ONTARIO COLLEGE OF TRADES

ORDRE DES MÉTIERS DE L'ONTARIO

Apprenticeship Curriculum Standard

Refrigeration and Air Conditioning Systems Mechanic Branch 1 - 313A

Level 2 Intermediate

Date: 2008

Please Note: Apprenticeship Training and Curriculum Standards were developed by the Ministry of Training, Colleges and Universities (MTCU). As of April 8th, 2013, the Ontario College of Trades (College) has become responsible for the development and maintenance of these standards. The College is carrying over existing standards without any changes.

However, because the Apprenticeship Training and Curriculum Standards documents were developed under either the *Trades Qualification and Apprenticeship Act* (TQAA) or the *Apprenticeship and Certification Act, 1998* (ACA), the definitions contained in these documents may no longer be accurate and may not be reflective of the *Ontario College of Trades and Apprenticeship Act, 2009* (OCTAA) as the new trades legislation in the province. The College will update these definitions in the future.

Meanwhile, please refer to the College's website (http://www.collegeoftrades.ca) for the most accurate and up-to-date information about the College. For information on OCTAA and its regulations, please visit: http://www.collegeoftrades.ca/about/legislation-and-regulations

Table of Contents

Introduction

This curriculum revision for the Level 2 – Refrigeration and Air Conditioning Systems Mechanic, Branch 1 (313A), is based upon the on-the-job performance objectives, located in the industry-approved training standard.

The curriculum is organized into 6 reportable subjects. The Program Summary of Reportable Subjects chart summarizes the training hours for each reportable subject.

The curriculum identifies only the learning that takes place off-the-job. The in-school program focuses primarily on the theoretical knowledge and the essential skills required to support the performance objectives of the Apprenticeship Training Standards. Employers/Sponsors are expected to extend the apprentice's knowledge and skills through practical training on the work site. Regular evaluations of the apprentice's knowledge and skills are conducted throughout training to ensure that all apprentices have achieved the learning outcomes identified in the curriculum standard.

It is not the intent of the in-school curriculum to perfect on-the-job skills. The practical portion of the in-school program is used to reinforce theoretical knowledge. Skill training is provided on the job.

Program Summary of Reportable Subjects – Level 2 – Intermediate
Refrigeration and Air Conditioning Systems Mechanic – Branch 1

Number	Reportable Subjects	Hours Total	Hours Theory	Hours Practical
S0744.0	Pressure Enthalpy and Refrigerants – Industrial, Commercial, Institutional (ICI)	30	6	24
S0745.0	Plans, Specifications, and Load Calculations – Industrial, Commercial, Institutional (ICI)	27	9	18
S0746.0	Cooling Systems and Components – Industrial, Commercial, Institutional (ICI)	30	24	6
S0747.0	System Design and Installation – Industrial, Commercial, Institutional (ICI)	72	36	36
S0748.0	Electrical and Control Systems – Industrial, Commercial, Institutional (ICI)	69	33	36
S0749.0	Material Handling Procedures	12	9	3
	Total	**240**	**117**	**123**

Number: **S0744**

Title: **PRESSURE ENTHALPY AND REFRIGERANTS** – **INDUSTRIAL, COMMERCIAL, AND INSTITUTIONAL (ICI**)

Duration: Total 30 hours Theory 6 hours Practical 24 hours

Prerequisites: L1CC – S0731, S0732, S0733, S0734, S0735, S0736, S0737

Content:

S0744.1 Describe specific conditions of a refrigerant as characterized on a thermodynamic table used with refrigeration and air conditioning systems. **(1 / 0 hrs)**

S0744.2 Describe procedures for interpreting pressure enthalpy graphs. **(2 / 0 hrs)**

S0744.3 Describe procedures for plotting or determining mechanical cooling cycles in a refrigeration and air conditioning system using pressure enthalpy information. **(2 / 20 hrs)**

S0744.4 Describe the application of refrigerants used in a refrigeration and air conditioning system that are plotted on a pressure enthalpy graph. **(0 / 2 hrs)**

S0744.5 Describe the function and application of ammonia when used as a refrigerant in refrigeration and air conditioning systems. **(1 / 2 hrs)**

Evaluation & Testing: Assignments related to theory and application skills
Minimum of one mid-term test during the term
Final test at end of term
Periodic quizzes

Mark Distribution:

Theory Testing	Practical Application Testing	Final Assessment
20%	80%	100%

Instructional and Delivery Strategies:

Lecture
Video
Paper based material
Demonstration – Practical Lab Assignments
CBT
E-Learning

Reference Materials:

Occupational Health and Safety Manual for Refrigeration and Air Conditioning
Dangerous Goods Transportation Act
Workplace Hazardous Materials Information System
Occupational Health and Safety Act and Regulations for Construction Projects
Environmental Code of Practice for the Reduction of Chlorofluorocarbon (ODP program)
Emissions from Refrigeration and Air Conditioning Systems
Modern Refrigeration and Air Conditioning (Althouse, Turnquist & Bracciano)
Applicable Software Training Materials
Manufacturers' Literature
Applicable Acts, Regulations, Legislation, and Codes

- Ontario Fire Code
- Canadian Electrical Code
- Boiler Pressure Vessels Act
- Mechanical Refrigeration Code CSA B52
- Provincial and Federal Halocarbon Regulations
- TSSA (Technical Standards and Safety Act)
- Building Code
- Municipal Codes

S0744.0 Pressure Enthalpy and Refrigerants - Industrial, Commercial, and Institutional (ICI)

Duration: Total 30 Hours Theory 6 hours Practical 24 hours

Cross-Reference to Training Standards:
313A: U6238.0, U6239.0, U6240.0, U6241.0, U6242.0, U6243.0, U6244.0, U6245.0

GENERAL LEARNING OUTCOME

Upon successful completion, the apprentice will be able to: interpret thermodynamic tables; plot or determine cooling cycles from pressure enthalpy information; and, describe the application of fluorocarbons, ammonia, and other refrigerants used in refrigeration and air conditioning systems in Industrial, Commercial, or Institutional (ICI) applications.

LEARNING OUTCOMES AND CONTENT

44.1 Describe specific conditions of a refrigerant as characterized on a thermodynamic table used with refrigeration and air conditioning systems. **(1 / 0 hrs)**

Describe thermodynamic properties of a refrigerant used in refrigeration and air conditioning systems including:

- pressure
- temperature
- critical temperature
- specific volume
- specific density
- enthalpy
- entropy
- glide
- bubble point
- dew point

Describe factors of refrigerant including:

- refrigerant vapours
- refrigerant liquids
- saturated suction temperatures
- saturated condensing temperatures
- pressures
- temperatures
- specific volume
- specific density
- enthalpy

44.2 Describe procedures for interpreting pressure enthalpy graphs. **(2 / 0 hrs)**

Determine factors of refrigerant vapours and liquids at given saturated suction temperature and saturated condensing temperature conditions including:

- pressure
- temperature
- specific volume and density
- constant quality
- enthalpy

44.3 Describe procedures for plotting or determining mechanical cooling cycles in a refrigeration and air conditioning system using pressure enthalpy information. **(2 / 20 hrs)**

Describe the plotting of mechanical cooling cycles using computerized refrigerant software programs.

Interpret data plotted on a pressure enthalpy chart including:

- heat absorbed or rejected through various components
  - piping
  - evaporator
  - condenser
- amount of superheat at compressor inlet or the discharge
- amount of sub-cooling in liquid line
- amount of flash gas
- refrigerating effect
- weight of refrigerant circulated per ton
- volume of refrigerant circulated per ton
- heat of compression
- co-efficient of performance (COP)
- theoretical and actual horsepower

Identify cooling cycle operating characteristics including:

- medium temperature versus low temperature cycles
- compound compression systems
- systems with a liquid to suction heat exchanger
- systems with a mechanical sub-cooler
- systems with liquid pressure amplification

44.3 Continued

Describe changes that are plotted on a pressure enthalpy graph if the refrigeration and air conditioning system is operating under abnormal conditions including:

- contaminated refrigeration
- fractionated refrigeration
- system short of refrigerant
- high head pressure
- low load conditions
- refrigerant piping pressure drop
- restricted filter drier
- malfunctioning metering device

44.4 Describe the application of refrigerants used in refrigeration and air conditioning systems that are plotted on a pressure enthalpy graph**. (0 / 2 hrs)**

Describe the function and application of a variety of refrigerants by comparing ideal cycles plotted on a pressure enthalpy graph including:

- heat absorbed by evaporator
- amount of superheat at compressor inlet
- amount of compressor discharge superheat
- heat rejected by condenser
- heat rejection factor
- amount of sub-cooling in liquid line
- amount of flash gas
- refrigerating effect
- weight of refrigerant circulated per ton
- volume of refrigerant circulated per ton
- heat of compression
- co-efficient of performance (cop)
- theoretical and actual horsepower

44.5 Describe the function and application of ammonia when used as a refrigerant in refrigeration and air conditioning systems. **(1 / 2 hrs)**

Describe the contrast between components used in refrigeration and air conditioning systems using ammonia and ones using a hydrocarbon and fluorocarbon based refrigerant.

