools, measuring tapes, levelling devices *constructing and fabricating* includes: cutting, bending, bolting, welding, fastening *base materials* include: concrete products, decking, metal (steel and aluminum), wood/lumber, wall board, composite

mounting includes: placing, drilling, anchoring, adhering, screwing, nailing, bolting, clamping

	Knowledge						
	Learning Outcomes	Learning Objectives					
D-11.06.01L	demonstrate knowledge of procedures to install fasteners, brackets and hangers	identify types of fasteners, brackets and hangers, and describe their characteristics and applications					
		interpret information pertaining to fasteners, brackets and hangers found on drawings and specifications					
		identify <b>tools and equipment</b> used to install fasteners, brackets and hangers, and describe their applications and procedures for use					
		describe procedures to install fasteners, brackets and hangers					
		identify procedures to fabricate a bracket or support					
		identify when scope of work requires additional certification					
		identify requirements for selecting hardware and fasteners for specific base materials					
D-11.06.02L	demonstrate knowledge of codes and regulations pertaining to installation of fasteners, brackets and hangers	identify and interpret code requirements for securing fasteners, brackets and hangers					

tools and equipment include: hand tools, power tools, measuring tapes, levelling devices

## D-11.07 Installs HVAC/R piping and tubing

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Skills				
	Performance Criteria	Evidence of Attainment			
D-11.07.01P	bend tubing	tubing is bent according to installation requirements			
D-11.07.02P	support piping and tubing	piping and tubing is supported using hangers, supports and saddles according to codes and design specifications			
D-11.07.03P	install <b>accessories</b>	<i>accessories</i> are installed according to design specifications, manufacturers' recommendations and site conditions			

D-11.07.04P	connect piping, tubing and accessories	piping, tubing and accessories are connected by brazing (while purging with inert gas) or using mechanical connections
D-11.07.05P	perform pressure test on system to ensure integrity of joints	pressure test is performed on system to determine if it is leak-free
D-11.07.06P	insulate piping and tubing	piping and tubing are insulated according to environmental conditions, location, applications, and design and manufacturers' specifications

*accessories* include: valves (isolation, solenoid, regulating, check), metering devices, filter driers, sight glasses, flow controls, vibration eliminators, oil separators, accumulators, receivers, heat exchangers, pressure vessels

	Knowledge							
	Learning Outcomes	Learning Objectives						
D-11.07.01L	demonstrate knowledge of HVAC/R piping and tubing, their components, accessories, characteristics and applications	identify types of <i>piping and tubing</i> <i>materials</i> , fittings and accessories used in HVAC/R systems						
		interpret information pertaining to installation of piping and tubing found in manufacturers' and code specifications						
D-11.07.02L	demonstrate knowledge of installing piping and tubing	describe procedures to install HVAC/R piping and tubing						
		describe <b>procedures</b> to cut, fit and connect piping and tubing						
D-11.07.03L	demonstrate knowledge of codes and regulations pertaining to installation of HVAC/R piping and tubing	interpret codes and regulations pertaining to HVAC/R piping and tubing installations						

#### **Range of Variables**

*piping and tubing materials* include: copper, copper-iron, brass, steel, stainless steel, aluminum, fittings *procedures* include: cleaning, reaming, swaging, annealing, brazing, welding, threading, flaring, purging with inert gas

## D-11.08 Applies HVAC/R holding charge

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Skills						
	Performance Criteria	Evidence of Attainment					
D-11.08.01P	select and use <i>tools and equipment</i>	<i>tools and equipment</i> are selected and used according to task					
D-11.08.02P	select <b>refrigerant</b>	<i>refrigerant</i> is selected according to design specifications					
D-11.08.03P	add <b>refrigerant</b> into system and monitor quantity	<i>refrigerant</i> is added into system and quantity is monitored to a positive pressure according to industry practices and standards					
D-11.08.04P	label system and complete <i>records</i>	system is labelled and <i>records</i> are completed					

#### **Range of Variables**

*tools and equipment* include: service valve wrenches, charging scales, transfer pumps, gauge manifolds, refrigerant hoses

*refrigerants* include: primary (CFC, HFC, HFO, HCFC, HC), natural (R-744, R-717), secondary (water, glycol solutions, brine solutions)

records include: refrigerant type, quantity, ambient and space temperature, holding charge and pressure

	Knowledge						
	Learning Outcomes	Learning Objectives					
D-11.08.01L	demonstrate knowledge of <i>refrigerants</i> , their applications and procedures for use	identify types of <i>refrigerants</i> , and describe their <i>characteristics</i> and applications					
D-11.08.02L	demonstrate knowledge of applying HVAC/R holding charge	identify <b>tools and equipment</b> used to apply holding charge, and describe their applications and procedures for use					
		describe procedures to pressurize system with <b>refrigerant</b> to achieve positive pressure					
		identify hazards and safe work practices pertaining to <b>refrigerants</b> and applying a holding charge					
D-11.08.03L	demonstrate knowledge of codes and regulations pertaining to applying HVAC/R holding charge	interpret codes and regulations pertaining to <i>refrigerants</i>					

*refrigerants* include: primary (CFC, HFC, HFO, HCFC, HC), natural (R-744, R-717), secondary (water, glycol solutions, brine solutions)

*characteristics* include: glide, fractionation, saturation, dew point, bubble point, flammability, subcooled, superheated, triple point (R-744)

*tools and equipment* include: service valve wrenches, charging scales, transfer pumps, gauge manifolds, refrigerant hoses

## Task D-12 Installs control systems

#### **Task Descriptor**

Refrigeration and air conditioning mechanics assemble, place, secure and connect controls for HVAC/R systems for all types of applications such as residential, commercial, industrial and institutional. The controls enable systems to start, stop, modulate, monitor and report conditions.

#### D-12.01 Places control system components

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Skills						
	Performance Criteria	Evidence of Attainment					
D-12.01.01P	select and use <i>tools and equipment</i>	<i>tools and equipment</i> are selected and used according to task					
D-12.01.02P	unpack and perform pre-assembly check	controls and devices are unpacked and checked to ensure they are correct and in good condition					
D-12.01.03P	determine location, <i>orientation and position</i> of controls and devices	location, <b>orientation and position</b> of controls and devices are determined according to design specifications and site conditions					
D-12.01.04P	assemble and install controls and devices	controls and devices are assembled and installed according to <b>codes</b> , jurisdictional regulations and manufacturers' specifications					
D-12.01.05P	mount and secure controls and devices	controls and devices are mounted and secured according to manufacturers' specifications and site conditions					
D-12.01.06P	configure <i>hardware options</i>	<i>hardware options</i> are configured prior to installation according to job requirements and manufacturers' specifications					
D-12.01.07P	update documentation	documentation is updated to reflect changes					

*tools and equipment* include: hand tools, power equipment, instruments, access equipment *orientation and position* include: spring or capacitor action, clockwise vs counter-clockwise, fail-safe *codes* include: CEC, NBC, CSA codes (B51, B52)

hardware options include: dip switches, jumpers, clockwise/counter-clockwise settings

	Knowledge						
	Learning Outcomes	Learning Objectives					
D-12.01.01L	demonstrate knowledge of types of controls and devices, their applications and operation	interpret information pertaining to controls and devices found on drawings and specifications					
D-12.01.02L	demonstrate knowledge of installing control systems	identify <b>tools and equipment</b> used to install control systems, and describe their applications and procedures for use					
		describe method for determining location, orientation and position of control systems					
		describe procedures to install and configure control systems					
		interpret information pertaining to control systems found in drawings, wiring diagrams, and schematic diagrams					
		identify hazards and describe safe work practices pertaining to control systems					
D-12.01.03L	demonstrate knowledge of codes and regulations pertaining to controls and devices	interpret <i>codes</i> and regulations pertaining to controls and devices					

#### **Range of Variables**

*tools and equipment* include: hand tools, power equipment, instruments, access equipment *orientation and position* include: spring or capacitor action, clockwise vs counter-clockwise, fail-safe *codes* include: CEC, NBC, CSA codes (B51, B52)

## D-12.02 Connects control systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Skills						
	Performance Criteria	Evidence of Attainment					
D-12.02.01P	determine circuitry and load requirements	calculations are completed based on voltage and amperage requirements, specifications and codes					
D-12.02.02P	select wiring, cabling and tubing	wiring, cabling and tubing are selected according to manufacturers' specifications, codes, standards, trade practices and job specifications					
D-12.02.03P	lay out wiring, cabling and tubing path	wiring, cabling and tubing layout is performed according to drawings					
D-12.02.04P	install interconnecting wiring, cabling and tubing	interconnecting wiring, cabling and tubing are installed according to codes, standards, job specifications and wiring diagrams					
D-12.02.05P	prepare wiring and tubing for final connection to control devices	wiring and tubing are prepared for final connection to control devices using <b>tools</b> and materials					
D-12.02.06P	select termination points	termination points are selected according to system requirements					
D-12.02.07P	arrange and secure wiring and tubing	wiring and tubing are arranged and secured for aesthetics, protection and serviceability					
D-12.02.08P	terminate control wiring and tubing	control wiring and tubing are terminated according to site-specific drawings, manufacturers' specifications and jurisdictional regulations					
D-12.02.09P	update documentation	documentation is updated to reflect changes					

#### **Range of Variables**

*tools and materials* include: hand tools, power tools, dielectric paste, instruments, heat transfer compounds, fittings, clamps, connectors, cable ties, conduits

	Knowledge							
	Learning Outcomes	Learning Objectives						
D-12.02.01L	demonstrate knowledge of connecting system wiring and control tubing	identify <b>tools and materials</b> used to connect and secure wiring and control tubing, and describe their applications and procedures for use						
		identify hazards and describe safe work practices pertaining to control circuits						
		describe sequence of operation of control circuit and explain its relationship to its physical wiring and tubing configuration						
		interpret information pertaining to control systems found in drawings, <i>wiring</i> <i>diagrams</i> and schematic diagrams						
		identify types of <i>wiring diagrams</i> and describe their characteristics and applications						
D-12.02.02L	demonstrate knowledge of codes and regulations pertaining to HVAC/R control system wiring and tubing	interpret codes and regulations pertaining to HVAC/R control system wiring and tubing						

*tools and materials* include: hand tools, power tools, dielectric paste, instruments, heat transfer compounds, fittings, clamps, connectors, cable ties, conduits *wiring diagrams* include: pictorial, schematic, ladder, component location, installation

#### D-12.03 Retrofits control systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Skills						
	Performance Criteria	Evidence of Attainment					
D-12.03.01P	select and use <i>tools and materials</i>	tools and materials are selected and used according to task					
D-12.03.02P	document disconnections for future reference	disconnections are documented for future reference					
D-12.03.03P	unpack and perform pre-assembly check	controls and devices are unpacked and checked to ensure they are correct and in good condition					
D-12.03.04P	isolate energy sources	energy sources are isolated using lock-out and tag-out procedures					

D-12.03.05P	remove old devices	old devices are removed and disposed of or repurposed according to client's requirements and jurisdictional regulations
D-12.03.06P	determine location, <i>orientation and position</i> of controls and devices	location, <b>orientation and position</b> of controls and devices are determined according to design specifications and site conditions
D-12.03.07P	assemble and install controls and devices	controls and devices are assembled and installed according to <b>codes</b> , jurisdictional regulations and manufacturers' specifications
D-12.03.08P	mount and secure controls and devices	controls and devices are mounted and secured according to manufacturers' specifications and site conditions
D-12.03.09P	configure <i>hardware options</i>	<i>hardware options</i> are configured according to job requirements and manufacturers' specifications
D-12.03.10P	update documentation	documentation is updated to reflect changes

*tools and materials* include: hand tools, power tools, dielectric paste, instruments, heat transfer compounds, fittings, clamps, connectors, cable ties, conduit, tubing, wiring

*orientation and position* include: spring or capacitor action, clockwise vs counter-clockwise, fail-safe *codes* include : CEC, NBC, CSA (B51, B52)

hardware options include: dip switches, jumpers, clockwise/counter-clockwise settings

	Knowledge						
	Learning Outcomes	Learning Objectives					
D-12.03.01L	demonstrate knowledge of <i>control</i> systems and their components	define terminology associated with control systems and their components					
		identify types of <i>control systems</i> and their components, and describe their characteristics and applications					
		explain purpose and operation of <i>control systems</i> , devices and components					
		identify <i>communication protocols</i> for <i>control systems</i> and describe their associated security levels					

D-12.03.02L	demonstrate knowledge of retrofitting control systems	identify <b>tools and materials</b> used to retrofit <b>control systems</b> , and describe their applications and procedures for use
		describe procedures to retrofit <i>control</i> <i>systems</i>
		interpret information pertaining to <i>control systems</i> found in drawings, wiring diagrams and schematic diagrams
D-12.03.03L	demonstrate knowledge of <i>codes</i> and regulations pertaining to <i>control systems</i> and devices	interpret <i>codes</i> and regulations pertaining to <i>control systems</i> and devices

*control systems* include: electrical, mechanical, electronic, integrated control circuits, app-based, wireless, predictive (Al-capable), pneumatic, centralized, distributed

*communication protocols* include: standards, codes and regulations, baud rates, addressing network communication protocols (Modbus, BACnet [MS/TP, IP], Hypertext Transfer Protocol [HTTP], Address Resolution Protocol [ARP], Highway Addressable Remote Transducer [HART], local operation network [LON]), serial port protocols (e.g., RS-232, RS-485, RS-422), communication speeds, wireless networks (e.g., Wi-Fi, ZigBee, Z-Wave), ethernet, Bluetooth, manufacturers' proprietary systems

*tools and materials* include: hand tools, power tools, dielectric paste, instruments, heat transfer compounds, fittings, clamps, connectors, cable ties, conduit, tubing, wiring *codes* include : CEC, NBC, CSA (B51, B52)

# Major Work Activity E Performs commissioning

# Task E-13 Commissions new and retrofitted HVAC/R and control system components

#### **Task Descriptor**

Commissioning of HVAC/R systems is an important final step to ensure all components are complete, refrigerant charge is verified, and all required adjustments are finalized. A commissioning procedure occurs when new equipment, replacement equipment, or retrofitted equipment is installed, including all new and existing components, within a system.