Describe the operating pressures and temperatures for a refrigeration cycle that uses ammonia as the refrigerant.

Identify applications that use ammonia as a refrigerant.

Number: **S0745**

Title: **PLANS, SPECIFICATIONS, AND LOAD CALCULATIONS - INDUSTRIAL, COMMERCIAL AND INSTITUTIONAL (ICI)**

Duration: Total 27 hours Theory 9 hours Practical 18 hours

Prerequisites: L1CC – S0731, S0732, S0733, S0734, S0735, S0736, S0737

Content:

S0745.1 Interpret drawings for the design of an structure that includes a refrigeration and air conditioning system. **(4 / 5 hrs)**

S0745.2 Demonstrate freehand sketching of refrigeration and air conditioning systems. **(1 / 3 hrs)**

S0745.3 Describe procedures for gathering data regarding conditions and requirements for refrigeration storage of products. **(1 / 1 hrs)**

S0745.4 Calculate heat gain for medium temperature and low temperature for refrigeration storage of products. **(3 / 9 hrs)**

Evaluation & Testing:
Assignments related to theory and application skills
Minimum of one mid-term test during the term
Final test at end of term
Periodic quizzes

Mark Distribution:

Theory Testing	Practical Application Testing	Final Assessment
33%	67%	100%

Instructional and Delivery Strategies:
Lecture
Video
Paper based material
Demonstration – Practical Lab Assignments
CBT
E-Learning

Reference Materials:

Occupational Health and Safety Manual for Refrigeration and Air Conditioning
Dangerous Goods Transportation Act
Workplace Hazardous Materials Information System
Occupational Health and Safety Act and Regulations for Construction Projects
Environmental Code of Practice for the Reduction of Chlorofluorocarbon (ODP program)
Emissions from Refrigeration and Air Conditioning Systems
Modern Refrigeration and Air Conditioning (Althouse, Turnquist & Bracciano)
Applicable Software Training Materials
Manufacturers' Literature
Applicable Acts, Regulations, Legislation, and Codes

- Ontario Fire Code
- Canadian Electrical Code
- Boiler Pressure Vessels Act
- Mechanical Refrigeration Code CSA B52
- Provincial and Federal Halocarbon Regulations
- TSSA (Technical Standards and Safety Act)
- Building Code
- Municipal Codes

S0745.0 Plans, Specifications, and Load Calculations - Industrial, Commercial and Institutional (ICI) Systems

Duration: Total 27 hours Theory 9 hours Practical 18 hours

Cross-Reference to Learning Outcomes/Training Standard:
U6238; U6239; U6241; U6242; U6243.07; U6244; U6245

GENERAL LEARNING OUTCOME

Upon successful completion, the apprentice will be able to: interpret building plans; demonstrate freehand sketching; gather data for the refrigeration storage of products; and, calculate heat gain in refrigeration and air conditioning systems for Industrial, Commercial, or Institutional (ICI) applications.

LEARNING OUTCOMES AND CONTENT

45.1 Interpret building drawings for the design of a structure that includes a refrigeration and air conditioning system. **(4 / 5 hrs)**

Interpret isometric, orthographic and multi-view drawings.

Interpret working drawings and manuals to determine mechanical equipment requirements in refrigeration and air conditioning systems.

Interpret architectural, mechanical, electrical, and structural drawings including:
- title block
- revisions column
- precise installation locations
- scale(s)

Identify sections of the Mechanical Refrigeration Installation Code that refer to installation procedures for refrigeration and air conditioning systems for industrial, commercial or institutional locations.

Interpret technical installation manuals including:
- symbols
- abbreviations
- nomenclature

Determine the precise location and size of mechanical components from working drawings.

45.1 Continued

Describe the function of lines used on working drawings including:
- object
- dimension
- extension
- projection
- hidden

Interpret mechanical system drawing symbols to identify:
- piping
- motors
- compressors
- air moving devices
  - fans
  - blowers
- evaporators
- condensers
- metering devices
- pumps

Determine size and lengths of piping runs in a refrigeration and air conditioning system by scaling the drawings.

45.2 Demonstrate freehand sketching of refrigeration and air conditioning systems**. (1 / 3 hrs)**

Demonstrate freehand sketching to locate and position equipment for the installation of refrigeration and air conditioning systems including:
- evaporators
- compressors
- condensers
- refrigerant piping layout

Demonstrate freehand sketching for the fabrication of items required for installations including:
- brackets for piping
- supports system for components or accessories

45.3 Describe procedures for gathering data regarding conditions and requirements for refrigeration storage of products. **(1 / 1 hrs)**

Identify pertinent information by conducting a job site survey including:
- geographical location
- room dimensions or fixture description
- type of construction
- type and thickness of insulation
- location of fixture
- type and amount of product
- heavy or light usage

Identify features of available facilities including:
- access
  - truck
  - crane
  - building openings
- unit location
- ambient conditions
- availability of condensate removal
- water supply
- air supply-condensing medium temperature
- defrost type
- structural strength
- electrical service amperage
- electrical service voltage and phase
- electrical service location
- piping distance
- local codes and permits
- work to be completed by others

Determine class of operation including:
- holding cooler or freezer
- product chilling
- product freezing
- blast freezing

45.4 Calculate heat gain for medium temperature and low temperature for refrigeration storage of products. **(3 / 9 hrs)**

Determine heat gain for refrigerant storage of products using manufacturers' tables including:

- design ambient temperature
- product storage temperature
- product storage humidity
- product freezing temperature

Calculate heat gain for over a twenty-four hour time period using manufacturers' load estimate forms and tables including:

- transmission load
  - wall
  - floor
  - ceiling
- air change load
- sensible product heat load
- latent product heat load
- product heat load due to respiration
- miscellaneous load

Number: **S0746**

Title: **COOLING SYSTEMS AND COMPONENTS - INDUSTRIAL, COMMERCIAL, AND INSTITUTIONAL (ICI)**

Duration: Total 30 hours Theory 24 hours Practical 6 hours

Prerequisites: L1CC – S0731, S0732, S0733, S0734, S0735, S0736, S0737

Content:

S0746.1 Describe the operating principles and function of various compressors used in cooling systems for (ICI) applications. **(6 / 0 hrs)**

S0746.2 Describe procedures for checking wear tolerances of a reciprocating compressor used in cooling systems in (ICI) applications. **(1 / 3 hrs)**

S0746.3 Describe the operating principles and function of condensers used in cooling systems in (ICI) applications. **(5 / 0 hrs)**

S0746.4 Describe the operating principles and function of evaporators used in cooling systems designed to preserve perishable goods in (ICI) applications. **(4 / 0 hrs)**

S0746.5 Describe the operating principles and function of metering devices used in cooling systems in (ICI) applications. **(2 / 2 hrs)**

S0746.6 Describe the operating principles and function of accessories used in cooling systems in (ICI) applications. **(4 / 1 hrs)**

S0746.7 Describe operating principles and function of cascade compression of cooling systems in (ICI) applications. **(1 / 0 hrs)**

S0746.8 Describe the operating principles and function of compound compression of cooling systems in (ICI) applications**. (1 / 0 hrs)**

Evaluation & Testing: Assignments related to theory and application skills
Minimum of one mid-term test during the term
Final test at end of term
Periodic quizzes

Mark Distribution:

Theory Testing	Practical Application Testing	Final Assessment
80%	20%	100%

Instructional and Delivery Strategies: Lecture
Video
Paper based material
Demonstration – Practical Lab Assignments
CBT
E-Learning

Reference Materials:

Occupational Health and Safety Manual for Refrigeration and Air Conditioning
Dangerous Goods Transportation Act
Workplace Hazardous Materials Information System
Occupational Health and Safety Act and Regulations for Construction Projects
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- Boiler Pressure Vessels Act
- Mechanical Refrigeration Code CSA B52
- Provincial and Federal Halocarbon Regulations
- TSSA (Technical Standards and Safety Act)
- Building Code
- Municipal Codes

S0746.0 Cooling Systems and Components - Industrial, Commercial and Institutional (ICI)

Duration: Total 30 hours Theory 24 hours Practical 6 hours

Cross-Reference to Learning Outcomes/Training Standard:
U6238; U6239; U6241; U6242; U6243; U6244, U6245

GENERAL LEARNING OUTCOME

Upon successful completion, the apprentice will be able to describe the operating principles and function of cooling systems and components used for refrigeration and cooling systems in Industrial, Commercial, or Institutional (ICI) applications.

LEARNING OUTCOMES AND CONTENT

46.1 Describe the operating principles and function of various compressors used in cooling systems in industrial, commercial or institutional (ICI) applications. **(6 / 0 hrs)**

Describe positive displacement versus dynamic displacement compression of cooling systems.

Identify the information on a compressor nameplate.

Identify the mechanical components of a reciprocating compressor in a cooling system including:

- crankcase construction
- types of crankshafts
- crankshaft seals
- scotch yoke
- swash plate
- cylinder construction
- pistons
- piston rings
- connecting rods
- service valves
- valves
- valve plates
- bearings

46.1 Continued

Describe the operating principles and function of reciprocating compressors including:

- refrigerant-cooled
- air-cooled
- water-cooled
- valve operation
- lubrication system
- bore stroke and rpm
- swept volume
- compression ratio
- clearance volume
- volumetric efficiency

Describe procedures used to control the capacity of a reciprocating compressor to ensure that the operating efficiency matches the load requirements including:

- hot gas bypass
- cylinder bypass
- suction cut-off
- hydraulic and electric unloaders
- increased clearance volume
- variable speed
- multiple compressors

Solve problems that might occur with the reciprocating compressor including:

- compression ratios
- compressor displacement
- volumetric efficiency

Describe the construction of a rotary compressor in cooling systems including:

- stationary blade type
- rotary blade type

Describe the operating principles and function of a rotary compressor including:

- refrigerant travel through the compressor
- unique operating characteristics
- lubrication
- applications
  - ammonia
  - fluorocarbon

46.1 Continued

Describe the construction of a scroll compressor for cooling systems including:
- fixed and orbiting scroll
- discharge check valve
- wall thickness

Describe the operating principles and function of a scroll compressor including:
- refrigerant travel through the compressor
- unique operating characteristics
- lubrication
- application
- advantages of scroll versus reciprocating
- disadvantages of scroll versus reciprocating

Describe the operating principles and function of a screw compressor for cooling systems including:
- construction of a screw compressor
- helical rotor construction
- intake and exhaust
- crankcase construction
- refrigerant travel through the compressor
- unique operating characteristics
- lubrication
- application
- capacity control slide valve

Describe the operating principles and function of compound compression for cooling systems .

Describe procedures for analyzing efficiency of an operational reciprocating compressor for cooling applications including:
- testing methods
- hand tools
- power tools
- specialty instruments
- measuring and testing devices

Describe troubleshooting procedures for identifying problems that can occur with compressors for cooling systems.

46.2 Demonstrate procedures for checking wear tolerances of a reciprocating compressor used in cooling systems in industrial, commercial, or institutional (ICI) applications. **(1 / 3 hrs)**

Describe procedures to isolate compressor from system by pumping down and recovering the refrigerant in cooling systems.

Describe procedures for measuring wear tolerances in a reciprocating compressor including:

- dismantling/disassembly procedures
- hand tools
- power equipment
- inspection procedures
- measuring and checking procedures

Describe troubleshooting procedures for a reciprocating compressor in cooling systems including:

- inspection procedures
- hand tools
- power equipment
- seal replacement
- valve and valve plate replacement
- piston assembly replacement
- crankshaft replacement
- gasket replacement
- oil pump replacement
- unloader mechanism replacement
- re-assembly procedures

46.3 Describe the operating principles and function of condensers used in cooling systems in industrial, commercial, or institutional (ICI) applications. **(5 / 0 hrs)**

Describe operating principles of air-cooled condensers in cooling systems including:

- surface area
- single versus double
- layer
- subcooling coils
- secondary heat transfer surface
- fin design
- fin spacing
- internal volume
- circulation of the refrigerant
- acceptable pressure drop
- design temperature differences

Describe methods to install connecting piping in air-cooled condensers.

Describe procedures for eliminating vibration when connecting air-cooled condensers.

Identify problems that can occur with air-cooled condensing pressures and temperatures when there are:

- changes in refrigeration load
- changes in air flow over the condenser
- temperature variation of ambient
- changes of refrigerant flow through the condenser

Describe methods used to control condensing pressure and temperatures during low ambient conditions including:

- condenser flooding
- fan cycling
  - temperature
  - pressure
- fan speed control
- air volume dampers

Describe the construction and function of water/liquid-cooled condensers for cooling systems including:

- tube in tube
- shell and coil
- shell and tube condenser

46.3 Continued

Identify problems that can occur with water/liquid cooled condensing pressures and temperatures when there are:
- changes in refrigeration load
- changes in water flow through the condenser
- cooling water temperature variation
- changes of refrigerant flow through the condenser

Describe methods used to control condensing pressure and temperatures in water/liquid cooled condensers including:
- controlling water flow rate
- controlling inlet water temperature

Describe the operating principles and function of evaporative condensers for cooling systems.

Identify problems that can occur with condensing pressures and temperatures in evaporative condensers when there are:
- changes in refrigeration load
- changes in water flow across the condenser
- changes in entering wet bulb temperature
- cooling water temperature variation
- changes of refrigerant flow through the condenser

Describe methods used to control evaporative condenser pressure and temperatures.

Interpret manufacturers' data regarding condenser capacity of cooling systems including:
- compressor power requirements
- air-cooled versus water-cooled

Identify devices and instruments used to determine condenser temperature difference.

Calculate condenser operating capacity of refrigeration and cooling systems using:
- temperature difference
- manufacturers' data

46.4 Describe the operating principles and function of evaporators used in cooling systems designed to preserve perishable goods in industrial, commercial or institutional (ICI) applications. **(4 / 0 hrs)**

Identify conditions required for the preservation of various products using cooling systems .

Describe the operating principles for evaporator feeds used in cooling systems including:

- dry/direct expansion
- flooded type

Describe evaporator design used in cooling systems including:

- surface area and depth
- secondary heat transfer
- surface fin design
- fin spacing
- internal volume
- circulation of the refrigerant
- acceptable pressure drop
- design temperature differences
- sensible heat factor

Identify the differences between various dry/direct expansion evaporators used in cooling systems including:

- bar tube
- plate surface
- finned forced convection
- finned natural convection

Identify the differences between dry/direct expansion and flooded type chillers used in cooling systems .

Describe the effect of humidity in the conditioned space and the role of the evaporator temperature difference in changing humidity.

Describe how conditions at the evaporator will cause a change in the operating of cooling systems including:

- conditioned space temperature
- conditioned space humidity
- refrigerant superheat
- product load
- heat transfer media flow

46.4 Continued

Describe the need for defrosting of cooling systems .

Describe the operating principles and function for system defrost cycles in cooling systems including:

- installation procedures
- layout
- sequence of operation
- off-cycle
- timed-off air defrost
- hot gas
- cool gas
- water or glycol
- electric
- reverse cycle

Describe troubleshooting procedures for identifying normal and abnormal operations of defrost system components including:

- low-pressure control
- defrost timer
  - time-terminated
  - temperature-terminated
  - pressure-terminated
- electronic defrost control modules
- liquid-line solenoid valve
- hot gas solenoid valve
- check valves
- pressure regulating valves
- defrost termination thermostats
- fan delay thermostats
- electric heaters
- reversing valves

Describe procedures for repairing evaporator assemblies in cooling systems including:

- brazing
- soldering
- repairing or replacing fittings
- combing or realigning of fins
- replacing defrost heaters
- repairing or replacing hangers
- repairing or replacing fan blades
- repairing or replacing fan motors
- protecting fins in transit and during installation

46.5 Describe the operating principles and function of metering devices used in cooling systems in industrial, commercial, or institutional (ICI) applications. **(2 / 2 hrs)**

Identify types of metering devices in cooling systems including:
- hand operated expansion valves
- automatic expansion valve
- low side floats
- high side floats
- pilot operated devices

Describe capillary tube and fixed orifice-type metering devices in cooling systems including:
- application (types of systems)
- factors affecting capacity
- critical charge
- floating with the load
- effects on performance
  - overcharge of refrigerant
  - undercharge of refrigerant
  - overcharge of oil
  - lack of or excessive airflow
  - system contaminants

Describe electronic metering devices including:
- pulsing solenoids
- metering devices employing stepper motors
- electronic thermostatic expansion valves

Describe features of thermostatic expansion valves on cooling systems including:
- internal operating forces
- internally and externally equalized
- balanced port
- superheat settings
- system shutdown and start-up
- bulb charge applications
  - advantages
  - disadvantages
- liquid charged
- gas charged
- cross-charged

Describe the effect of a pressure drop in an evaporator and the use of externally equalized thermostatic valves to compensate in refrigeration and cooling systems.