Procedures which occur during commissioning shall validate the required operation as detailed in the site and manufacturers' specifications to ensure optimal operating efficiency, while maintaining compliance with current jurisdictional and environmental regulations.

#### **E-13.01** Performs pre-start-up checks for HVAC/R systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Skills						
	Performance Criteria	Evidence of Attainment					
E-13.01.01P	select and use <i>tools and equipment</i>	<i>tools and equipment</i> are selected and used according to task and manufacturers' specifications					
E-13.01.02P	ensure energy/power source and equipment are compatible	compatibility of energy/power source and equipment are verified					
E-13.01.03P	verify control wiring	control wiring is verified according to manufacturers' specifications and jurisdictional regulations					
E-13.01.04P	verify completion of installation	completion of installation is verified by checking for <i>factors</i>					
E-13.01.05P	check control settings	control settings are set to maintain safe operation according to manufacturers' specifications					
E-13.01.06P	verify that equipment is securely fastened and mounted	equipment is securely fastened and mounted according to codes, regulations, site conditions and manufacturers' specifications					

E-13.01.07P	check <i>electrical connections</i> and components	electrical connections and components are checked to detect loose or damaged wiring according to jurisdictional regulations and manufacturers' specifications
E-13.01.08P	ensure free movement of <i>movable</i> components	<i>movable components</i> are free to move
E-13.01.09P	verify holding charge applied during installation	holding charge applied during installation is verified by checking circuit pressure and referring to holding charge reports
E-13.01.10P	verify oil and lubricant level	level of oil and lubricant are verified according to site conditions and manufacturers' specifications
E-13.01.11P	energize crankcase heaters	crankcase heaters are energized according to manufacturers' recommendations
E-13.01.12P	verify <b>heat transfer mediums</b>	<i>heat transfer mediums</i> are present and verified for quality and concentration according to site conditions and manufacturers' specifications

*tools and equipment* include: hand tools, diagnostic and measuring equipment *factors* include: presence of field installed parts, missing parts, shipping mounts and straps that have not been removed, placement of controls, positioning of valves

*electrical connections* include: terminal strips, crimped and wire nuts, grounding and bonding wires *movable components* include: drives, dampers, actuators, fans, motors, pumps, valves *heat transfer mediums* include: glycol, brine, water, refrigerants

	Knowledge						
	Learning Outcomes	Learning Objectives					
E-13.01.01L	demonstrate knowledge of performing pre-start-up checks for <i>HVAC</i> and <i>refrigeration systems</i>	identify <b>tools and equipment</b> used for checking <b>HVAC</b> and <b>refrigeration</b> <b>systems</b> , <b>components</b> and <b>accessories</b> , and describe their applications and procedures for use					
		identify new and retrofitted <i>HVAC</i> and <i>refrigeration systems</i> , and describe their characteristics and applications					
		describe procedures to ensure proper installation of <i>HVAC</i> and <i>refrigeration systems</i>					
		interpret information pertaining to <b>HVAC</b> and <b>refrigeration systems</b> found in drawings, wiring diagrams, manufacturers' literature and schematic diagrams					
		identify correct sequence of operation prior to start-up					

		identify <b>heat transfer mediums</b> , and describe their characteristics and applications
		identify calculations to determine volume of <i>heat transfer mediums</i>
		describe <i>methods used to determine</i> charge of HVAC and refrigeration systems
E-13.01.02L	demonstrate knowledge of codes and regulations pertaining to <i>HVAC</i> and <i>refrigeration systems</i> , <i>components</i> and <i>accessories</i>	interpret codes and regulations pertaining to <i>HVAC</i> and <i>refrigeration systems</i> , <i>components</i> and <i>accessories</i>

*HVAC systems* include: air conditioning systems, heat pump systems, packaged units, split systems, ductless split systems, VRF, chillers, geothermal systems, CRAC units, field built-up systems, inverter driven systems, humidification systems, dehumidification systems, heat reclaim equipment, HRVs, ERVs, district heating and cooling systems, evaporative coolers, hydronic systems

*refrigeration systems* include: coolers, freezers, food/beverage equipment, ice machines, supermarket and warehouse systems, plate freezers, blast coolers and freezers, compound systems, process refrigeration systems, chillers, cooling towers, ice rinks, refrigerated containers, marine refrigeration systems, ultra-low systems, cascade systems, cryogenic systems, adsorption and absorption systems tools, diagnostic, and measuring equipment.

tools and equipment include: hand tools, diagnostic and measuring equipment

*HVAC/R components* include: compressors, condensers, metering devices, evaporators, remote aircooled condensers, filter driers, sight glasses, valves, regulators, receivers, pressure vessels, heat exchangers, vibration eliminators, liquid pumps, temperature sensors, pressure transducers, fans, blowers, air filters, economizers, controllers, oil management devices, insulation, condensate drains, supply diffusers, return grilles, dampers, flow switches

*accessories* include: pressure controls, temperature controls, safety controls, time clocks, defrost controls, crankcase heaters, pipe hangers and clamps, solenoid valves, regulating valves, check valves, oil separators, accumulators, stands and supports, condensate pumps, IAQ devices

heat transfer mediums include: glycol, brine, water, refrigerants

*methods used to determine charge of HVAC and refrigeration systems* include: weighing critical charge; interpreting charge charts; checking sight glass, internal volume of refrigerant piping and components; checking subcooling and superheat

#### **E-13.02** Performs start-up of HVAC/R systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Skills						
	Performance Criteria	Evidence of Attainment					
E-13.02.01P	select and use <i>tools and equipment</i>	<i>tools and equipment</i> are selected and used according to task					
E-13.02.02P	turn on and verify <b>utilities</b>	<i>utilities</i> are turned on and verified to allow equipment to start with correct rotation, acceptable voltage range, and utility parameters are within specifications					
E-13.02.03P	verify <i>factors</i>	<i>factors</i> are verified according to components, and site specifications and requirements					
E-13.02.04P	verify direction of rotating components	direction of rotating components is verified visually or by using a phase sequencing meter to allow equipment to operate according to manufacturers' specifications					
E-13.02.05P	test and adjust HVAC/R control components	HVAC/R control components are tested according to design specifications and adjusted according to operating conditions					
E-13.02.06P	verify system sequence of operation	sequence of system operation is verified					
E-13.02.07P	verify system operation	system operation is verified by measuring <i>system conditions</i> according to site conditions and manufacturers' specifications					

#### **Range of Variables**

*tools and equipment* include: hand tools, diagnostic and measuring equipment *utilities* include: electrical, gas, water

*factors* include: phasing, voltage imbalance and amperage, refrigerant charge adjustments, oil levels, operating pressures and temperatures, system control adjustments, manufacturers' specifications and recommendations, liquid or air requirements, superheat and subcooling

system conditions include: amperage draw, pressures, temperatures, air and fluid flow

	Know	/led ge
	Learning Outcomes	Learning Objectives
E-13.02.01L	demonstrate knowledge of performing start-up of <i>HVAC</i> and <i>refrigeration</i> <i>systems</i>	identify <b>tools and equipment</b> used to perform start-up of <b>HVAC</b> and <b>refrigeration systems</b> , and describe their applications and procedures for use
		identify hazards and describe safe work practices when commissioning <i>HVAC</i> and <i>refrigeration systems</i>
		identify new and retrofitted <b>HVAC</b> and <b>refrigeration systems</b> , and describe their characteristics and applications
		identify <i>factors</i> to consider when performing an <i>HVAC</i> and <i>refrigeration</i> <i>system</i> start-up
		identify documentation requirements for system start-up and commissioning
		describe procedures required to start up and commission <i>HVAC</i> and <i>refrigeration</i> <i>systems</i>
		describe procedures to test and adjust components
		describe sequence of operation of <b>HVAC</b> and <i>refrigeration systems</i>
		describe operating system conditions and procedures to validate
E-13.02.02L	demonstrate knowledge of codes and regulations pertaining to <i>HVAC</i> and <i>refrigeration systems</i>	interpret codes and regulations pertaining to <i>HVAC</i> and <i>refrigeration systems</i>

*HVAC systems* include: air conditioning systems, heat pump systems, packaged units, split systems, ductless split systems, VRF, chillers, geothermal systems, CRAC units, field built-up systems, inverter driven systems, humidification systems, dehumidification systems, heat reclaim equipment, HRVs, ERVs, district heating and cooling systems, evaporative coolers, hydronic systems

*refrigeration systems* include: coolers, freezers, food/beverage equipment, ice machines, supermarket and warehouse systems, plate freezers, blast coolers and freezers, compound systems, process refrigeration systems, chillers, cooling towers, ice rinks, refrigerated containers, marine refrigeration systems, ultra-low systems, cascade systems, cryogenic systems, adsorption and absorption systems

tools and equipment include: hand tools, diagnostic and measuring equipment

*factors* include: phasing, voltage imbalance and amperage, refrigerant charge adjustments, oil levels, operating pressures and temperatures, system control adjustments, manufacturers' specifications and recommendations, liquid or air requirements, superheat and subcooling

#### E-13.03

#### Performs start-up checks for control systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Sł	kills
	Performance Criteria	Evidence of Attainment
E-13.03.01P	select and use <i>tools and equipment</i>	<i>tools and equipment</i> are selected and used according to task
E-13.03.02P	verify that electrical, pneumatic and electronic connections are completed	electrical, pneumatic and electronic connections on <i>control systems</i> are completed according to manufacturers' specifications and jurisdictional regulations
E-13.03.03P	apply power	power is applied to energize control system
E-13.03.04P	configure <b>software options</b>	<b>software options</b> are configured according to job requirements and manufacturers' specifications
E-13.03.05P	check <i>control signals</i>	<i>control signals</i> are checked according to site requirements

#### **Range of Variables**

tools and equipment include: hand tools, diagnostic and measuring equipment control systems include: electrical, mechanical, electronic, integrated control circuits, app-based, wireless, predictive (AI-capable), pneumatic, centralized, distributed

software options include: BAS, equipment controller, remote monitoring, adjusting set points control signals include: voltage, pressures, current, resistance

	Know	/ledge
	Learning Outcomes	Learning Objectives
E-13.03.01L	demonstrate knowledge of performing start-up checks for <i>control systems</i>	identify <b>tools and equipment</b> used to start up <b>control systems</b> , and describe their applications and procedures for use
		identify hazards and describe safe work practices when commissioning <i>control</i> <i>systems</i>
		identify new and retrofitted <b>HVAC</b> and <b>refrigeration systems</b> , and describe their characteristics and applications
		describe system and control operation processes and sequences

		describe procedures to start up and commission <i>control systems</i>
		describe procedures to verify electrical control circuit systems and components using schematic wiring diagrams
		identify <b>control signals</b> and describe their characteristics and applications
		interpret information pertaining to HVAC/R electronic controls found on drawings, specifications and service manuals
		describe procedures to perform diagnosis of electronic controls
E-13.03.02L	demonstrate knowledge of codes and regulations pertaining to HVAC/R <i>control systems</i>	identify codes and regulations pertaining to HVAC/R <i>control systems</i>
E-13.03.03L	demonstrate knowledge of <i>digital</i> <i>technology</i> and <i>electronic devices</i> used with <i>control systems</i>	describe procedures to start up <b>control</b> systems with <b>digital technology</b> and electronic devices

control systems include: electrical, mechanical, electronic, integrated control circuits, app-based, wireless, predictive (AI-capable), pneumatic, centralized, distributed

tools and equipment include: hand tools, diagnostic and measuring equipment

HVAC systems include: air conditioning systems, heat pump systems, packaged units, split systems, ductless split systems, VRF, chillers, geothermal systems, CRAC units, field built-up systems, inverter driven systems, humidification systems, dehumidification systems, heat reclaim equipment, HRVs, ERVs, district heating and cooling systems, evaporative coolers, hydronic systems

refrigeration systems include: coolers, freezers, food/beverage equipment, ice machines, supermarket and warehouse systems, plate freezers, blast coolers and freezers, compound systems, process refrigeration systems, chillers, cooling towers, ice rinks, refrigerated containers, marine refrigeration systems, ultra-low systems, cascade systems, cryogenic systems, adsorption and absorption systems control signals include: voltage, pressures, current, resistance

digital technology includes: direct digital control, PLC, microprocessor, communication protocols, software

electronic devices include: computers, laptops, smart phones, user interface modules, tablets

### E-13.04 Completes HVAC/R system charge

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Sk	ills
	Performance Criteria	Evidence of Attainment
E-13.04.01P	select and use <i>tools and equipment</i>	<i>tools and equipment</i> are selected and used according to task
E-13.04.02P	verify type of <i>refrigerant</i> required for system	type of <b>refrigerant</b> required for system is verified according to site conditions and manufacturers' specifications
E-13.04.03P	operate system	system is operated according to site conditions and manufacturers' specifications
E-13.04.04P	measure and interpret <b>operating load</b> conditions	operating load conditions are measured and interpreted according to site conditions and manufacturers' specifications
E-13.04.05P	verify and adjust <i>refrigerant</i> charge and oil level	<b>refrigerant</b> charge and oil level are verified and adjusted according to site conditions and manufacturers' specifications
E-13.04.06P	label system	system is labelled with type and amount of <i>refrigerant</i> and oil according to code and jurisdictional regulations

#### **Range of Variables**

*tools and equipment* include: hand tools, diagnostic and measuring equipment, charging tools and equipment

*refrigerants* include: primary (CFC, HFC, HFO, HCFC, HC), natural (R-744, R-717), secondary (water, glycol solutions, brine solutions)

*operating load conditions* include: amperage, voltage, RPM, temperatures, operating pressures, superheat and subcooling

	Know	rledge
	Learning Outcomes	Learning Objectives
E-13.04.01L	demonstrate knowledge of completing HVAC/R system charge	identify <b>tools and equipment</b> used to complete HVAC/R system charge, and describe their applications and procedures for use
		identify hazards and describe safe work practices when completing HVAC/R system charge
		identify new and retrofitted <i>HVAC</i> and <i>refrigeration systems</i> , and describe their characteristics and applications
		describe pressure/temperature chart and its use in determining refrigerant <i>characteristics</i>
		describe methods to determine charge of an HVAC and refrigeration system
		describe procedures to complete system charge
E-13.04.02L	demonstrate knowledge of <i>refrigerants</i> , their applications and procedures for use	identify types of <i>refrigerants</i> , and describe their <i>characteristics</i> and applications
E-13.04.03L	demonstrate knowledge of codes and regulations pertaining to <i>refrigerants</i>	identify codes and regulations pertaining to <i>refrigerants</i>