46.5 Continued

Describe the operating principles and function of distributors in cooling systems including:

- function
- operation
- connection
- venturi type
- orifice type

Describe troubleshooting procedures for identifying thermostatic expansion valve malfunctions of cooling systems including:

- incorrect superheat setting
- loss of bulb charge
- bulb improperly secured
- improperly installed external equalizer line
- incorrectly selected valve
- system problems
- air or water flow
- high-side pressure
- low-side pressure
- line restrictions
- incorrect component sizing
- moisture in the system

Describe procedures for analyzing cooling system operations to identify the effects of a malfunctioning thermostatic expansion valve including:

- evaporator frost pattern
- incorrect superheat setting
- low suction pressure
- oil logging
- incorrect location of the bulb

Describe procedures to replace or service thermostatic expansion valve components including:

- screen
- head assembly
- cage assembly

46.6 Describe the operating principles and function of accessories used in cooling systems in industrial, commercial, or institutional (ICI) applications. **(4 / 1 hrs)**

Identify characteristics of piping accessories used with cooling systems including:
- liquid line filter driers
- suction line filters
- liquid moisture indicators

Describe methods to determine pressure drop across liquid line filter and suction filters on cooling systems .

Describe the application and operation of filters and filter driers on cooling systems .

Describe procedures for installing or servicing accessories including:
- filter driers
- suction filters
- liquid moisture indicators

Identify original equipment manufacturer versus field replacement sizing procedures for filters and filters driers.

Describe characteristics of filter drier accessories on cooling systems including:
- suction accumulators
- oil separators
- discharge mufflers

Describe troubleshooting procedures to identify whether system:
- suction accumulators are operating to design specifications
- oil separators are operating to design specifications

Describe procedures to install or service filter drier accessories.

Describe the operating principles and function of crankcase heaters in a cooling system .

Describe operating principles and function of refrigerant control devices in cooling systems including:
- evaporator pressure regulators (EPR)
- crankcase pressure regulators (CPR)
- hot gas bypass pressure regulators
- head pressure control regulators
- check valves

46.6 Continued

Describe procedures to determine if devices are operating to specifications:
- evaporator pressure regulator valves
- crankcase pressure regulator valves
- hot gas bypass valves
- head pressure control regulators
- check valves
- crankcase heater

Describe operating principles and function of service valves in cooling systems including:
- discharge service
- suction service
- liquid receiver valves
- access valves

Describe installation and servicing procedures for service valves, and evaporator pressure regulator valves including:
- crankcase pressure regulator valves
- hot gas bypass valves
- head pressure control regulators
- check valves
- crankcase heaters

Describe the application of liquid to suction heat exchangers and sub-coolers including the effects of added suction superheat on cooling systems .

Describe procedures for installing or servicing liquid-to-suction heat exchangers and sub-coolers on cooling systems .

Describe the operating principles and function of three-way heat reclaim valves on cooling systems .

Describe the operating principles and function of pressure relief devices on cooling systems including:
- applicable codes
- sizing procedure
- fire relief lines (discharge lines)
- diffusers

Describe procedures for installing or replacing pressure-relief devices on cooling systems.

46.6 Continued

Describe the operating principles and function of solenoid valves on cooling systems :

- direct acting
- pilot operated
- manual stem

Describe operating principles and function of solenoid valves.

Describe procedures for installing or replacing solenoid valves.

Identify types of shut off valves used in cooling systems.

Describe operating principles and function of water regulating valves used in cooling systems

Describe procedures for installing or replacing water regulating valves.

46.7 Describe operating principles and function of cascade compression in cooling systems in industrial, commercial, or institutional (ICI) applications. **(1 / 0 hrs)**

Identify cascade cycle components on a cooling system .

Describe the operating principles and function of a cascade cooling cycle on cooling systems .

Identify various refrigerants used for cascade systems.

Describe cascade cycle applications of cooling systems .

Interpret a cascade cycle plotted on a pressure enthalpy chart.

46.8 Describe the operating principles and function of compound compression in cooling systems in industrial, commercial, or institutional (ICI) applications. **(1 / 0 hrs)**

Identify compound cycle components for a cooling system

Describe the operation and function of a compound cooling cycle in cooling systems .

Describe the change in refrigerant conditions that occur during the passage through a compound compressor or compressors.

Describe the application of inter-coolers or liquid injection for cooling systems .

Interpret a compound cycle plotted on pressure enthalpy chart.

Describe compound cycle applications for cooling systems .

Number: **S0747**

Title: **SYSTEM DESIGN AND INSTALLATION – INDUSTRIAL, COMMERCIAL AND INSTITUTIONAL (ICI)**

Duration: Total 72 hours Theory 36 hours Practical 36 hours

Prerequisites: L1CC – S0731, S0732, S0733, S0734, S0735, S0736, S0737

Content:

S0747.1 Identify safe practices during the installation of refrigeration and air conditioning systems at (ICI) locations. **(1 /0 hrs)**

S0747.2 Describe planning and preparation procedures for the installation of refrigeration and air conditioning systems in (ICI) locations. **(2 / 0 hrs)**

S0747.3 Describe refrigerant-piping design and installation of piping in refrigeration and air conditioning systems. **(14 / 6 hrs)**

S0747.4 Identify components and accessories for refrigeration and air conditioning systems. **(3 / 9 hrs)**

S0747.5 Describe procedures for the installation of refrigeration and air conditioning system compressors and condensing units. **(1 / 3 hrs)**

S0747.6 Describe procedures for the installation of refrigeration and air conditioning system condensers. **(1 / 3 hrs)**

S0747.7 Describe procedures for the installation of refrigeration and air conditioning system evaporators**. (1 / 3 hrs)**

S0747.8 Describe procedures for the installation of refrigeration and air conditioning system accessories. **(3 / 2 hrs)**

S0747.9 Describe procedures for detecting refrigerant leaks in refrigeration and air conditioning systems. **(2 / 2 hrs)**

S0747.10 Describes procedures for evacuating refrigeration and air conditioning systems in (ICI) applications. **(1 / 3 hrs)**

S0747.11 Describe procedures for charging refrigeration and air conditioning systems. **(3 / 1 hrs)**

S0747.12 Describe pre-operational checks to verify utilities and energy sources. **(1 / 1 hrs)**

S0747.13 Describe commissioning procedures for refrigeration and air conditioning systems in (ICI) applications. **(3 / 3 hrs)**

Evaluation & Testing: Assignments related to theory and application skills
Minimum of one mid-term test during the term
Final test at end of term
Periodic quizzes

Mark Distribution:

Theory Testing	Practical Application Testing	Final Assessment
50%	50%	100%

Instructional and Delivery Strategies: Lecture
Video
Paper based material
Demonstration – Practical Lab Assignments
CBT
E-Learning

Reference Materials:

Occupational Health and Safety Manual for Refrigeration and Air Conditioning
Dangerous Goods Transportation Act
Workplace Hazardous Materials Information System
Occupational Health and Safety Act and Regulations for Construction Projects
Environmental Code of Practice for the Reduction of Chlorofluorocarbon (ODP program)
Emissions from Refrigeration and Air Conditioning Systems
Modern Refrigeration and Air Conditioning (Althouse, Turnquist & Bracciano)
Applicable Software Training Materials
Manufacturers' Literature
Applicable Acts, Regulations, Legislation, and Codes