*tools and equipment* include: hand tools, diagnostic and measuring equipment, charging tools and equipment

*HVAC systems* include: air conditioning systems, heat pump systems, packaged units, split systems, ductless split systems, VRF, chillers, geothermal systems, CRAC units, field built-up systems, inverter driven systems, humidification systems, dehumidification systems, heat reclaim equipment, HRVs, ERVs, district heating and cooling systems, evaporative coolers, hydronic systems

**refrigeration systems** include: coolers, freezers, food/beverage equipment, ice machines, supermarket and warehouse systems, plate freezers, blast coolers and freezers, compound systems, process refrigeration systems, chillers, cooling towers, ice rinks, refrigerated containers, marine refrigeration systems, ultra-low systems, cascade systems, cryogenic systems, adsorption and absorption systems *characteristics* include: glide, fractionation, saturation, dew point, bubble point, flammability, subcooled, superheated, triple point (R-744)

*methods to determine charge of an HVAC and refrigeration system* include: measuring superheat and subcooling, weighing critical charge, interpreting charge charts, checking sight glass, internal volume, condenser flooding considerations, amperage, temperatures, manufacturers' specifications *refrigerants* include: primary (CFC, HFC, HFO, HCFC, HC), natural (R-744, R-717), secondary (water, glycol solutions, brine solutions)

#### **E-13.05** Sets up primary and secondary HVAC/R system components

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Sk	ills
	Performance Criteria	Evidence of Attainment
E-13.05.01P	select and use <i>tools and equipment</i>	<i>tools and equipment</i> are selected and used according to task
E-13.05.02P	adjust controls, valves and regulators	controls, valves and regulators are operating according to site conditions and specifications
E-13.05.03P	measure and interpret readings from primary and secondary <i>HVAC</i> and <i>refrigeration systems</i>	readings from primary and secondary <i>HVAC</i> and <i>refrigeration systems</i> are measured and interpreted
E-13.05.04P	adjust <b>primary HVAC/R components</b>	<i>primary HVAC/R components</i> are adjusted according to site conditions and specifications
E-13.05.05P	adjust secondary HVAC/R components	<b>secondary HVAC/R components</b> are adjusted according to site conditions and specifications

#### **Range of Variables**

tools and equipment include: hand tools, diagnostic and measuring equipment

*HVAC systems* include: air conditioning systems, heat pump systems, packaged units, split systems, ductless split systems, VRF, chillers, geothermal systems, CRAC units, field built-up systems, inverter driven systems, humidification systems, dehumidification systems, heat reclaim equipment, HRVs, ERVs, district heating and cooling systems, evaporative coolers, hydronic systems

*refrigeration systems* include: coolers, freezers, food/beverage equipment, ice machines, supermarket and warehouse systems, plate freezers, blast coolers and freezers, compound systems, process refrigeration systems, chillers, cooling towers, ice rinks, refrigerated containers, marine refrigeration systems, ultra-low systems, cascade systems, cryogenic systems, adsorption and absorption systems

*primary HVAC/R components* include: metering devices, flow controls, pressure regulating valves, compressors, fans, pumps, dampers, heat exchangers

*secondary HVAC/R components* include: valves (balancing, relief), pumps, fans, flow controls, temperature controls, heat exchangers, expansion tanks

	Know	vledge
	Learning Outcomes	Learning Objectives
E-13.05.01L	demonstrate knowledge of setting up primary and secondary HVAC/R components	identify <b>tools and equipment</b> used to set up <b>primary</b> and <b>secondary HVAC/R</b> <b>components</b> , and describe their applications and procedures for use
		identify hazards and describe safe work practices when setting up <b>primary</b> and <b>secondary HVAC/R components</b>
		identify new and retrofitted <b>HVAC</b> and <b>refrigeration systems</b> , and describe their characteristics and applications
		identify types of <i>primary HVAC/R</i> <i>components</i> , their characteristics, applications and operation
		identify types of <b>secondary HVAC/R</b> <b>components</b> , their characteristics, applications and operation
		describe procedures to set up <b>primary</b> and <b>secondary HVAC/R components</b>
E-13.05.02L	demonstrate knowledge of codes and regulations pertaining to <i>primary</i> and <i>secondary HVAC/R components</i>	identify codes and regulations pertaining to <i>primary</i> and <i>secondary HVAC/R components</i>

*primary HVAC/R components* include: metering devices, flow controls, pressure regulating valves, compressors, fans, pumps, dampers, heat exchangers

*secondary HVAC/R components* include: valves (balancing, relief), pumps, fans, flow controls, temperature controls, heat exchangers, expansion tanks

tools and equipment include: hand tools, diagnostic and measuring equipment

*HVAC systems* include: air conditioning systems, heat pump systems, packaged units, split systems, ductless split systems, VRF, chillers, geothermal systems, CRAC units, field built-up systems, inverter driven systems, humidification systems, dehumidification systems, heat reclaim equipment, HRVs, ERVs, district heating and cooling systems, evaporative coolers, hydronic systems

*refrigeration systems* include: coolers, freezers, food/beverage equipment, ice machines, supermarket and warehouse systems, plate freezers, blast coolers and freezers, compound systems, process refrigeration systems, chillers, cooling towers, ice rinks, refrigerated containers, marine refrigeration systems, ultra-low systems, cascade systems, cryogenic systems, adsorption and absorption systems

## **Task E-14 Verifies system performance**

#### **Task Descriptor**

Refrigeration and air conditioning mechanics perform start-up checks and set operating parameters of new and retrofitted control systems to ensure that controls and safety components are set up correctly and to ensure proper operation of HVAC/R systems.

#### **E-14.01** Verifies/sets operating parameters

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Skills	
	Performance Criteria	Evidence of Attainment
E-14.01.01P	select and use <i>tools and equipment</i>	<i>tools and equipment</i> are selected and used according to task
E-14.01.02P	verify <b>parameters</b>	<i>parameters</i> are verified according to manufacturers' specifications, site conditions and client requirements
E-14.01.03P	program <i>controllers</i>	<i>controllers</i> are programmed to defined sets of <i>parameters</i>
E-14.01.04P	adjust operating controls	<i>operating controls</i> are adjusted according to manufacturers' specifications, site conditions and client requirements
E-14.01.05P	adjust parameter set points	parameter set points are adjusted according to load requirements and ambient conditions
E-14.01.06P	calibrate <i>components</i>	<i>components</i> are calibrated to ensure accurate measurement and communication of <i>components</i> to <i>controllers</i>
E-14.01.07P	test operation of safety controls	operation of <i>safety controls</i> is tested

#### **Range of Variables**

tools and equipment include: hand tools, diagnostic and measuring equipment

parameters include: alarm, humidity, temperature, pressures, flow, levels

*controllers* include: timers, microprocessors, analog and digital control systems, electronic devices *operating controls* include: thermostats, economizer controls, pressure switches

*components* include: thermostats, pressure controls, transducers, hybrid systems (pneumatic, electronic), enthalpy controllers

*safety controls* include: high and low pressure switches, high and low temperature switches, compressor overload switches, oil pressure safety switches, flow switches

	Knowledge	
	Learning Outcomes	Learning Objectives
E-14.01.01L	demonstrate knowledge of setting operating parameters	identify <b>tools and equipment</b> used to set operating parameters, and describe their applications and procedures for use
		describe procedures to verify and set operating parameters
		interpret information pertaining to control systems found on drawings and specifications
		describe procedures to calibrate components and operating controls
		describe procedures to adjust parameter set points
E-14.01.02L	demonstrate knowledge of codes and regulations pertaining to safety parameters	identify and interpret codes and regulations pertaining to safety parameters

*tools and equipment* include: hand tools, diagnostic and measuring equipment *components* include: thermostats, pressure controls, transducers, hybrid systems (pneumatic, electronic), enthalpy controllers

operating controls include: thermostats, economizer controls, pressure switches
# E-14.02 Verifies system integration

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Skills						
	Performance Criteria	Evidence of Attainment					
E-14.02.01P	select and use <i>tools and equipment</i>	<i>tools and equipment</i> are selected and used according to task					
E-14.02.02P	verify operating parameters	operating parameters are verified to ensure integration and compatibility with existing systems according to site conditions and manufacturers' specifications					
E-14.02.03P	adjust controls, valves and regulators	controls, valves and regulators are operating according to site conditions and specifications					
E-14.02.04P	measure and interpret readings from <i>HVAC</i> and <i>refrigeration systems</i>	readings from <b>HVAC</b> and <b>refrigeration</b> <b>systems</b> are measured and interpreted with integrated systems					

#### **Range of Variables**

tools and equipment include: hand tools, diagnostic and measuring equipment

*HVAC systems* include: air conditioning systems, heat pump systems, packaged units, split systems, ductless split systems, VRF, chillers, geothermal systems, CRAC units, field built-up systems, inverter driven systems, humidification systems, dehumidification systems, heat reclaim equipment, HRVs, ERVs, district heating and cooling systems, evaporative coolers, hydronic systems

**refrigeration systems** include: coolers, freezers, food/beverage equipment, ice machines, supermarket and warehouse systems, plate freezers, blast coolers and freezers, compound systems, process refrigeration systems, chillers, cooling towers, ice rinks, refrigerated containers, marine refrigeration systems, ultra-low systems, cascade systems, cryogenic systems, adsorption and absorption systems

	Knowledge							
	Learning Outcomes	Learning Objectives						
E-14.02.01L	demonstrate knowledge of verifying system integration	identify <b>tools and equipment</b> used to verify system integration, and describe their applications and procedures for use						
		describe procedures to verify system integration						
		interpret information pertaining to system integration found on drawings and specifications						
E-14.02.02L	demonstrate knowledge of codes and regulations pertaining to system integration	identify and interpret codes and regulations pertaining to system integration						

tools and equipment include: hand tools, diagnostic and measuring equipment

# **E-14.03** Performs system optimization

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Skills						
	Performance Criteria	Evidence of Attainment					
E-14.03.01P	select and use <i>tools and equipment</i>	<i>tools and equipment</i> are selected and used according to task					
E-14.03.02P	verify operating parameters	operating parameters are verified to ensure optimal energy efficiency according to site conditions and manufacturers' specifications					
E-14.03.03P	adjust operating parameters	operating parameters are adjusted to ensure optimal energy efficiency according to site conditions and manufacturers' specifications					

#### **Range of Variables**

tools and equipment include: hand tools, diagnostic and measuring equipment

	Knowledge								
	Learning Outcomes	Learning Objectives							
E-14.03.01L	demonstrate knowledge of performing system optimization	identify <b>tools and equipment</b> used to perform system optimization, and describe their applications and procedures for use							
		describe procedures to perform system optimization							
		interpret information pertaining to system optimization found on drawings and specifications							
E-14.03.02L	demonstrate knowledge of codes and regulations pertaining to system optimization	identify and interpret codes and regulations pertaining to system optimization							

# **Range of Variables**

tools and equipment include: hand tools, diagnostic and measuring equipment

# E-14.04

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Skills						
	Performance Criteria	Evidence of Attainment					
E-14.04.01P	record <b>testing results</b> of operating parameters	operating parameters are recorded for reference and warranty issues, and compared with baseline information					
E-14.04.02P	record data from testing <i>parameters</i>	data from testing <b>parameters</b> are recorded according to manufacturers' specifications, site requirements and jurisdictional regulations					
E-14.04.03P	complete and submit <b>commissioning</b> documentation	<i>commissioning documentation</i> is completed according to engineering and manufacturers' specifications, site requirements and jurisdictional regulations					
E-14.04.04P	explain system operational procedures and specifications to end user, project personnel or client	system operational procedures and specifications are explained to end user, project personnel or client					
E-14.04.05P	provide <i>service and installation</i> <i>documentation</i> to end user, project personnel or client	service and installation documentation is provided to end user, project personnel or client according to manufacturers' specifications					

## **Range of Variables**

*testing results* include: voltages, pressures, efficiencies, temperatures, amperages, combustion analyzes (may require further certification in some jurisdictions), flow rates, fluid quality *parameters* include: alarm, humidity, temperature, pressures, flow, levels

*commissioning documentation* includes: start-up sheets, commissioning reports, punch lists, check lists, site specifications

service and installation documentation includes: manuals, as-built drawings, start-up sheets, warranty letters

	Knowledge								
	Learning Outcomes	Learning Objectives							
E-14.04.01L	demonstrate knowledge of documentation requirements for commissioning, their characteristics and applications	identify documentation requirements for commissioning, and describe their characteristics and applications							
		interpret information pertaining to documentation requirements for commissioning found in manufacturers' specifications							
E-14.04.02L	demonstrate knowledge of procedures to complete <i>commissioning documentation</i>	describe procedures to complete commissioning documentation							
		identify tests that need to be completed to take measurements for commissioning and how to record <b>testing results</b>							
		describe procedures to hand over systems to end users							
E-14.04.03L	demonstrate knowledge of regulatory requirements pertaining to <b>commissioning documentation</b>	identify codes, standards and regulations pertaining to <i>commissioning documentation</i>							

*commissioning documentation* includes: start-up sheets, commissioning reports, punch lists, check lists, site specifications

*testing results* include: voltages, pressures, efficiencies, temperatures, amperages, combustion analyzes (may require further certification in some jurisdictions), flow rates, fluid quality

# Major Work Activity F Performs maintenance and service

# Task F-15 Maintains HVAC/R systems

# **Task Descriptor**

Refrigeration and air conditioning mechanics maintain systems to increase longevity, reliability and efficiency by analyzing the system and its application, and ensuring safe operating conditions.

# F-15.01 Inspects HVAC/R systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Skills								
	Performance Criteria	Evidence of Attainment							
F-15.01.01P	select and use <i>tools and equipment</i>	<i>tools and equipment</i> are selected and used according to task							
F-15.01.02P	inspect monitoring equipment and system operational logs to identify operation history	operational checks are performed according to manufacturers' specifications and jurisdictional regulations							
F-15.01.03P	perform <b>sensory inspection</b> of <b>HVAC/R</b> components	<i>sensory inspection</i> of <i>HVAC/R</i> <i>components</i> is performed to determine abnormalities and conformity to codes							
F-15.01.04P	perform safety and <b>operational checks</b>	safety and <b>operational checks</b> are performed by simulating demand according to requirements, manufacturers' recommendations and jurisdictional regulations							
F-15.01.05P	identify source of abnormalities	source of abnormalities is identified							
F-15.01.06P	identify HVAC/R components that require additional service	HVAC/R components that require additional service are identified							

*tools and equipment* include: thermometers, gauges, hand tools, electrical meters, psychrometers, air flow measurement tools, fluid flow measurement tools, manifold gauges, leak detection tools

sensory inspection includes: visual, touch, auditory, smell

*HVAC/R components* include: compressors, condensers, metering devices, evaporators, remote aircooled condensers, filter driers, sight glasses, valves, regulators, receivers, pressure vessels, heat exchangers, vibration eliminators, liquid pumps, temperature sensors, pressure transducers, fans, blowers, air filters, economizers, controllers, oil management devices, insulation, condensate drains, supply diffusers, return grilles, dampers, flow switches

*operational checks* include: motor operation, VFDs, actuator and damper, fan cycling, oil levels, building and environmental safety systems, compressor operation, air and fluid flow

*additional service* includes: adjusting, calibrating, replacing system components, testing, cleaning, filtering, power washing of coils, changing filters, performing chemical treatment, corrosion testing of heat exchange systems

	Knowledge						
	Learning Outcomes	Learning Objectives					
F-15.01.01L	demonstrate knowledge of <i>HVAC</i> and <i>refrigeration systems</i> , their <i>components</i> , characteristics, applications and operation	identify types of <i>HVAC</i> and <i>refrigeration systems</i> and their <i>components</i> , and describe their characteristics and applications					
		explain purpose and operation of <i>HVAC</i> and <i>refrigeration systems</i> and their <i>components</i>					
		identify sequence of operation required for correct operation of <i>HVAC</i> and <i>refrigeration systems</i>					
F-15.01.02L	demonstrate knowledge of inspecting <b>HVAC</b> and <b>refrigeration systems</b>	identify <b>tools and equipment</b> used to inspect <b>HVAC</b> and <b>refrigeration</b> <b>systems</b> , and describe their applications and procedures for use					
		describe procedures to inspect and test <i>HVAC</i> and <i>refrigeration systems</i> and their <i>components</i>					
		identify <b>HVAC</b> and <b>refrigeration system</b> and <b>component</b> abnormalities, and describe their causes and procedures for repair					
F-15.01.03L	demonstrate knowledge of codes and regulations pertaining to <i>HVAC</i> and <i>refrigeration systems</i>	interpret codes and regulations pertaining to <i>HVAC</i> and <i>refrigeration systems</i>					

*HVAC systems* include: air conditioning systems, heat pump systems, packaged units, split systems, ductless split systems, VRF, chillers, geothermal systems, CRAC units, field built-up systems, inverter driven systems, humidification systems, dehumidification systems, heat reclaim equipment, HRVs, ERVs, district heating and cooling systems, evaporative coolers, hydronic systems

*refrigeration systems* include: coolers, freezers, food/beverage equipment, ice machines, supermarket and warehouse systems, plate freezers, blast coolers and freezers, compound systems, process refrigeration systems, chillers, cooling towers, ice rinks, refrigerated containers, marine refrigeration systems, ultra-low systems, cascade systems, cryogenic systems, adsorption and absorption systems

*HVAC/R components* include: compressors, condensers, metering devices, evaporators, remote aircooled condensers, filter driers, sight glasses, valves, regulators, receivers, pressure vessels, heat exchangers, vibration eliminators, liquid pumps, temperature sensors, pressure transducers, fans, blowers, air filters, economizers, controllers, oil management devices, insulation, condensate drains, supply diffusers, return grilles, dampers, flow switches

*tools and equipment* include: thermometers, gauges, hand tools, electrical meters, psychrometers, air flow measurement tools, fluid flow measurement tools, manifold gauges, leak detection tools

#### F-15.02 Performs predictive and scheduled maintenance on HVAC/R systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Skills							
	Performance Criteria	Evidence of Attainment						
F-15.02.01.P	select and use <i>tools and equipment</i>	<i>tools and equipment</i> are selected and used according to task						
F-15.02.02P	replace <b>consumables</b>	<i>consumables</i> are replaced according to manufacturers' recommendations, maintenance schedule, normal wear and abnormalities						
F-15.02.03P	lubricate bearings, motors and linkages	bearings, motors and linkages are lubricated as required						
F-15.02.04P	replace oil in gear boxes and compressors	oil in gear boxes and compressors is replaced according to manufacturers' recommendations						
F-15.02.05P	clean <b>HVAC/R components</b>	HVAC/R components are cleaned to maintain system performance using system-compatible cleaners						
F-15.02.06P	visually check and torque electrical connections of <i>HVAC/R components</i>	electrical connections of <i>HVAC/R</i> <i>components</i> are visually checked and torqued to prevent electrical failure						

F-15.02.07P	verify operation and calibration of safety devices	operation and calibration of safety devices are verified according to manufacturers' specifications
F-15.02.08P	verify operation of system	system is operating according to system design
F-15.02.09P	update electronic records, documents and on-site logbooks	electronic records, documents and on-site logbooks are updated according to company and client policies

*tools and equipment* include: thermometers, gauges, hand tools, electrical meters, psychrometers, air flow measurement tools, fluid flow measurement tools, manifold gauges, leak detection tools, thermal imagers

*consumables* include: filters, belts, chemical treatment, grease, lubricants, seals, sealants, electrical connectors, tape, caps, plugs

*HVAC/R components* include: compressors, condensers, metering devices, evaporators, remote aircooled condensers, filter driers, sight glasses, valves, regulators, receivers, pressure vessels, heat exchangers, vibration eliminators, liquid pumps, temperature sensors, pressure transducers, fans, blowers, air filters, economizers, controllers, oil management devices, insulation, condensate drains, supply diffusers, return grilles, dampers, flow switches

	Knowledge					
	Learning Outcomes	Learning Objectives				
F-15.02.01L	demonstrate knowledge of <i>HVAC</i> and <i>refrigeration systems</i> , their <i>components</i> , <i>accessories</i> , <i>consumables</i> , characteristics, applications and operation	identify types of <i>HVAC</i> and <i>refrigeration</i> <i>systems</i> and their <i>components,</i> <i>accessories,</i> and <i>consumables</i> , and describe their characteristics and applications				
		explain purpose and operation of <i>HVAC</i> and <i>refrigeration systems</i> and their <i>components</i> , <i>accessories</i> and <i>consumables</i>				
F-15.02.02L	demonstrate knowledge of performing predictive and scheduled maintenance on <i>HVAC</i> and <i>refrigeration systems</i>	identify <b>tools and equipment</b> used to perform maintenance on <b>HVAC</b> and <b>refrigeration systems</b> , and describe their applications and procedures for use				
		describe procedures to maintain <i>HVAC</i> and <i>refrigeration systems</i> , <i>components</i> and <i>accessories</i>				
		identify <b>HVAC</b> and <b>refrigeration system</b> <b>abnormalities</b> and describe their causes and procedures for repair				
		describe procedures to perform a basic diagnosis of electronic controls				
		identify sequence of operation required for proper function of <i>HVAC</i> and <i>refrigeration systems</i>				

F-15.02.03L	demonstrate knowledge of thermal imaging	interpret thermal imaging to find system deficiencies
F-15.02.04L	demonstrate knowledge of codes and regulations pertaining to <i>HVAC</i> and <i>refrigeration systems</i>	interpret codes and regulations pertaining to <i>HVAC</i> and <i>refrigeration systems</i>

*HVAC systems* include: air conditioning systems, heat pump systems, packaged units, split systems, ductless split systems, VRF, chillers, geothermal systems, CRAC units, field built-up systems, inverter driven systems, humidification systems, dehumidification systems, heat reclaim equipment, HRVs, ERVs, district heating and cooling systems, evaporative coolers, hydronic systems

*refrigeration systems* include: coolers, freezers, food/beverage equipment, ice machines, supermarket and warehouse systems, plate freezers, blast coolers and freezers, compound systems, process refrigeration systems, chillers, cooling towers, ice rinks, refrigerated containers, marine refrigeration systems, ultra-low systems, cascade systems, cryogenic systems, adsorption and absorption systems

*HVAC/R components* include: compressors, condensers, metering devices, evaporators, remote aircooled condensers, filter driers, sight glasses, valves, regulators, receivers, pressure vessels, heat exchangers, vibration eliminators, liquid pumps, temperature sensors, pressure transducers, fans, blowers, air filters, economizers, controllers, oil management devices, insulation, condensate drains, supply diffusers, return grilles, dampers, flow switches

*accessories* include: pressure controls, temperature controls, safety controls, time clocks, defrost controls, crankcase heaters, pipe hangers and clamps, solenoid valves, regulating valves, check valves, oil separators, accumulators, stands and supports, condensate pumps, IAQ devices

*consumables* include: filters, belts, chemical treatment, grease, lubricants, seals, sealants, electrical connectors, tape, caps, plugs

*tools and equipment* include: thermometers, gauges, hand tools, electrical meters, psychrometers, air flow measurement tools, fluid flow measurement tools, manifold gauges, leak detection tools, thermal imagers

**system abnormalities** include: incorrect refrigerant charge, plugged/fouled heat exchangers, incorrect valve operation, insufficient system capacity, dirty or plugged filter driers, leaking valves, incorrect refrigerant condition, air and fluid flow issues

# **F-15.03** Tests HVAC/R system components and accessories

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Skills						
	Performance Criteria	Evidence of Attainment					
F-15.03.01P	select and use <i>tools and equipment</i>	<i>tools and equipment</i> are selected and used according to task					
F-15.03.02P	check refrigerant pressures and temperatures	refrigerant pressures and temperatures are checked for <b>system abnormalities</b>					
F-15.03.03P	check <b>heat transfer mediums</b>	<i>heat transfer mediums</i> are checked for flow rate, pressure, velocity, temperature and freeze point					
F-15.03.04P	test electrical supply and <b>electrical</b> components	electrical supply and <i>electrical</i> components are tested for issues					
F-15.03.05P	perform motor winding insulation tests	motor winding insulation tests are performed to identify breakdown of winding and wire insulation					
F-15.03.06P	verify <b>system parameters</b>	system parameters are within design specifications and system settings					
F-15.03.07P	test <b>mechanical components and</b> accessories	<i>mechanical components and</i> <i>accessories</i> are tested for wear and abnormalities					
F-15.03.08P	retrieve oil and fluid samples and send for analysis	oil and fluid samples are retrieved and sent for lab analysis, and results are documented and interpreted according to manufacturers' recommendations					
F-15.03.09P	perform acid test on oil or refrigerant	acid test is performed on oil or refrigerant sample to determine level of system contamination					
F-15.03.10P	check integrity of secondary <i>heat transfer mediums</i>	secondary <i>heat transfer mediums</i> are checked for freeze point, pH, contaminants and protection					
F-15.03.11P	test and document operation of safety controls and devices	operation of safety controls and devices are tested and documented					
F-15.03.12P	perform test procedures	test procedures are performed according to manufacturers' specifications					

**tools and equipment** include: thermometers, gauges, hand tools, electrical meters, psychrometers, air flow measurement tools, fluid flow measurement tools, manifold gauges, leak detection tools, instruments, electronic devices, interfaces and computers, analyzing devices

**system abnormalities** include: incorrect refrigerant charge, plugged/fouled heat exchangers, incorrect valve operation, insufficient system capacity, dirty or plugged filter driers, leaking valves, incorrect refrigerant condition, air and fluid flow issues

heat transfer mediums include: glycol, brine, water, refrigerants, air

*electrical components* include: motors (single-phase, three-phase, ECM), transformers, contactors, relays, solid state relays, starters, VSDs, VFDs, SCRs, capacitors, resistors, inverter drives, potentiometers, rheostats, disconnects

*issues* include: grounding, phase imbalances, brown outs, voltage drops, carbon tracking, excessive heat *system parameters* include: voltages, amperages, temperatures, pressures, sound, vibration, torque specifications, flow rates

*mechanical components and accessories* include: compressors, condensers, metering devices, evaporators, mechanical valves, linkages, bearings, fans and fan motors, actuators, dampers, accumulators, crankcase heaters, solenoid valves, limit switches, receivers, oil separators, pumps, safety devices

	Knowledge						
	Learning Outcomes	Learning Objectives					
F-15.03.01L	demonstrate knowledge of <i>HVAC</i> and <i>refrigeration systems</i> , their <i>components</i> , <i>accessories</i> , characteristics, applications and operation	identify types of <i>HVAC</i> and <i>refrigeration</i> <i>systems</i> and their <i>components</i> and <i>accessories</i> , and describe their characteristics and applications					
		explain purpose and operation of <i>HVAC</i> and <i>refrigeration systems</i> and their <i>components</i> and <i>accessories</i>					
F-15.03.02L	demonstrate knowledge of testing <i>HVAC</i> and <i>refrigeration systems</i> , their <i>components</i> and <i>accessories</i>	identify <i>tools and equipment</i> used to test <i>HVAC</i> and <i>refrigeration systems</i> and their <i>components</i> and <i>accessories</i> , and describe their applications and procedures for use					
		describe procedures to verify <b>system</b> <b>parameters</b> match design					
		describe procedures to test <b>electrical</b> components					
		describe procedures to test <i>mechanical</i> components and accessories					
		describe defrost cycle and operation					
F-15.03.03L	demonstrate knowledge of codes and regulations pertaining to <i>HVAC</i> and <i>refrigeration systems</i>	interpret codes and regulations pertaining to <i>HVAC</i> and <i>refrigeration systems</i>					

*HVAC systems* include: air conditioning systems, heat pump systems, packaged units, split systems, ductless split systems, VRF, chillers, geothermal systems, CRAC units, field built-up systems, inverter driven systems, humidification systems, dehumidification systems, heat reclaim equipment, HRVs, ERVs, district heating and cooling systems, evaporative coolers, hydronic systems

*refrigeration systems* include: coolers, freezers, food/beverage equipment, ice machines, supermarket and warehouse systems, plate freezers, blast coolers and freezers, compound systems, process refrigeration systems, chillers, cooling towers, ice rinks, refrigerated containers, marine refrigeration systems, ultra-low systems, cascade systems, cryogenic systems, adsorption and absorption systems