- Ontario Fire Code
- Canadian Electrical Code
- Boiler Pressure Vessels Act
- Mechanical Refrigeration Code CSA B52
- Provincial and Federal Halocarbon Regulations
- TSSA (Technical Standards and Safety Act)
- Building Code
- Municipal Codes

S0747.0 System Design And Installation - Industrial, Commercial and Institutional (ICI)

Duration: Total 72 hours Theory 36 hours Practical 36 hours

Cross-Reference to Learning Outcomes/Training Standard:
U6230; U6231; U6232; U6233; U6234; U6235; U6236

GENERAL LEARNING OUTCOME

Upon successful completion, the apprentice will be able to: interpret design documentation; plan and prepare for an installation; describe installation procedures; and, describe charging and commissioning of refrigeration and air conditioning systems for Industrial, Commercial, or Institutional (ICI) applications.
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LEARNING OUTCOMES AND CONTENT

47.1 Identify safe practices during the installation of refrigeration and air conditioning systems at industrial, commercial, or institutional (ICI) locations. **(1 / 0 hrs)**

Identify safe practices during the installation of refrigeration and air conditioning systems including:

- safety legislation
- protective clothing, equipment and gear
- hand and power tools
- material handling equipment
- hot work permit
- lockout and tagging procedures
- fall arrest systems
- working in confined spaces

47.2 Describe planning and preparation procedures for the installation of refrigeration and air conditioning systems at industrial, commercial, or institutional (ICI) locations. **(2 / 0 hrs)**

Identify applicable Codes, Acts, Regulations and Legislations that impact during the installation of refrigeration and air conditioning systems including:

- OHSA (Ontario Health and Safety Act)
- WCA (Workers' Compensation Act)
- EPA (Environmental Protection Act)
- DGTA (Dangerous Goods Transportation Act)
- WHMIS (Workplace Hazardous Materials Information System)
- OFC (Ontario Fire Code)
- CEC (Canadian Electrical Code)
- BPVA (Boiler Pressure Vessels Act) (Pressure Piping)
- MOE (Ministry of the Environment)
- ODP (Ozone Depletion Program)
- TSSA (Technical Standards and Safety Act)
- EA (Energy Act)
- Building Codes and Municipal Codes

Interpret the elements of work orders to identify:

- location of installation
- type of equipment
- tools and equipment
- installation equipment

Identify required permits for installations including:

- electrical permits
- traffic permits
- hoisting permits
- building permits

Identify organizations or utilities which must be notified when construction or renovation interferes with normal operations including:

- security and alarm companies
- public utilities

Describe procedures for refrigerant recovery and disposal of old equipment of refrigeration and air conditioning systems.

Describe preparation planning procedures including:

- sequence of equipment delivery
- sequence of equipment installation

47.2 continued

Interpret nameplate data to verify that the refrigeration and air conditioning equipment received is as per contract requirements including:
- voltage
- amperage
- capacity

Describe inspection procedures for equipment at the installation site including:
- checking the exterior for shipping damage
- checking the dimensions of equipment
- removing panels to verify major components

Describe procedures for setting up installation equipment at the work site.

Identify locations for installation equipment using manufacturers' instructions and job specifications.

Identify installation locations using engineering drawing and job specifications.

Describe procedures to verify site utilities.

Describe applications and function of mounting and support equipment including:
- slabs
- curbs
- brackets
- sleepers
- pads
- hangers

Identify required mounting and support equipment.

Identify trades people or permits that are required to install refrigeration and air conditioning systems including:
- electricians
- plumbers
- sheet metal workers
- carpenters
- insulators
- gas technicians
- roofers

Describe verification procedures to determine the correct placement of the refrigeration and air conditioning equipment.

47.3 Describe refrigerant-piping design and installation of piping in refrigeration and air conditioning systems.

Identify the refrigerant piping layout to:
- ensure oil return
- safeguard the compressor during shut down
- maintain compressor operating cycles

Identify piping installation and support methods to ensure minimum damage and release of refrigerants.

Identify materials and fittings used to connect components of refrigeration and air conditioning systems including:
- copper
- copper alloys
- aluminum
- ferrous alloys
- grades
- types
- isolating valves
- pipe insulation

Identify specific requirements and precautions for suction line piping in refrigeration and air conditioning systems.

Identify pipe sizes for suction lines in refrigeration and air conditioning systems using:
- equipment manuals
- manufacturers' specifications
- work orders
- charts
- tables

Solve problems regarding a pressure drop in suction line piping.

Describe characteristics of suction risers in refrigeration and air conditioning systems including:
- function of a downsized suction riser
- procedures for sizing reduced suction riser
- function of a double suction riser

Describe procedures for sizing including:
- double suction risers
- suction lines for multiple compressor installations
- suction lines for multiple evaporator installations

47.3 Continued

Identify specific requirements and precautions for discharge-line piping in refrigeration and air conditioning systems including:
- pipe sizes for discharge lines
- problems arising from pressure drop

Describe the function of a reduced diameter discharge riser in refrigeration and air conditioning systems.

Describe the function of a double discharge riser in refrigeration and air conditioning systems.

Describe the procedures for sizing including:
- reduced diameter discharge riser
- double-discharge risers
- discharge lines for multiple compressor installations
- discharge lines for multiple evaporator installations

Identify specific requirements and precautions for liquid line piping in refrigeration and air conditioning systems including:
- pipe sizes for liquid lines
- problems arising from pressure drop/gain
- subcooling for liquid line piping

Describe considerations for alternate refrigerant retrofit in a refrigeration and air conditioning system.

Demonstrate the use of pipe cutting tools including:
- cutting pipe sections to length
- deburring pipe sections

Demonstrate the use of flaring tools including:
- flaring copper tubing

Demonstrate the use of swaging tools including:
- swage copper tubing

47.3 Continued

Demonstrate the procedures for purging refrigerant piping with nitrogen during brazing operations.

Demonstrate brazing techniques to produce leak proof copper joints including:
- joint cleaning and preparation
- composition and purpose of brazing flux
- application of flux
- purging with an inert gas
- torch set-up and lighting procedure
- silver brazing to produce leak free joints
- brazing using silver bearing brazing allows (silfos$^{TM)}$ to produce leak free joints
- inspection procedures
- documentation of work

Describe the function and application of piping components including:
- vibration isolators
- pipe supports

Demonstrate installation procedures for associated components in refrigeration and air conditioning systems including:
- driers and liquid-moisture indicators
- vibration loops and vibration isolators
- metering devices
- valves
- traps

47.4 Identify system components and accessories for refrigeration and air conditioning systems. **(3 / 9 hrs)**

Interpret design data to identify compressor capacities and operations in refrigeration and air conditioning systems including:

- application
  - high
  - medium temperature
  - low temperature
- saturated suction temperature (SST)
- condensing medium temperature
- power supply required
- physical dimensions
- weight
- compressor or condensing unit to satisfy design load

Describe evaporator capacities and operating parameters in refrigeration and air conditioning systems including:

- high temperature
- medium temperature
- low temperature.

Describe the operating principles and function of evaporator or evaporators in a balanced refrigeration and air conditioning system.

Determine the operating balance point for the condensing unit and evaporator in a refrigeration and air conditioning system.

Describe condenser capacities and operating parameters in a refrigeration and air conditioning system including:

- high temperature cooling systems
- medium temperature cooling systems
- low temperature cooling systems

Identify a condenser for a balanced refrigeration and air conditioning system.

Identify a head pressure control system.

Describe metering device capacities and operating parameters in refrigeration and air conditioning systems.

Identify system accessories for a balanced refrigeration and air conditioning system.

47.4 Continued

Interpret design data to identify components and accessories for refrigeration and air conditioning systems including:

- receiver
- subcooler
- evaporator pressure regulator valve
- crankcase pressure regulator valve
- check valves
- liquid moisture indicator
- liquid line drier
- suction filter
- oil separator
- discharge muffler
- vibration eliminator
- water regulating valve

47.5 Describe procedures for the installation of refrigeration and air conditioning system compressors and condensing units. **(1 / 3 hrs)**

Describe procedures for the mounting of compressors and condensing unit assemblies.

Identify installation limitations and safety requirements including:

- spacing requirements
- mounting procedures
- isolating methods
- required airflow
- manufacturers' installation instructions
- piping layout
- Building Codes
- Municipal Codes
- Government Legislation and Regulations

47.6 Describe procedures for the installation of refrigeration and air conditioning system condensers. **(1 / 3 hrs)**

Describe procedures for the mounting of air-cooled condenser and condenser assemblies in refrigeration and air conditioning systems.