*HVAC/R components* include: compressors, condensers, metering devices, evaporators, remote aircooled condensers, filter driers, sight glasses, valves, regulators, receivers, pressure vessels, heat exchangers, vibration eliminators, liquid pumps, temperature sensors, pressure transducers, fans, blowers, air filters, economizers, controllers, oil management devices, insulation, condensate drains, supply diffusers, return grilles, dampers, flow switches

*accessories* include: pressure controls, temperature controls, safety controls, time clocks, defrost controls, crankcase heaters, pipe hangers and clamps, solenoid valves, regulating valves, check valves, oil separators, accumulators, stands and supports, condensate pumps, IAQ devices

**tools and equipment** include: thermometers, gauges, hand tools, electrical meters, psychrometers, air flow measurement tools, fluid flow measurement tools, manifold gauges, leak detection tools, instruments, electronic devices, interfaces and computers, analyzing devices

*system parameters* include: voltages, amperages, temperatures, pressures, sound, vibration, torque specifications, flow rates

*electrical components* include: motors (single-phase, three-phase, ECM), transformers, contactors, relays, solid state relays, starters, VSDs, VFDs, SCRs, capacitors, resistors, inverter drives, potentiometers, rheostats, disconnects

*mechanical components and accessories* include: compressors, condensers, metering devices, evaporators, mechanical valves, linkages, bearings, fans and fan motors, actuators, dampers, accumulators, crankcase heaters, solenoid valves, limit switches, receivers, oil separators, pumps, safety devices

# **F-15.04** Optimizes integrated system performance

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Skills					
	Performance Criteria	Evidence of Attainment				
F-15.04.01P	select and use <i>tools and equipment</i>	<i>tools and equipment</i> are selected and used according to task				
F-15.04.02P	collect and document relevant system data that reflects current operating conditions	current and relevant system data is collected and documented				
F-15.04.03P	observe, calculate and adjust systems to meet <i>building envelope values</i>	<i>building envelope values</i> are observed, loads are calculated and reviewed, and systems are adjusted to meet current building design and jurisdictional standards and regulations				
F-15.04.04P	compare current <b>system efficiency</b> to expected <b>system efficiency</b>	current <b>system efficiency</b> is compared to expected <b>system efficiency</b> to meet or exceed current building design and jurisdictional standards and regulations				
F-15.04.05P	communicate with client	clients are communicated with using various methods according to job specifications and jurisdictional regulations				

#### **Range of Variables**

**tools and equipment** include: software, flow meters, thermometers, gauges, hand tools, data loggers **building envelope values** include: change in heating and cooling loads, variations in occupancy, changes to standards and regulations

*system efficiency* includes: equipment performance, schedules, environment, energy consumption, improved environmental practices

	Knowledge						
	Learning Outcomes	Learning Objectives					
F-15.04.01L	demonstrate knowledge of optimizing integrated system performance	identify <b>tools and equipment</b> used to optimize integrated system performance, and describe their applications and procedures for use					
		describe procedures to optimize integrated system performance					
		identify applicable standards and regulations					
		identify design, and jurisdictional standards and regulations in relation to system performance					
F-15.04.02L	demonstrate knowledge of relevant system data	identify relevant system data and describe their collection and documentation					
		interpret system data collected over time to identify <b>system efficiency</b>					
		identify calculations for <b>system efficiency</b> and optimization					
		identify adjustments and related impacts on <b>system efficiency</b>					

*tools and equipment* include: software, flow meters, thermometers, gauges, hand tools, data loggers *system efficiency* includes: equipment performance, schedules, environment, energy consumption, improved environmental practices

# Task F-16 Services HVAC/R systems

## **Task Descriptor**

Refrigeration and air conditioning mechanics will use the most current procedures to troubleshoot, repair and retrofit HVAC/R systems and their components, and to return them to optimal operation.

# F-16.01 Troubleshoots HVAC/R systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Skills					
	Performance Criteria	Evidence of Attainment				
F-16.01.01P	communicate with client	equipment <i>concerns</i> and history are communicated with client				
F-16.01.02P	select and use <i>tools and equipment</i>	<i>tools and equipment</i> are selected and used to diagnose problems based on information obtained				
F-16.01.03P	interpret temperature, pressure, concentration of chemicals and additives, flow rate and velocity readings from relevant systems	temperature, pressure, concentration of chemicals and additives, flow rate and velocity readings from relevant systems are interpreted				
F-16.01.04P	use documents, reference materials, electrical schematics and diagrams to diagnose <b>problems</b>	documents, reference materials, electrical schematics and diagrams are used to diagnose <i>problems</i>				
F-16.01.05P	perform troubleshooting procedures on relevant systems	troubleshooting procedures are performed on relevant systems according to industry practices				
F-16.01.06P	interpret data	data is interpreted to identify cause of <i>problems</i>				
F-16.01.07P	identify components and accessories that need to be replaced or repaired	components and accessories that need to be replaced or repaired are identified				
F-16.01.08P	present options for repair, replacement or improvement and complete <i>documentation requirements</i>	options for repair, replacement or improvement are presented and <b>documentation requirements</b> completed				

#### **Range of Variables**

*concerns* include: noise problems, vibrations, high utility bills, comfort issues, indoor air quality, poor cooling/heating, humidity problems, drafts, temperature problems

*tools and equipment* include: hand tools, power tools, data loggers, instruments, electronic devices, interfaces, analyzing devices, meters, air quality monitors, flow meters

problems include: defective components, electrical issues, utility issues, leaks

**documentation requirements** include: service orders (verbal, written or electronic), GWP and ozone depletion prevention records, site/client specific documents, warranty requirements, jurisdictional documentation

	Knowledge					
	Learning Outcomes	Learning Objectives				
F-16.01.01L	demonstrate knowledge of <i>HVAC</i> and <i>refrigeration systems,</i> their <i>components</i> , <i>accessories</i> , characteristics, applications and operation	identify types of <i>HVAC</i> and <i>refrigeration</i> <i>systems</i> and their <i>components</i> and <i>accessories</i> , and describe their characteristics and applications				
		explain purpose and operation of <i>HVAC</i> and <i>refrigeration systems</i> and their <i>components</i> and <i>accessories</i>				
		interpret information pertaining to <i>HVAC</i> and <i>refrigeration systems</i> and their <i>components</i> and <i>accessories</i> found on drawings, specifications and service manuals				
F-16.01.02L	demonstrate knowledge of relevant systems	identify types of primary, secondary and adjacent systems, and describe their characteristics and applications				
F-16.01.03L	demonstrate knowledge of <i>heat pump</i> <i>systems</i> , their characteristics and applications	identify types of <i>heat pump systems</i> and describe their characteristics and applications				
F-16.01.04L	demonstrate knowledge of electrical systems, their <i>components</i> , characteristics and applications	identify electrical systems and their <i>components</i> , and describe their characteristics and applications				
F-16.01.05L	demonstrate knowledge of distribution systems, their characteristics and applications	identify types of distribution systems and their components, and describe their characteristics and applications				
		explain purpose and operation of air movement and IAQ devices				
F-16.01.06L	demonstrate knowledge of procedures to troubleshoot <i>HVAC</i> and <i>refrigeration</i> <i>systems</i> and their <i>components</i> and <i>accessories</i>	identify <b>tools and equipment</b> used to troubleshoot <b>HVAC</b> and <b>refrigeration</b> <b>systems</b> and their <b>components</b> and <b>accessories</b> , and describe their applications and procedures for use				
		describe sequence of operations and procedures to troubleshoot <i>HVAC</i> and <i>refrigeration systems</i> and their <i>components</i> and <i>accessories</i>				
		identify <i>HVAC</i> and <i>refrigeration system problems</i> , and describe their causes				
		identify pressure and temperature scales, and describe procedures to perform conversion calculations				
		describe procedures to troubleshoot <i>HVAC</i> and <i>refrigeration system</i> <i>electrical components</i> and control boards				

		identify troubleshooting techniques using documents, reference materials, electrical schematics and diagrams, and describe their associated procedures
		describe procedures to troubleshoot distribution systems and their components
		describe procedures to troubleshoot electrical control circuit systems and components using schematic wiring diagrams
F-16.01.07L	demonstrate knowledge of codes and regulations pertaining to <i>HVAC</i> and <i>refrigeration systems</i>	interpret codes and regulations pertaining to <i>HVAC</i> and <i>refrigeration systems</i>

*HVAC systems* include: air conditioning systems, heat pump systems, packaged units, split systems, ductless split systems, VRF, chillers, geothermal systems, CRAC units, field built-up systems, inverter driven systems, humidification systems, dehumidification systems, heat reclaim equipment, HRVs, ERVs, district heating and cooling systems, evaporative coolers, hydronic systems

*refrigeration systems* include: coolers, freezers, food/beverage equipment, ice machines, supermarket and warehouse systems, plate freezers, blast coolers and freezers, compound systems, process refrigeration systems, chillers, cooling towers, ice rinks, refrigerated containers, marine refrigeration systems, ultra-low systems, cascade systems, cryogenic systems, adsorption and absorption systems

*HVAC/R components* include: compressors, condensers, metering devices, evaporators, remote aircooled condensers, filter driers, sight glasses, valves, regulators, receivers, pressure vessels, heat exchangers, vibration eliminators, liquid pumps, temperature sensors, pressure transducers, fans, blowers, air filters, economizers, controllers, oil management devices, insulation, condensate drains, supply diffusers, return grilles, dampers, flow switches

*accessories* include: pressure controls, temperature controls, safety controls, time clocks, defrost controls, crankcase heaters, pipe hangers and clamps, solenoid valves, regulating valves, check valves, oil separators, accumulators, stands and supports, condensate pumps, IAQ devices

*heat pump systems* include: air-to-air, liquid-to-air, liquid-to-liquid, air-to-liquid, geothermal, solar, variable speed, VRF, dual fuel

*electrical components* include: motors (single-phase, three-phase, ECM), transformers, contactors, relays, solid state relays, starters, VSDs, VFDs, SCRs, capacitors, resistors, inverter drives

*tools and equipment* include: hand tools, power tools, data loggers, instruments, electronic devices, interfaces, analyzing devices, meters, air quality monitors, flow meters

problems include: defective components, electrical issues, utility issues, leaks

# F-16.02 Repairs HVAC/R systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Skills					
	Performance Criteria	Evidence of Attainment				
F-16.02.01P	select and use <i>tools and equipment</i>	<i>tools and equipment</i> are selected and used according to task				
F-16.02.02P	shut down and/or isolate failed <i>HVAC/R</i> components and accessories	failed <i>HVAC/R components</i> and <i>accessories</i> are shut down and/or isolated for repair using procedures according to system configuration				
F-16.02.03P	recover refrigerant	refrigerant is recovered and measured according to recovery procedures				
F-16.02.04P	drain, store and dispose of <i>lubricants</i> and fluids	<i>lubricants and fluids</i> are drained, disposed of, stored and refilled/recharged according to jurisdictional regulations and manufacturers' recommendations				
F-16.02.05P	protect system from contamination	system is protected from contamination using industry practices, jurisdictional regulations and manufacturers' specifications				
F-16.02.06P	determine if a retrofit is recommended or required	retrofit recommendation or requirement is determined based on availability of <i>HVAC/R components</i> , refrigerant and scope of work				
F-16.02.07P	select compatible replacement <i>HVAC/R</i> components	compatible replacement <i>HVAC/R</i> <i>components</i> are selected according to manufacturers' specifications, jurisdictional regulations, certifications and job requirements				
F-16.02.08P	repair or replace <i>HVAC/R components</i> and <i>accessories</i>	HVAC/R components and accessories are repaired or replaced according to requirements				
F-16.02.09P	perform pressure and leak tests	pressure and leak tests are performed according to industry practices, jurisdictional regulations and manufacturers' specifications				
F-16.02.10P	evacuate system	system is evacuated according to industry practices, jurisdictional regulations and manufacturers' specifications				
F-16.02.11P	charge/add refrigerant	refrigerant is charged/added according to charging procedures				

F-16.02.12P	test operation of system	operation of system is tested to verify performance is within parameters and according to system design
F-16.02.13P	update <i>documents</i> , on-site and electronic logbooks, and operating and maintenance instructions	<i>documents</i> , on-site and electronic logbooks, and operating and maintenance instructions are updated according to company and client policies, and jurisdictional regulations
F-16.02.16P	present options for additional repair, replacement, retrofit or improvement	options for additional repair, replacement, retrofit or improvement are presented

*tools and equipment* include: hand tools, power tools, data loggers, meters, air quality monitors, instruments, electronic devices, interfaces and computers, analyzing devices, recovery equipment, evacuation equipment

*HVAC/R components* include: compressors, condensers, metering devices, evaporators, remote aircooled condensers, filter driers, sight glasses, valves, regulators, receivers, pressure vessels, heat exchangers, vibration eliminators, liquid pumps, temperature sensors, pressure transducers, fans, blowers, air filters, economizers, controllers, oil management devices, insulation, condensate drains, supply diffusers, return grilles, dampers, flow switches

*accessories* include: pressure controls, temperature controls, safety controls, time clocks, defrost controls, crankcase heaters, pipe hangers and clamps, solenoid valves, regulating valves, check valves, oil separators, accumulators, stands and supports, condensate pumps, IAQ devices

#### lubricants and fluids include: oils, water, brine, glycol

*documents* include: wiring diagrams, piping diagrams, flow diagrams, piping and instrumentation (P&I) diagrams, sequence of operations, schematics, site layout diagrams, as-built drawings, jurisdictional approvals

	Knowledge					
	Learning Outcomes	Learning Objectives				
F-16.02.01L	demonstrate knowledge of <i>HVAC</i> and <i>refrigeration systems,</i> their <i>components</i> , <i>accessories</i> , characteristics, applications and operation	identify types of <i>HVAC</i> and <i>refrigeration</i> <i>systems</i> and their <i>components</i> and <i>accessories</i> , and describe their characteristics and applications				
		explain purpose and operation of <b>HVAC</b> and <b>refrigeration systems</b> and their <b>components</b> and <b>accessories</b>				
F-16.02.02L	demonstrate knowledge of repairing <i>HVAC</i> and <i>refrigeration systems</i>	identify <b>tools and equipment</b> used to repair <b>HVAC</b> and <b>refrigeration systems</b> , and describe their applications and procedures for use				
		identify <b>HVAC</b> and <b>refrigeration system</b> and <b>component</b> failures, and describe their causes and procedures for repair				
		identify distribution system, and component failures, and describe their causes and procedures for repair				