Identify installation limitations and safety requirements including:

- spacing requirements
- mounting
- isolating methods
- required airflow
- solar and radiation considerations
- prevailing winds
- manufacturers' installation instructions
- piping layout
- piping fire-relief lines
- Building Codes
- Municipal Codes
- Government Legislation and Regulations

47.7 Describe procedures for the installation of refrigeration and air conditioning system evaporators**. (1 / 3 hrs)**

Describe procedures for the mounting of refrigeration and air conditioning system evaporators and evaporator assemblies.

Identify installation limitations and safety requirements including:

- space requirements
- mounting procedures
- suspending methods
- installing refrigerant piping
- connecting refrigerant piping
- condensate drainage systems
- environmental considerations

47.8 Describe procedures for the installation of refrigeration and air conditioning system accessories. **(3 / 2 hrs)**

Describe the function and installation requirements for system accessories including:

- liquid line filter driers
- liquid-moisture indicators
- receivers
- sub-coolers
- evaporator pressure regulating valves
- crankcase pressure regulating valves
- check valves
- crankcase heaters
- pressure relief valves
- solenoid valves
- heat reclaim valves
- suction filters
- oil separators
- discharge mufflers
- vibration eliminators
- water regulating valves
- humidifiers
- mechanical ventilation equipment
- condensate drain lines
- condensate pumps
- secondary refrigerant pumps
- economizers
- heat recovery ventilators
- energy recovery ventilators

47.9 Describe procedures for detecting refrigerant leaks in a refrigeration and air conditioning system. **(2 / 2 hrs)**

Identify devices to detect leaks in a refrigeration and cooling systems including:

- NH_3
- CFC
- HCFC
- HFC

Describe the operating principles and function of leak detection devices in a refrigeration and cooling systems including:

- electronic leak detectors
- bubble solution leak detectors
- ultraviolet leak detectors
- ultrasound leak detectors
- sulfur stick
- litmus paper

Describe procedures for system additives.

Describe procedures for performing system pressure tests in a refrigeration and cooling system including:

- using inert gases
- using leak detection soap solution
- handling nitrogen
- operating a two-stage regulator
- determining maximum test pressure
- pressure testing entire system using nitrogen
- pressurizing system with nitrogen
- leak testing with soap solution

47.10 Describes procedures for evacuating refrigeration and air conditioning systems in industrial, commercial, or institutional (ICI) applications. **(1 / 3 hrs)**

Interpret vacuum readings including:
- inches of mercury
- microns
- micrometers

Describe operating principles and function of evacuation equipment including:
- vacuum pumps
- high vacuum gauge (thermistors)
- cold traps

Describe the effects of moisture in the system including:
- acid
- sludge
- insulation breakdown
- corrosion

Describe the application of equipment to perform an system evacuation to specified micron readings.

Describe procedures to speed up the evacuation and dehydration process including:
- multiple evacuation
- addition of heat
- vacuum pump maintenance
- Schrader fittings
- evacuation line sizes

47.11 Describe procedures for charging refrigeration and air conditioning systems. **(3 / 1 hrs)**

Describe procedures for verifying the type of refrigerant to be charged into a refrigeration and air conditioning system.

Determine the quantity of refrigerant to be charged in the system.

Identify instruments and materials to charge the required quantity of refrigerant including:
- temperature measuring devices
- gauge manifold
- compound gauges
- pressure measuring devices
- scales
- liquid charging cylinder
- manufacturers' charts and graphs

47.11 Continued

Describe procedures for charging a refrigeration and air conditioning system with refrigerant to achieve maximum efficiency.

Describe procedures for checking the charge in refrigeration and air conditioning systems including:
- manufacturers' superheat charts
- superheat graphs
- scales
- charging cylinder
- liquid indicator (sight glass)
- approach temperature
- frost line

Describe procedures for recording and analyzing refrigeration and air conditioning system operating conditions including:
- saturated suction pressure
- saturated condensing pressure
- superheat
- total suction superheat
- refrigerant temperature entering the compressor
- compressor motor amperage
- sub-cooling
- coil approaches
- coil TDs or splits
- conditioned space
  - temperatures
  - flow rates
  - humidity levels

Identify types of oil based on the type of refrigerant including:
- mineral oil
- alkyl-benzene oil
- polyol ester oil

Identify the required oil charge using manufacturers' recommendations and job specifications.

Identify tools and equipment required to remove and charge the correct amount of oil into the compressor crankcase.

47.12 Describe pre-operational checks to verify utilities and energy sources. **(1 / 1 hrs)**

Identify required incoming utilities at the work site including:

- power supply
- water pressure
- water flow rate
- waste water or condensate removal

Interpret system design and installation specifications to start the system.

Identify the control settings at start-up to ensure that system operational sequence is in accordance with design parameters.

Describe verification procedures for essential elements in a refrigeration and air conditioning system including:

- power supply
- incoming water pressure
- water flow rate to start system
- condensing mediums
- load mediums
- heat transfer media
- condensing medium
  - temperature
  - pressure
  - flow
  - specific gravity
- load medium
  - temperature
  - pressure
  - flow
  - specific gravity
- system charge
- oil level

47.13 Describe commissioning procedures for refrigeration and air conditioning systems in institutional, commercial, and institutional applications. **(3 / 3 hrs)**

Identify applicable safety procedures when confirming that the system operating conditions conform to design and manufacturers' specifications.

Describe a verification schedule for work being done by other trades.

Identify essential performance criteria including:
- pressures
- temperatures
- flows
- voltages
- amperages
- power
- sound levels
- operating sequences

Identify tools and equipment used to verify the operation of the refrigeration and air conditioning system including:
- pressure measuring devices
- temperature measuring instruments
- electrical measuring instruments
- tachometers
- flow meters
- psychrometer
- hydrometers

Describe checking procedures including:
- equipment rotation
- oil levels
- secondary refrigerant levels
- safety guards
- safety equipment.

Describe procedures for making adjustments in a refrigeration and air conditioning system so that cooling medium temperature drop is in accordance with design specifications.

Describe procedures for making system adjustments so that condensing medium temperature rise is in accordance with design specifications.

Describe procedures for adjusting air flow in a refrigeration and air conditioning system to meet distribution specifications.

47.13 Continued

Identify required operating control parameters in a refrigeration and air conditioning system.

Describe procedures to verify that the control system in Industrial, Commercial, and Institutional (ICI) applications is operating to design specifications including:

- pressures
- temperatures
- flows
- voltages
- amperages
- power
- sound levels
- operating sequences

Identify the elements and information required on a commissioning report.

Describe procedures for recording the operating conditions of a refrigeration and air conditioning system on a commissioning report including:

- control system set points
- supply voltage
- operating current
- condensing medium conditions
- operating temperatures
- pressures
- system operation
- contract requirements

Identify the required regulations and legislation.

Identify the requirements for the completion of warranty documentation.

Describe information that is communicated to customers including:

- equipment operation
- routine maintenance procedures
- location of all equipment and controls
- control system operation

Number: **S0748**

Title: **ELECTRICAL AND CONTROL SYSTEMS – INDUSTRIAL, COMMERCIAL AND INSTITUTIONAL (ICI)**

Duration: Total 69 hours Theory 33 hours Practical 36 hours

Prerequisites: L1CC – S0731, S0732, S0733, S0734, S0735, S0736, S0737

Content:

S0748.1 Identify applicable Acts, Regulations, Legislation, and Codes, when working on electrical accessories and components in refrigeration and air conditioning systems. **(2 / 0 hrs)**

S0748.2 Describe the operating principles and function of alternating current inductive devices and circuits in a refrigeration and cooling system. **(10 / 6 hrs)**

S0748.3 Describe the operating principles and function of electric motors in refrigeration and cooling systems. **(2 / 3 hrs)**

S0748.4 Describe methods for installing component wiring in refrigeration and air conditioning systems. **(6 / 6 hrs)**

S0748.5 Describe maintenance procedures for electrical circuits and components in refrigeration and air conditioning systems. **(6 / 18 hrs)**

S0748.6 Describe the operating principles and function of electronic devices and controls in refrigeration and air conditioning systems. **(7 / 3 hrs)**

Evaluation & Testing:
Assignments related to theory and application skills
Minimum of one mid-term test during the term
Final test at end of term
Periodic quizzes

Mark Distribution:

Theory Testing	Practical Application Testing	Final Assessment
45%	55%	100%

Instructional and Delivery Strategies:

Lecture
Video
Paper based material
Demonstration – Practical Lab Assignments
CBT
E-Learning

Reference Materials:

Occupational Health and Safety Manual for Refrigeration and Air Conditioning
Dangerous Goods Transportation Act
Workplace Hazardous Materials Information System
Occupational Health and Safety Act and Regulations for Construction Projects
Environmental Code of Practice for the Reduction of Chlorofluorocarbon (ODP program)
Emissions from Refrigeration and Air Conditioning Systems
Modern Refrigeration and Air Conditioning (Althouse, Turnquist & Bracciano)
Applicable Software Training Materials
Manufacturers' Literature
Applicable Acts, Regulations, Legislation, and Codes

- Ontario Fire Code
- Canadian Electrical Code
- Boiler Pressure Vessels Act
- Mechanical Refrigeration Code CSA B52
- Provincial and Federal Halocarbon Regulations
- TSSA (Technical Standards and Safety Act)
- Building Code
- Municipal Codes

S0748.0 Electrical and Control Systems – Industrial, Commercial and Institutional (ICI)

Duration: Total 69 hours Theory 33 hours Practical 36 hours

Cross-Reference to Learning Outcomes/Training Standard:
U6238; U6239; U6241; U6240; U6242; U6243.09; U6244; U6245

GENERAL LEARNING OUTCOME

Upon successful completion, the apprentice will be able to describe the operating principles and function of electrical components and controls used in refrigeration and air conditioning systems for Industrial, Commercial, or Institutional (ICI) applications.

LEARNING OUTCOMES AND CONTENT

48.1 Identify applicable Acts, Regulations, Legislation, and Codes, when working on electrical system accessories and components in refrigeration and air conditioning systems. **(2 / 0 hrs)**

Identify applicable requirements of Canadian Electrical Code (CEC) including:
- CEC regulations regarding grounding (section 10)
- CEC regulations regarding wiring methods for air conditioning systems (section 12).

Describe procedures for lockout and tagging electrical devices on refrigeration and air conditioning systems.

Identify procedures for the connection and disconnection of electrical equipment on refrigeration and air conditioning systems including:
- legal requirements
- mandatory permits
- inspections.

Identify legislative limitations and scope of electrical work of Refrigeration and Air Conditioning Systems Mechanics including:
- ESA (Electrical Safety Authority)
- TQAA (Trade Qualification and Apprenticeship Act)
- Ministry of Labour
- Ontario Health and Safety Act

48.2 Describe the operating principles and function of alternating current inductive devices and circuits in refrigeration and air conditioning systems. **(10 / 6 hrs)**

Calculate parameters for refrigeration and air conditioning systems including:
- electrical quantities for series circuits
- electrical quantities for parallel circuits
- electrical quantities for combination circuits.

Describe characteristics of inductance in refrigeration and air conditioning systems including:
- factors which effect inductance
- AC induction and the effect on current.
- purpose of the iron core
- induced electro-motive force
- unit of measurement
- symbol for inductance
- inductive reactance
- equation for inductive reactance.

Describe the phase relationship between voltage and current in an inductive circuit in refrigeration and air conditioning systems.

Describe the operating principles and function of solenoids in refrigeration and air conditioning systems including:
- relays
- contactors
- valves

Demonstrate procedures for constructing circuits in refrigeration and air conditioning systems including:
- circuits in which contactors control various loads
- circuits in which solenoid valves control the flow of a fluid.

Describe the operating principles and function of transformers in refrigeration and air conditioning systems including:
- turns ratio
- step-up versus step-down
- VA rating
- primary and secondary voltage
- primary and secondary current
- no load voltage

Describe standard terminal and winding identification in refrigeration and air conditioning systems.

48.2 Continued

Describe characteristics of loads in transformers in refrigeration and air conditioning systems including:
- connected in series
- connected in parallel
- transformer polarity
- load sharing for two transformers connected in parallel

Describe procedures for identifying failures that can occur with transformers in refrigeration and air conditioning systems including:
- visually inspecting
- testing procedures
- oil leakage
- defects
- discoloration

Identify three phase transformers and power supplies in refrigeration and air conditioning systems.

Describe operating principles and function of 120/240 volt single phase electrical services and panels.

Describe operating principles and function of over-current protection devices in refrigeration and air conditioning systems including:
- circuit breakers
- fuses

Describe procedures for sizing over-current devices including:
- hermetic
- non-hermetic loads.

Describe operating principles and function of over-load protection devices including:
- hermetic
- non-hermetic loads.

Describe operating principles and function of conductors in refrigeration and air conditioning systems.

Describe operating principles and function of capacitors in refrigeration and air conditioning systems.

Describe the phase relationship between voltage and current in a capacitive circuit in refrigeration and air conditioning systems.

Determine the total capacitance for capacitors in series or parallel in refrigeration and air conditioning systems.

48.2 Continued

Describe characteristics of impedance.

Describe characteristics of AC power.

Describe the operating principles and function of low voltage thermostats including:
- installation considerations
- thermostat troubleshooting techniques.

Describe the operating principles and function of relays including:
- control transformer
- relays and contactors in condensing units or compressors
- relays on fans

Demonstrate repairing or replacement procedures for components including:
- capacitors
- transformers
- relays
- terminal blocks
- fuse blocks
- contactors
- coils
- circuit breakers
- thermal overloads
- fuses and fusible links
- connectors
- wiring
- switches

Describe procedures for checking the operation of electric heaters in refrigeration and air conditioning systems.

48.3 Describe the operating principles and function of electric motors in refrigeration and air conditioning systems. **(2 / 3 hrs)**

Identify the components of an electric motor including:
- stator
- rotor
- cover plates
- bearings
- starting switches
- capacitors
- number of poles and synchronous speed
- overload devices
- wiring
- information on motor nameplate

Describe the sequence of events to start and run a shaded pole motor including:
- transformer action between the stator and the rotor

Describe the sequence of events to start and run a split-phase motor including:
- transformer action between the stator and the rotor
- operation of starting switches or relays

Describe the sequence of events to start and run a capacitor start motor including:
- transformer action between the stator and the rotor
- start capacitor
- operation of starting switches or relays

Describe the sequence of events to start and run a permanent-split capacitor motor including:
- transformer action between the stator and the rotor
- purpose of the run capacitor

Describe the sequence of events to start and run a capacitor-start and capacitor-run motor including:
- transformer action between the stator and the rotor
- purpose of the run and start capacitors
- operation of starting relays

Describe the operating principles and application of motor speed control circuits and associated devices in refrigeration and air conditioning systems.

48.4 Describe methods for installing component wiring in refrigeration and air conditioning systems. **(6 / 6 hrs)**

Identify pertinent codes, acts, legislation, and regulations to be followed when wiring refrigeration and air conditioning systems.

Identify other trades people, credentials or permits required to service electrical power or components that feed the refrigeration and air conditioning system.

Determine conductor size from drawings and the electrical code.

Interpret manufacturers' instructions and specifications that relate to line and low voltage wiring in refrigeration and air conditioning systems.

Identify applicable codes and regulations that relate to wire lines and low voltage wiring including:
- wire sizing tables
- types of wire and insulation
- enclosure types and application
- rules for installing wiring

Identify installation hand and power tools for:
- flexible conduit
- cabling
- wiring conductors

Identify characteristics of raceways including:
- type of raceway
- cabling
- conductors
- location
- environment
- site conditions.

Describe different types of raceways including:
- liquid-tight flexible conduit
- flexible cords
- armored cable
- aluminum sheath cable
- conductors

48.4 Continued

Describe procedures for terminating different types of cabling.

Describe procedures for terminating and splicing stranded and solid conductors including:

- solder-less wire connectors
- crimp-on devices
- terminal screws
- manufacturers' specifications

Describe procedures for installing component wiring in refrigeration and air conditioning systems using:

- manufacturers' specifications
- design specifications
- electrical layout
- schematic drawings.

48.5 Describe maintenance procedures for electrical circuits and components in refrigeration and air conditioning systems. **(6 / 18 hrs)**

Interpret schematic diagrams to determine the sequence of operation for a refrigeration and air conditioning system that employs a pump down control circuit.

Interpret schematic diagrams to determine the sequence of operation for a refrigeration and air conditioning system that employs a non-recycling pump out control circuit.