F-16.02.03L	demonstrate knowledge of procedures to retrofit refrigerant and oil in <i>HVAC</i> and <i>refrigeration systems</i>	describe procedures to retrofit refrigerant and oil in <i>HVAC</i> and <i>refrigeration</i> systems
F-16.02.04L	demonstrate knowledge of codes and regulations pertaining to <b>HVAC</b> and <b>refrigeration systems</b>	identify and interpret codes and regulations pertaining to <i>HVAC</i> and <i>refrigeration systems</i>
		identify codes and regulations pertaining to retrofit requirements
		identify codes and regulations pertaining to availability and lifespan of refrigerant and components
		identify safety regulations pertaining to retrofitting <i>HVAC</i> and <i>refrigeration</i> systems

*HVAC systems* include: air conditioning systems, heat pump systems, packaged units, split systems, ductless split systems, VRF, chillers, geothermal systems, CRAC units, field built-up systems, inverter driven systems, humidification systems, dehumidification systems, heat reclaim equipment, HRVs, ERVs, district heating and cooling systems, evaporative coolers, hydronic systems

**refrigeration systems** include: coolers, freezers, food/beverage equipment, ice machines, supermarket and warehouse systems, plate freezers, blast coolers and freezers, compound systems, process refrigeration systems, chillers, cooling towers, ice rinks, refrigerated containers, marine refrigeration systems, ultra-low systems, cascade systems, cryogenic systems, adsorption and absorption systems

*HVAC/R components* include: compressors, condensers, metering devices, evaporators, remote aircooled condensers, filter driers, sight glasses, valves, regulators, receivers, pressure vessels, heat exchangers, vibration eliminators, liquid pumps, temperature sensors, pressure transducers, fans, blowers, air filters, economizers, controllers, oil management devices, insulation, condensate drains, supply diffusers, return grilles, dampers, flow switches

*accessories* include: pressure controls, temperature controls, safety controls, time clocks, defrost controls, crankcase heaters, pipe hangers and clamps, solenoid valves, regulating valves, check valves, oil separators, accumulators, stands and supports, condensate pumps, IAQ devices

*tools and equipment* include: hand tools, power tools, data loggers, meters, air quality monitors, instruments, electronic devices, interfaces and computers, analyzing devices, recovery equipment, evacuation equipment

# **Task F-17 Maintains and services control systems**

#### **Task Descriptor**

Control systems need to be maintained to ensure accuracy, reliability and efficiency of systems. Maintenance includes routine inspection, testing and calibration activities. When control systems malfunction, refrigeration and air conditioning mechanics need to troubleshoot and repair or replace the system components.

### **F-17.01** Performs maintenance and inspection on control systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Skills					
	Performance Criteria	Evidence of Attainment				
F-17.01.01P	select and use <i>tools and equipment</i>	<i>tools and equipment</i> are selected and used according to task				
F-17.01.02P	perform visual inspection of <b>control</b> systems and <b>components</b>	visual inspection of <i>control systems</i> and <i>components</i> is performed according to manufacturers' specifications, client requirements and jurisdictional regulations				
F-17.01.03P	secure and clean connections on components	connections on <i>components</i> are secured and cleaned				
F-17.01.04P	verify system operation	system operation is observed and verified with system documentation				
F-17.01.05P	verify <b>safety controls</b>	<i>safety controls</i> are within system parameters according to jurisdictional regulations				
F-17.01.06P	perform <b>test procedures</b>	<b>test procedures</b> are performed according to manufacturers' specifications, client requirements and jurisdictional regulations				
F-17.01.07P	identify <i>components</i> that need to be replaced or repaired	<i>components</i> that need to be replaced or repaired are identified				
F-17.01.08P	present options for additional repair, replacement or improvement	options for additional repair, replacement or improvement are presented				

*tools and equipment* include: hand tools, power tools, data loggers, instruments, electronic devices, interfaces and computers, analyzing devices, meters, air quality monitors, flow meters

*control systems* include: electrical, mechanical, electronic, integrated control circuits, app-based, wireless, predictive (Al-capable), pneumatic, distributed

*components* include: thermostats, pressure switches, limit switches, flow switches, timers, control boards, transformers, relays, fuses, wire, transmitters, receivers, tubing, valves, connectors, transducers, sensors, modems, routers, network switches

*safety controls* include: limit switches, current sensing devices, flow switches, low/high pressure switches, refrigerant monitors, environmental monitors

test procedures include: cycling safety controls, simulating out of range/unsafe conditions

	Knowledge					
	Learning Outcomes	Learning Objectives				
F-17.01.01L	demonstrate knowledge of <i>control systems</i> , their <i>components</i> , characteristics, applications and operation	identify types of <i>control systems</i> and their <i>components</i> , and describe their characteristics and applications				
		explain purpose and operation of <i>control systems</i> and their <i>components</i>				
		interpret information pertaining to <b>control</b> systems and their <b>components</b> found on manufacturers' specifications and maintenance schedule				
		describe <b>communication protocols</b> for control systems				
F-17.01.02L	demonstrate knowledge of procedures to maintain <i>control systems</i> and their <i>components</i>	identify <b>tools and equipment</b> used to maintain <b>control systems</b> and their <b>components</b> , and describe their applications and procedures for use				
		describe procedures to maintain <i>control</i> systems and their components				
		describe procedures to inspect <i>control systems</i> and their <i>components</i>				
		describe sequence of operation required for proper function of <i>control systems</i>				
		describe procedures to perform a diagnosis of controls				
F-17.01.03L	demonstrate knowledge of codes and regulations pertaining to <i>control systems</i> and their <i>components</i>	interpret codes and regulations pertaining to <i>control systems</i> and their <i>components</i>				

*control systems* include: electrical, mechanical, electronic, integrated control circuits, app-based, wireless, predictive (Al-capable), pneumatic, distributed

*components* include: thermostats, pressure switches, limit switches, flow switches, timers, control boards, transformers, relays, fuses, wire, transmitters, receivers, tubing, valves, connectors, transducers, sensors, modems, routers, network switches

*communication protocols* include: baud rates, addressing network communication protocols (Modbus, BACnet [MS/TP, IP], HTTP, ARP, HART, LON), serial port protocols (e.g., RS-232, RS-485, RS-422), communication speeds, wireless networks (e.g., Wi-Fi, ZigBee, Z-Wave), ethernet, Bluetooth, manufacturers' proprietary systems

*tools and equipment* include: hand tools, power tools, data loggers, instruments, electronic devices, interfaces and computers, analyzing devices, meters, air quality monitors, flow meters

#### F-17.02 Troubleshoots control systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Skills			
	Performance Criteria	Evidence of Attainment		
F-17.02.01P	communicate with client	equipment concerns are communicated with client		
F-17.02.02P	select and use tools and equipment	tools and equipment are selected and used according to task		
F-17.02.03P	use system documentation and schematics	system documentation and schematics are used to diagnose <i>problems</i>		
F-17.02.04P	interpret <b>system readings</b>	<i>system readings</i> are interpreted from collected information		
F-17.02.05P	identify <b>problems</b>	<b>problems</b> are identified by sensory inspection and use of test equipment		
F-17.02.06P	combine <b>system readings</b> and <b>data</b>	system readings and data are interpreted to identify cause and source of problems		
F-17.02.07P	identify <b>components</b> and accessories that need to be reconfigured, repaired or replaced	<i>components</i> and accessories that need to be reconfigured, repaired or replaced are identified		
F-17.02.08P	present options to client for reconfiguration, repair, replacement or improvement	options for reconfiguration, repair, replacement or improvement are presented to client		

*problems* include: incorrect design/installation, user misuse, defective components, utility issues, open/closed circuits, irregularities in sequence of operation, missing components, poor environmental controls, sensor inaccuracy, interference, lack of shielding, improper grounding, improper phasing, harmonic interference, termination issues, equipment address issues, sensor drift/calibration issues

*system readings* include: temperature, humidity, pressure, voltage, amperage, flow, levels *data* includes: trend logs, data loggers, information from test equipment, sensory information, system documentation, graphics

*components* include: thermostats, pressure switches, limit switches, flow switches, timers, control boards, transformers, relays, fuses, wires, transmitters, receivers, tubing, valves, connectors, transducers, sensors, modems, routers, network switches

	Knowledge			
	Learning Outcomes	Learning Objectives		
F-17.02.01L	demonstrate knowledge of schematics and wiring diagrams	define terminology associated with schematic and wiring diagrams		
		identify symbols on schematics and wiring diagrams and their application		
		interpret schematics and wiring diagrams		
F-17.02.02L	demonstrate knowledge of procedures to troubleshoot <i>control systems</i> and their <i>components</i>	identify tools and equipment used to troubleshoot <i>control systems</i> and their <i>components</i> , and describe their applications and procedures for use		
		describe procedures to inspect <i>control</i> systems and their components		
		describe procedures to troubleshoot control systems and their components		
F-17.02.03L	demonstrate knowledge of codes and regulations pertaining to <i>control systems</i> and their <i>components</i>	interpret codes and regulations pertaining to <i>control systems</i> and their <i>components</i>		

#### **Range of Variables**

*control systems* include: electrical, mechanical, electronic, integrated control circuits, app-based, wireless, predictive (Al-capable), pneumatic, centralized, distributed

*components* include: thermostats, pressure switches, limit switches, flow switches, timers, control boards, transformers, relays, fuses, wires, transmitters, receivers, tubing, valves, connectors, transducers, sensors, modems, routers, network switches

# **F-17.03** Calibrates operating and safety controls

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Skills			
	Performance Criteria	Evidence of Attainment		
F-17.03.01P	select and use <i>tools and equipment</i>	<i>tools and equipment</i> are selected and used according to task		
F-17.03.02P	test and record <i>conditions</i>	<i>conditions</i> are tested and recorded to compare to system settings		
F-17.03.03P	verify operating and safety controls	operating and safety controls operate according to system design settings and jurisdictional regulations		
F-17.03.04P	adjust controls that are operating outside parameters	controls are adjusted to meet parameters according to jurisdictional regulations		
F-17.03.05P	identify and replace faulty controls that cannot be calibrated	faulty controls that cannot be calibrated are replaced according to jurisdictional regulations		
F-17.03.06P	update documentation and on-site or digital logbooks	documentation and on-site or digital logbooks are updated according to jurisdictional regulations, and company and client policies		
F-17.03.07P	repair or replace cabling and wiring	cabling and wiring are installed and terminated according to manufacturers' specifications, job requirements and industry practices		
F-17.03.08P	communicate with <i>project personnel</i>	<i>project personnel</i> are communicated with using various methods according to job specifications and jurisdictional regulations		

#### **Range of Variables**

*tools and equipment* include: hand tools, power tools, data loggers, instruments, electronic devices, interfaces and computers, analyzing devices, meters, air quality monitors, flow meters *conditions* include: temperature, pressure, humidity, flow, levels, air quality, voltage, current, resistance, velocity

operating and safety controls include: thermostats, humidity controls, limit switches, current sensing devices, loss of charge switches, flow switches, low/high pressure switches, refrigerant and gas monitors, timers, transducers, thermocouples, thermistors, resistive temperature devices (RTDs), transmitters *project personnel* include: electricians, network and information technology technicians, plumbers, engineers, sheet metal workers, site personnel, utilities providers, monitoring and alarm suppliers, jurisdictional regulators

	Knowledge			
	Learning Outcomes	Learning Objectives		
F-17.03.01L	demonstrate knowledge of calibrating operating and safety controls	identify <b>tools and equipment</b> used to calibrate <b>operating and safety controls</b> , and describe their applications and procedures for use		
		describe procedures to calibrate operating and safety controls		
F-17.03.02L	demonstrate knowledge of codes and regulations pertaining to control systems	interpret codes and regulations pertaining to control systems		

operating and safety controls include: thermostats, humidity controls, limit switches, current sensing devices, loss of charge switches, flow switches, low/high pressure switches, refrigerant and gas monitors, timers, transducers, thermocouples, thermistors, resistive temperature devices (RTDs), transmitters **tools and equipment** include: hand tools, power tools, data loggers, instruments, electronic devices, interfaces and computers, analyzing devices, meters, air quality monitors, flow meters

# **F-17.04** Repairs control systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	yes	yes	yes	NV	NV	NV

	Skills			
	Performance Criteria	Evidence of Attainment		
F-17.04.01P	select and use <i>tools and equipment</i>	<i>tools and equipment</i> are selected and used according to task		
F-17.04.02P	select compatible and acceptable replacement <i>components</i>	compatible and acceptable replacement <b>components</b> are selected according to manufacturers' specifications, availability and retrofit requirements		
F-17.04.03P	adjust, repair or replace <i>components</i> , wiring, cabling and connections that are operating outside parameters	<i>components</i> , wiring, cabling and connections that are operating outside parameters are adjusted, repaired or replaced		
F-17.04.04P	test operation of repaired or replaced components	operation of repaired or replaced components are tested		
F-17.04.05P	update control system schematics, documentation and on-site or digital logbooks	control system schematics, documentation and on-site or digital logbooks are updated according to jurisdictional regulations, and company and client policies		

*tools and equipment* include: hand tools, power tools, data loggers, instruments, electronic devices, interfaces and computers, analyzing devices, meters, air quality monitors, flow meters *components* include: thermostats, pressure switches, limit switches, flow switches, timers, control boards, transformers, relays, fuses, wire, transmitters, receivers, tubing, valves, connectors, transducers, sensors, modems, routers, network switches

	Knowledge			
	Learning Outcomes	Learning Objectives		
F-17.04.01L	demonstrate knowledge of repairing control systems and their <i>components</i>	identify <i>tools and equipment</i> used to repair control systems and their <i>components</i> , and describe their applications and procedures for use		
		identify control system failures and describe their causes and sources		
		explain procedures to isolate, de-energize and lock out control systems		
		describe procedures to repair control systems and their <i>components</i> , wiring, cabling and connections		
F-17.04.02L	demonstrate knowledge of codes and regulations pertaining to control systems and their <i>components</i>	interpret codes and regulations pertaining to control systems and their <i>components</i>		

#### **Range of Variables**

*components* include: thermostats, pressure switches, limit switches, flow switches, timers, control boards, transformers, relays, fuses, wire, transmitters, receivers, tubing, valves, connectors, transducers, sensors, modems, routers, network switches

*tools and equipment* include: hand tools, power tools, data loggers, instruments, electronic devices, interfaces and computers, analyzing devices, meters, air quality monitors, flow meters

# Appendix A Acronyms

AHJ	Authority Having Jurisdiction
AB	alkylbenzene
AI	artificial intelligence
ACH	air changes per hour
ANSI	American National Standards Institute
ARP	Address Resolution Protocol
ASHRAE	American Society of Heating, Refrigerating, and Air Conditioning Engineers
AWEF	annual walk-in energy factor
BAS	building automation systems
BCuP	brazing alloy copper phosphorous
BAg	brazing alloy silver
CEC	Canadian Electrical Code
CO <sub>2</sub>	carbon dioxide
CSA	Canadian Standards Association
CFC	chlorofluorocarbon
CFM	cubic feet per minute
COP	coefficient of performance
CPR	crankcase pressure regulator
CRAC	computer room air conditioning
DDC	direct digital control
DX	direct-expansion
ECM	electronically commutated motors
EPR	evaporator pressure regulator
ERV	energy recovery ventilator
GHG	greenhouse gas
GPM	gallons per minute
GWP	global warming potential
HART	Highway Addressable Remote Transducer
HC	hydrocarbons
HCFC	hydrochlorofluorocarbon
HFC	hydrofluorocarbons
HFO	hydrofluoroolefin
HLHG	heat loss, heat gain
HRV	heat recovery ventilator
HSPF	heating seasonal performance factor

HTTP	Hypertext Transfer Protocol
HVAC/R	heating, ventilation and air conditioning/refrigeration
IAQ	indoor air quality
ITP	inspection test plans
LEED	Leadership in Energy and Environmental Design
LON	local operation network
NCV	non-contact voltage
NBC	National Building Code of Canada
ODSHAR	Ozone-depleting Substances and Halocarbon Alternatives Regulations
OEM	original equipment manufacturer
OHS	Occupational Health and Safety
Р	proportional
PAG	polyalkylene glycol
PAO	polyalphaolefin
PI	proportional integral
P&I	piping and instrumentation
PID	proportional integral derivative
PLC	programmable logic controller
POE	polyolester
PPE	personal protective equipment
PVE	polyvinyl ether
P/T	pressure/temperature
PWM	pulse width modulation
RMS	root mean square
RTD	resistive temperature device
SCBA	self-contained breathing apparatus
SCR	silicon-controlled rectifiers
SDS	Safety Data Sheets
SEER	seasonal energy efficiency ratio
SOP	safe operating procedures
TDG	Transportation of Dangerous Goods
VAV	variable air volume
VFD	variable frequency drive
VRF	variable refrigerant flow
VSD	variable speed drives
VVT	variable volume and temperature
WHMIS	Workplace Hazardous Materials Information System
ZCB	Zero Carbon Building
ZEV	zero-emission vehicle

# Appendix B Tools and Equipment / Outils et équipement

# Hand Tools / Outils à main

awls bending tools and springs brushes (wire, paint, acid, tube)

caulking guns chalk lines chisels core removal tools crowbars crimpers (wire, tin, pipe, fitting)

cutters (side, wire, bolt, pipe, tube)

drywall saws files fin combs fish tapes flare nut wrenches flaring tools flashlights funnels fuse pullers grease guns hack saws hammers hand carts hand seamers hand sprayers hex keys knives (utility, duct, pocket, multi)

knock-out kits labelling machines levels (laser, bubble, precision, line, transit)

inspection mirrors nitrogen purging adapters nut drivers orifice drill sets O-ring removal tools paint equipment pinch-off tools pipe dies pipe threaders pliers pry bars pullers punches alènes outils et ressorts de cintrage brosses (métallique, pinceau, pour application d'acide, goupillon) pistolets de calfeutrage cordeaux burins outils d'élimination de cartouches pinces monseigneur pinces à sertir (câbles, fils en étain, tuyaux, raccords) pinces coupantes (de côté, coupe-câble, coupeboulons, coupe-tuyaux, coupe-tubes) scies pour cloison sèche limes peignes à ailettes câbles de tirage clé polygonale ouverte outils à évaser lampes de poche entonnoirs arrache-fusibles pistolets graisseurs scie à métaux marteaux chariot à bras sertisseuses à main pulvérisateurs à main clés hexagonales couteaux (universel, à conduit, de poche, polvvalent) ensemble d'emporte-pièce machine à étiqueter niveaux (à laser, à bulle d'air, de précision, de cordeau, à lunette) miroirs d'examen adapteurs de purge d'azote tournevis à douille ieux de forêts d'orifices outils de dépose de joints toriques matériel à peinture pinces à tuyaux filières à tuvaux machines à fileter les tuvaux pinces leviers extracteurs poinçons

reamers regulators (CO<sub>2</sub>, nitrogen, oxygen, acetylene) rivet auns scrapers screw extractors screwdrivers snap ring pliers socket sets squares staplers straight edges strippers (wire, cable) swaging tools tap and die sets tin snips tube piercing tools tube straighteners wrenches (pipe, open end, adjustable, valve, torque) vices

alésoirs régulateurs (CO<sub>2</sub>, azote, oxygène, acétylène) riveteuse pneumatique arattoirs extracteurs à vis tournevis pinces pour anneau élastique ieux de douilles équerres agrafeuses règles dévêtisseurs (de fil, de câble) outils à rétreindre ieux de tarauds et de filières cisailles de ferblantier outils de perforation pour tubes machines à dresser les tubes clés (à tuyaux, à fourche, réglable, de vanne, dynamométrique) étaux

#### Portable and Stationary Power Tools / Outils électriques portatifs et fixes

- air compressors and regulators drill index drills (electric, cordless, hammer) glue guns denerators grinders heat guns hole saw kits impact guns powder-actuated tools power flaring tools power threaders power tube benders power tube expanders power washers pumps (circulating, transfer, sump) router saws (jig, reciprocating, band, chop, circular) trouble lights tube and pipe press tool kits vacuum cleaners
- compresseurs d'air et régulateurs calibre à forets perceuses (électriques, sans fil, à percussion) pistolets à colle dénératrices meuleuses pistolet thermique ieux de scies-cloche pistolets à clouer fixateurs à cartouche évaseurs mécaniques filières mécaniques appareils mécaniques à plier les tubes appareils mécaniques à mandriner les tubes laveuses à pression pompes (de circulation, de transfert, de puisard) toupies scies (sauteuses, alternative, à ruban) lampes baladeuses trousse de presses à tubes et tuyaux aspirateurs

## Brazing and Soldering Tools / Outils de brasage et de soudage

air-fuel equipment brazing barriers (fire blankets) cloth (sand, emery, sandpaper) oxy-fuel equipment soldering iron/gun striker torch kits matériel à aérogaz barrières de brasage (couvertures ignifuges) toiles (abrasive, émeri, papier de verre) matériel à oxy-gaz fer/pistolet à souder gâches jeux de chalumeaux

#### Recovery and Recycling Equipment / Matériel de récupération et de recyclage

filter/driers hazardous waste containers liquid pumps pressure/temperature charts recovery and recycle units recovery and storage cylinders subcoolers

# Charging Tools and Equipment / Outils et équipement de charge

charging scales core removal tools dye injector tool kits manifolds (charging, digital) precision weigh scale refrigerant hoses refrigerant oil pumps intrinsically safe recovery equipment tank heater (heat blankets) vacuum pumps déshydrateurs/filtres conteneurs de déchet dangereux pompes à liquide diagrammes pression/température appareils de récupération et de recyclage bouteilles de récupération et de stockage sous-refroidisseur

balances de charge outils d'élimination de cartouches trousses d'outils pour l'injection de colorant collecteurs (de charge, numériques) balance de précision tuyaux souples de frigorigène pompes à huile frigorigène appareils de récupération à sécurité intrinsèque chauffe-réservoir pompes à vide

# Diagnostic and Measuring Equipment / Équipement de diagnostic et de mesure

air flow hoods air flow/volume test equipment air quality testers alignment tools belt tension indicators black lights calculators calipers capacitor testers circuit tracers carbon monoxide analyzers/detectors combustion analyzers compound gauges computers communication devices control signal generator data loggers decibel meters dial indicators dye penetrant kits eddy current testers feeler gauges flame safeguard testers flowmeters gauges hydrometers hvarometers infrared thermography cameras and display units débitmètres à hotte appareil de vérification du débit/volume appareil d'analyse de la qualité de l'air outils d'alignement indicateurs de tension de courroie lampes à lumière noire calculatrices pied à coulisse capacimètres traceurs de circuit analyseurs/détecteurs de monoxyde de carbone analyseurs de gaz de combustion manovacuomètres ordinateurs appareils de communication générateur de signaux de commande enregistreurs de données décibelmètres comparateur à cadran appareils de liquide pénétrant coloré testeurs des courants de Foucault jauges d'épaisseur à lames dispositifs de surveillance de flamme débitmètres iaudes hydromètres hvaromètres appareil de visualisation et caméra de thermographie infrarouge appareils à interface

interface devices

leak detectors (electronic, ultrasonic, halide, soap tests, litmus test, sulphur test, ultraviolet)

litmus paper magnehelic gauges manifold gauge sets manometers (U-tube, incline, electronic) measuring tapes megohmmeters (insulation resistance testers) micrometers micron gauges (mechanical, electronic) multimeters (true root mean square [RMS]) non-contact voltage (NCV) testers oil test kits pH testing kits phase meters (mechanical, electronic) Pitot tubes pneumatic calibration kits potentiometers proximity meters refractometers refrigerant scales (mechanical, electronic) rulers psychrometers smoke testers stethoscopes tachometers thermocouple testers thermometers (infrared, electronic, mechanical, pipe-clamp) transducers (humidity, pressure, current, voltage, temperature) vacuum gauges vibration analysis equipment video scope (inspection camera) water analysis kits wireless probes

détecteurs de fuites (électroniques, ultrasons, halogénures, solution savonneuse, papier de tournesol, soufre, ultraviolets) papiers de tournesol manomètres différentiels iauges de collecteurs manomètres (à tube en U, inclinés, électroniques) rubans à mesurer mégohmmètres micromètres microvacuomètre (mécanique, électronique) multimètre (valeur efficace) détecteur de courant sans contact trousses à essai d'huile nécessaire d'analyse du pH phasemètres (mécanique, électronique) tubes de Pitot nécessaire d'étalonnage pneumatique potentiomètres détecteurs de proximité réfractomètres balances à frigorigène (mécanique, électronique) règles psychromètres testeurs de fumée stéthoscopes tachvmètres contrôleurs de thermocouple thermomètres (à infrarouges, électroniques, mécaniques, pour collier de serrage) transducteurs (humidité, pression, intensité, tension) vacuomètres équipement d'analyse de vibrations vidéoscopes (caméra d'inspection) trousses d'analyse d'eau sondes sans fil

## Access Equipment / Équipement d'accès

ladders (step, extension) personnel lifts scaffolding/staging échelles (escabeau, à rallonge) plateforme de levage de personnel échafaudages/plateformes de travail

#### Rigging, Hoisting and Lifting Equipment / Équipement de gréage, de hissage et de levage

block and tackle chain falls chains and cables come-alongs cranes (gantry, mobile) dollies eye bolts forklifts hoists jacks (hydraulic, mechanical) palans à moufle palans à chaîne chaînes et câbles treuils manuels grues plateaux roulants boulons à œil chariots élévateurs à fourche palans crics (hydrauliques, mécaniques) material lifts ropes shackles slings spreader bars stair climber trolley toe jacks winches appareils de levage cordes manilles élingues palonniers diable d'escaliers cric relève-voie treuils

# Personal Protective Equipment (PPE) and Safety Equipment / Équipement de protection individuelle (EPI) et de sécurité

barricades/pylons electrical live test safety equipment /arc flash

fall arrest equipment fire blankets fire extinguishers first aid kits/stations flagging gas detector (hazardous gases) gloves (rubber, insulated, leather) hard hats hearing protection (ear plugs, muffs)

high-visibility apparel lock-out kits masks (dust, particle, filter, vapour)

personal monitors rain suits respirators rubber aprons and coveralls rubber boots safety boots safety face shields safety glasses safety goggles self-contained breathing apparatus (SCBA) tape (caution, danger) two-way radios warning signs welding gloves welding goggles welding helmets

palissades/cônes de signalisation équipement de sécurité d'épreuve sous tension d'un outillage électrique et équipement de protection contre l'arc électrique équipement antichute couvertures ignifuges extincteurs trousses/postes de premiers soins signalisation détecteur de gaz (gaz dangereux) gants (en caoutchouc, isolés, en cuir) casques de protection protège-oreilles (bouchons d'oreilles, serre-tête antibruit) vêtement de sécurité à haute visibilité nécessaire de cadenassage masques (anti-poussière, contre les particules, filtrant) moniteurs personnels vêtements de pluie respirateurs tabliers et combinaisons en caoutchouc bottes en caoutchouc bottes de sécurité écrans protecteurs lunettes de sécurité lunettes de protection appareil de protection respiratoire autonome ruban (d'avertissement, de danger) radios bidirectionnelles panneaux de mise en garde gants de soudeur lunettes de soudeur casque de soudage

# Appendix C Glossary / Glossaire

absorption system	system where refrigeration is created by evaporating a refrigerant in a heat exchanger (evaporator) with the vapor then absorbed by an absorbent medium from which it is subsequently expelled by heating at a higher partial vapor pressure (in a generator) and condensed by cooling in another heat exchanger (condenser)	système d'absorption	système où la réfrigération est créée en faisant évaporer un réfrigérant dans un échangeur de chaleur (évaporateur) avec la vapeur, puis absorbée par un produit absorbant à partir duquel elle est ensuite expulsée en la chauffant à une pression de vapeur partielle plus élevée (dans une génératrice) et condensée par refroidissement dans un autre échangeur de chaleur (condenseur)
adsorption system	system that is designed to cool interior spaces through adsorption, a process that uses solid substances to attract to their surfaces molecules of gases or solutions with which they are in contact. Instead of using large amounts of electricity, the cooling process is driven by the evaporation and condensation of water.	système d'adsorption	système conçu pour refroidir les espaces intérieurs par adsorption, un processus qui utilise des substances solides pour attirer à leur surface des molécules de gaz ou des solutions avec lesquelles ils sont en contact. Au lieu d'utiliser de grandes quantités d'électricité, le processus de refroidissement est entraîné par l'évaporation et la condensation de l'eau
accessories	optional parts added to equipment or system	accessoires	pièces optionnelles ajoutées à l'équipement ou au système
access equipment	equipment used to allow mechanics to reach work location (e.g., ladder, scaffolds, personnel lift)	équipement d'accès	équipement utilisé par le mécanicien ou la mécanicienne pour atteindre l'emplacement des travaux (p. ex., échelle, échafaudages, plateforme de levage de personnel)

accumulator	vessel in the suction line that collects liquid refrigerant to be boiled off	réservoir tampon	réservoir monté sur le circuit frigorifique basse pression permettant d'accumuler du frigorigène liquide en vue de son ébullition ultérieure
analog controls	controls which are continuously variable between two points	commandes analogiques	commandes qui sont variables de façon continue entre deux points
building envelope	all the building components that separate the indoors from the outdoors, including the exterior walls, foundations, roof, windows, and doors	enveloppe du bâtiment	tous les éléments du bâtiment qui séparent l'intérieur de l'extérieur, y compris les murs extérieurs, les fondations, le toit, les fenêtres et les portes
commission	final start-up activities before a system is fully functional that ensures the system meets design specifications and client requirements	mise en service	dernières activités de démarrage effectuées pour vérifier si le système est entièrement fonctionnel afin de s'assurer qu'il respecte les spécifications de conception et les exigences du client
component	parts required as part of a system	composant	pièce nécessaire faisant partie d'un système
compressor	component that creates pressure differential in a system that allows a refrigerant to flow	compresseur	composant qui crée la différence de pression dans un système qui permet à un réfrigérant de s'écouler
computer room air conditioning (CRAC) unit	device that monitors and maintains the temperature, air distribution and humidity in a data center, network or server room. CRAC units replace the air-conditioning units used in the past to cool data centers. By comparison, CRAC systems have better air filtration, better humidity control mechanisms and higher airflow than typical AC systems	appareil de conditionnement de l'air de centre de données	appareil qui surveille et maintient la température, la distribution de l'air et l'humidité dans un centre de données, un réseau ou une salle de serveurs. Les appareils de conditionnement de l'air de centre de données remplacent les climatiseurs anciennement utilisés pour refroidir les centres de données. En comparaison, les appareils de conditionnement de l'air de centre de données permettent une meilleure filtration de l'air, et ont de meilleurs mécanismes de contrôle de l'humidité et un débit d'air plus élevé que les climatiseurs en courant alternatif typiques
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condenser	heat rejection component that provides a state change of refrigerant (from vapour to a liquid)	condenseur	composant qui permet d'effectuer un changement d'état du frigorigène par rejet de chaleur (de vapeur à liquide)
control system	electrical, electronic, mechanical and pneumatic components and wiring that are used to operate and protect the system	système de commandes	composants électriques, électroniques, mécaniques et pneumatiques et câblages utilisés pour faire fonctionner le système
digital controls	control that use an on/off signal	commandes numériques	commande utilisant un signal tout-ou-rien
district heating and cooling system	centralized facility for generation and distribution of the heating and cooling needs of a community, rather than individual heat or cold generators (i.e., furnace or air conditioner) at each residential, commercial, or institutional site	réseau de chauffage et de climatisation urbain	installation centralisée pour la production et la distribution des services de chauffage et de climatisation selon les besoins d'une collectivité, au lieu de l'équipement individuel générant de la chaleur ou du froid (càd. fournaises ou climatiseurs) à chaque site résidentiel, commercial ou institutionnel

energy recovery ventilator (ERV)	type of heat recovery ventilator (HRV) that can exchange both heat and moisture	ventilateur récupérateur d'énergie (VRE)	type de ventilateur- récupérateur de chaleur (VRC) qui peut échanger à la fois de la chaleur et de l'humidité
evacuation	removal of moisture, air and non-condensable gases from a refrigeration system	évacuation	élimination de l'humidité, de l'air et des gaz non condensables d'un système de réfrigération
distribution	conveying means, such as ducts, pipes, and wires, to bring substances or energy from a source to the point of use. The distribution system includes auxiliary equipment such as fans, pumps and transformers	distribution	moyens de transport, tels que des conduits, des tuyaux et des fils, servant à amener des substances ou de l'énergie de la source au point d'utilisation. Le système de distribution comprend de l'équipement auxiliaire comme des ventilateurs, des pompes et des transformateurs
evaporative cooling	method of cooling air by using evaporating water	refroidissement évaporatif	méthode de refroidissement de l'air qui utilise de l'eau en évaporation
evaporator	heat absorption component that provides a state change of refrigerant (from liquid to a vapour)	évaporateur	composant qui permet d'effectuer un changement d'état du frigorigène par absorption de chaleur (de liquide à vapeur)
field wiring	wiring required to be done on site	câblage sur place	câblage qu'il est nécessaire d'effectuer sur le chantier
flow control	device for controlling the flow of primary and secondary refrigerants (e.g., crankcase pressure regulator [CPR], evaporator pressure regulator [EPR], solenoid valve)	régulateur de débit	dispositif permettant de réguler le débit des frigorigènes primaire et secondaire (p. ex., RPA, RPE, vanne électromagnétique)
fluid cooler	heat rejection device that cools a secondary heat transfer medium	refroidisseur de liquide	dispositif de rejet de la chaleur qui refroidit un milieu de transfert de chaleur secondaire
heat exchanger	device used to transfer heat energy from one medium to another	échangeur de chaleur	dispositif utilisé pour transférer l'énergie thermique d'un milieu à un autre

heat pump system	thermodynamic heating/refrigerating system to transfer heat. The condenser and evaporator may change roles to transfer heat in either direction. By receiving the flow of air or other fluid, a heat pump is used to cool or heat. Heat pumps may be the air source with heat transfer between the indoor air stream to outdoor air or water source with heat transfer between the indoor air stream and a hydronic source (ground loop, evaporative cooler, cooling tower or domestic water)	thermopompe	système thermodynamique de chauffage ou de réfrigération servant à transférer la chaleur. Le condenseur et l'évaporateur peuvent changer de rôle pour transférer la chaleur dans les deux sens. En recevant le flux d'air ou d'un autre liquide, une thermopompe est utilisée pour refroidir ou chauffer. Les thermopompes peuvent être la source d'air avec transfert de chaleur entre le flux d'air intérieur et l'air extérieur ou la source d'eau avec transfert de chaleur entre le flux d'air intérieur et une source hydronique (boucle souterraine, refroidisseur évaporatif, tour de refroidissement ou eau domestique)
heat reclaim equipment	equipment that uses heat taken from internal heat sources; applications are space heating, domestic or service water heating, air reheat in air conditioning, process heating in industrial applications, or other similar purposes	équipement de récupération de chaleur	équipement qui utilise la chaleur provenant de sources de chaleur internes; comme pour le chauffage de locaux, le chauffage de l'eau domestique ou de service, le réchauffage de l'air dans la climatisation, le chauffage industriel ou pour d'autres applications similaires
heat recovery ventilators (HRV)	ventilation device that captures heat from stale air leaving a building and uses it to preheat fresh air coming into the building. An HRV can reverse this process during the cooling season	ventilateur récupérateur de chaleur (VRC)	dispositif de ventilation qui capte la chaleur de l'air vicié sortant d'un bâtiment et l'utilise pour préchauffer l'air frais entrant dans le bâtiment. Un VRC peut inverser ce processus pendant la saison de refroidissement
holding charge	temporary or partial charge used for the protection of the system until commissioning	charge d'attente	charge temporaire ou partielle utilisée pour protéger le système jusqu'à la mise en service

humidifier	device that introduces water vapour to conditioned space to raise relative humidity	humidificateur	dispositif qui permet d'ajouter de la vapeur d'eau à l'air distribué dans les locaux climatisés afin d'augmenter l'humidité relative
humidity	measurement of moisture in air	humidité	quantité totale de vapeur d'eau dans l'air
internal wiring	wiring inside the system that includes factory and optional wiring	câblage interne	câblage à l'intérieur du système comprenant le câblage effectué en usine et le câblage en option
isolation	act of providing separation between 2 or more items, systems, areas, spaces, etc. Isolation is typically performed using an isolating device such as a disconnect switch, valve, damper or separate system	isolement	fournir une séparation entre deux ou plusieurs éléments, systèmes, zones, espaces, etc. L'isolement est généralement effectué à l'aide d'un dispositif d'isolement tel qu'un interrupteur de débranchement, une vanne, un amortisseur ou un système distinct
lock-out	isolating an energy source to ensure equipment is inoperable	verrouillage	isoler une source d'énergie pour s'assurer que l'équipement est inutilisable
maintain	performing functions to prevent premature deterioration and breakdown of system	entretenir	exécuter des fonctions pour empêcher la détérioration et la défaillance prématurée du système
material take-off	listing of material and components required for a project as taken from design drawings and job requirements	liste des matériaux	préparation des matériaux et des composants nécessaires à un projet selon les dessins des devis descriptifs et les exigences de la tâche
metering device	device designed to regulate flow of liquid refrigerant entering the evaporator	dispositif de régulation	dispositif conçu pour réguler le débit de frigorigène liquide qui entre dans l'évaporateur
oil separator	device used to remove oil from refrigerant	séparateur d'huile	dispositif utilisé pour enlever l'huile du frigorigène

predictive maintenance	monitoring system and components and analyzing operational data to assist in predicting performance of system and components and performing activities to prevent downtime or costly repairs. Some methods of predictive maintenance may include sensory inspection, vibration analysis, testing and maintenance of components	entretien préventif	surveillance du système et des composants, et analyse des données opérationnelles pour aider à prévoir le rendement du système et des composants et à effectuer des activités pour éviter les temps d'arrêt ou les réparations dispendieuses. Certaines méthodes d'entretien préventif peuvent inclure l'inspection sensorielle, l'analyse des vibrations, les essais et l'entretien des composants
pressure control	pressure-activated safety or operational control	régulateur de pression	commande de sécurité ou de fonctionnement réagissant à la pression
psychrometric	study of air and its thermodynamic properties, particularly regarding moisture mixed with air	psychrométrie	étude de l'air et de ses propriétés thermodynamiques, en particulier en ce qui concerne l'humidité mélangée à l'air
receiver	storage vessel for liquid refrigerant	réservoir de liquide	réservoir destiné au stockage de frigorigène liquide
refrigerant	heat transfer medium used in a primary or secondary refrigeration system	frigorigène	fluide de transfert thermique utilisé dans un système de réfrigération primaire ou secondaire
refrigeration	transferring of heat from a place where it is not wanted to a place where it is required or unobjectionable	réfrigération	transfert de la chaleur d'un endroit où elle n'est pas désirée vers un autre sans conséquence
regulator	device that controls voltage or the pressure of liquid or gases	régulateur	dispositif qui permet de réguler la tension et la pression du liquide et des gaz
repair	fix system by repairing or replacing components and accessories	réparer le système	réparer le système en réparant ou en remplaçant les composants et les accessoires
replace	change a component on a system	remplacer	changer le composant d'un système

retrofit	process of upgrading systems either by replacing equipment, components, accessories, refrigerant and refrigerant oils, or by replacing entire systems. Retrofits are done to improve system performance and efficiency, and to comply with current industry standards and legislative requirements	transformation	processus de mise à niveau des systèmes soit en remplaçant l'équipement, les composants, les accessoires, les réfrigérants et les huiles réfrigérants et les huiles réfrigérantes, soit en remplaçant des systèmes entiers. Les transformations sont effectuées pour améliorer le rendement et l'efficacité du système et pour se conformer aux normes actuelles de l'industrie et aux exigences législatives
sensory inspection	inspection done without tools using sight, smell, touch and sound	inspection sensorielle	inspection effectuée sans outil, en utilisant la vue, l'odorat, le toucher et l'ouïe
service	troubleshoot and repair system	entretien	établir un diagnostic et réparer le système
solenoid valve	device that permits or stops liquid and gas flow	vanne électromagnétique	dispositif permettant ou arrêtant le passage du débit d'un liquide et d'un gaz
tag-out	labelling process that is always used when lock-out is required. The process of tagging out a system involves attaching or using an information tag or indicator	étiquetage	processus qui est toujours utilisé lorsque le cadenassage est requis. L'étiquetage d'un système implique la fixation ou l'utilisation d'une étiquette ou d'un indicateur d'information
terminate	final connection of wiring or tubing to any device	raccorder	terminaison du câblage ou de la tubulure à un dispositif quelconque
trade standards	procedures based on codes, regulations, manufacturers' recommendations and best practices	normes du métier	procédures élaborées en se fondant sur les codes, la réglementation, les recommandations des fabricants et les meilleures pratiques
transducer	electronic device that sends a digital or analog signal to a control board	transducteur	appareil électrique qui transmet un signal numérique ou analogique vers un tableau de commande
troubleshoot	diagnosing system failures and malfunctions	diagnostiquer	déterminer les défaillances et les anomalies du système

utilities	services such as electricity, drainage, water or gas provided by the city or utility companies	services publics	services comme l'électricité, l'évacuation des eaux, l'alimentation en eau ou en gaz fournis par la ville ou par les services publics
variable refrigerant flow (VRF)	engineered direct-expansion (DX) multi-split system incorporating at least one variable capacity compressor distributing refrigerant through a piping network to multiple indoor fan-coil units, each capable of individual zone temperature control, through integral zone temperature control devices and common communications network. Variable refrigerant flow utilizes three or more steps of control on common, interconnecting piping	débit de frigorigène variable	système d'ingénierie à détente directe à plusieurs blocs comprenant au moins un compresseur à capacité variable distribuant du frigorigène dans un réseau de tuyauterie jusqu'à plusieurs ventilo- convecteurs intérieurs, chacune capable de contrôler la température d'une zone individuelle, grâce à des dispositifs intégrés de contrôle de la température de zone et à un réseau de communication commun. Le débit de frigorigène variable utilise trois

sur la tuyauterie commune et interconnectée