Interpret schematic diagrams to determine the sequence of operation for a refrigeration and air conditioning system that employs a time-time or time-temperature defrost cycle.

Interpret schematic diagrams to determine the sequence of operation for a rooftop heating and air conditioning unit.

Interpret schematic diagrams to determine the sequence of operation for a refrigeration and air conditioning system that has a three-phase compressor.

Demonstrate sketching procedures to construct electrical schematic diagrams for refrigeration and air conditioning systems.

48.5 Continued

Demonstrate the use of electrical measuring devices to measure the performance of electrical control circuits and electrical components on refrigeration and air conditioning systems including:

- ammeters
- voltmeters
- ohmmeters
- megohmmeters
- wattmeters
- multimeters
- capacitor analyzers

Demonstrate procedures for measuring and testing electrical and controls in refrigeration and air conditioning systems including:

- single phase and three phase current flow
- single phase and three-phase voltage
- single phase and three-phase power
- circuit or component resistance
- circuit or component continuity
- capacitance

Describe procedures for checking electrical and control components in refrigeration and air conditioning systems including:

- panel fuses
- power wiring
- control wiring
- switches
- safety controls
- electronic air cleaners
- heaters
- motors

Demonstrate verification procedures for the parameters of control operations in refrigeration and air conditioning systems including:

- simulators
- analyzers
- computers

Describe procedures to adjust and calibrate controls and switches in refrigeration and air conditioning systems.

Demonstrate the hopscotch method to systematically locate electrical faults in refrigeration and air conditioning systems.

48.6 Describe the operating principles and function of electronic devices and controls in refrigeration and air conditioning systems. **(7 / 3 hrs)**

Describe the operating principles and function of electronic components, input and output devices, and DC power supplies in refrigeration and air conditioning systems including:

- semiconductors (PN junction)
- diodes
- triads
- rectifiers
- silicon-controlled rectifiers
- sensors and thermistors
- transducers
- thermocouples
- thermoelectric devices

Describe troubleshooting procedures for identifying failures that can occur with electronic devices and control systems including:

- discoloration
- odours
- moisture
- corrosion

Demonstrate verification procedures using diagnostic tests for electronic devices and controls in refrigeration and air conditioning systems.

Describe procedures for setting up programmable controllers on refrigeration and air conditioning systems for Industrial, Commercial, and Institutional applications.

Number: **S0749**

Title: **MATERIAL HANDLING PROCEDURES**

Duration: Total 12 hours Theory 9 hours Practical 3 hours

Prerequisites: L1CC – S0731, S0732, S0733, S0734, S0735, S0736, S0737

Content:

S0749.1 Identify procedures for operating lifting equipment and materials. **(6 / 2 hrs)**

S0749.2 Identify procedures for moving and setting down loads. **(3 / 1 hrs)**

Evaluation & Testing:

Assignments related to theory and application skills
Minimum of one mid-term test during the term
Final test at end of term
Periodic quizzes

Mark Distribution:

Theory Testing	Practical Application Testing	Final Assessment
75%	25%	100%

Instructional and Delivery Strategies:

Lecture
Video
Paper based material
Demonstration – Practical Lab Assignments
CBT
E-Learning

Reference Materials:

Occupational Health and Safety Manual for Refrigeration and Air Conditioning
Dangerous Goods Transportation Act
Workplace Hazardous Materials Information System
Occupational Health and Safety Act and Regulations for Construction Projects
Environmental Code of Practice for the Reduction of Chlorofluorocarbon (ODP program)
Emissions from Refrigeration and Air Conditioning Systems
Modern Refrigeration and Air Conditioning (Althouse, Turnquist & Bracciano)
Applicable Software Training Materials
Manufacturers' Literature
Applicable Acts, Regulations, Legislation, and Codes

- Ontario Fire Code
- Canadian Electrical Code
- Boiler Pressure Vessels Act
- Mechanical Refrigeration Code CSA B52
- Provincial and Federal Halocarbon Regulations
- TSSA (Technical Standards and Safety Act)
- Building Code
- Municipal Codes

S0749.0 Material Handling Procedures

Duration: Total 12 hours Theory 9 hours Practical 3 hours

Cross-Reference to Learning Outcomes/Training Standard:
U6238; U6239; U6240; U6241; U6242; U6243.09; U6244; U6245

GENERAL LEARNING OUTCOME

Upon successful completion, the apprentice will be able to identify procedures for the handling and operation of material handling equipment in accordance with the Construction Safety Association of Ontario guidelines.

LEARNING OUTCOMES AND CONTENT

49.1 Identify procedures for operating lifting equipment and materials. **(6 / 2 hrs)**

Perform calculations to identify required material handling equipment including:
- job documentation
- safety legislation
- load weights
- allowable loads
- size of load
- centre of gravity
- vertical and horizontal forces
- distribution of loads
- sling patterns
- sling configurations
- height of lift
- distance of move
- capacity of material handling equipment

Identify required certification and licenses for operating material handling equipment including:
- fork lift vehicles
- cranes
- hoisting equipment

49.1 Continued

Identify the operating principles and function of hoists, winches, and related devices including:

- safety legislation
- government regulations
- job documentation
- hoisting equipment
  - chain hoists
  - lever-operated hoists
  - come-along
  - grip-action hoists
  - turfers
  - electric wire rope hoists
  - electric chain hoists
  - pendant cranes
  - winches
- anchorage points
- centre of gravity
- inspection procedures
- shut-down and start-up procedures
- lifting and moving procedures
- documentation of work

Identify the operating principles and function of chains including:

- safety legislation
- government regulations
- job documentation
- clamps
- chain block hoists
- inspection procedures
- defective chains
- damaged links
- load weights
- allowable loads
- size of load
- centre of gravity
- types and characteristics of chain
- inspection procedures
- storage procedures
- maintenance procedures

49.1 Continued

Identify the operating principles and function of rigging hardware including:
- safety legislation
- government regulations
- job documentation
- type and size of load
- wire rope clips
- hooks
- shackles
- eyebolts
- turnbuckles
- thimbles
- sockets
- sheaves
- blocks
- rings, links and swivels
- spreaders and equalizer beams
- inspection procedures
- maintenance and storage procedures

Identify the operating principles and function of slings including:
- safety legislation
- government regulations
- job documentation
- type and size of load
- sling configuration
- sling angles
- centre of gravity
- wire rope
- chain slings
- synthetic web slings
- metal mesh slings
- fiber rope slings
- inspection procedures
- maintenance and storage procedures

Identify the operating principles and function of wire rope including:
- safety legislation
- government regulations
- job documentation
- type and size of load
- construction of rope
- type and characteristics of wire rope
- inspection procedures
- maintenance and storage procedures

49.1 Continued

Identify the operating principles and function of fiber rope including:

- safety legislation
- government regulations
- job documentation
- type and size of load
- construction of rope
- type and characteristics of fiber rope
- inspection procedures
- storage procedures
- maintenance procedures

Identify procedures for using personnel lift equipment including:

- personnel lift equipment
  - scaffolds
  - elevating work platforms
  - ladders
  - fall arrest system
- safety legislation
- legislation and regulations
- job documentation
- visual inspection techniques
- defective equipment
- damaged equipment
- assembly procedures
- fall arrest protection procedures
- disassembly procedures
- tagging of equipment for further action

Identify the licensing and re-certification requirements for hoisting and lifting equipment.

Identify the certification required for using fall arrest equipment.

49.2 Identify procedures for moving and setting down loads. **(3 / 1 hrs)**

Identify procedures for preparing the worksite for the moving and setting down of load including:

- safety legislation
- legislation and regulations
- job documentation
- site inspection procedures
  - workers in operating areas
  - overhead power lines
  - proximity of structures and other equipment
  - ground conditions
  - outriggers and blocking
  - factors affecting capacity
- worksite/pathway clearing procedures
- notification of sub-trades, power utilities

Identify procedures for tying knots, hitches, and bends including:

- triple sliding hitch (safety knot)
- round turn and two half hitches
- timber hitch and two half hitches
- reef knot
- two half hitches
- bowline
- double bowline
- triple bowline

Identify procedures for moving loads or workpiece including:

- safety legislation
- protective clothing, equipment and gear
- job documentation
- capacity of material handling equipment
- type and distance of move
- size of workpiece
- load control
- speed and travel
- turning and positioning load
- operators keep to the back end of the load
- use of hand signals
- documentation of moving loads

49.2 Continued

Identify procedures for moving loads including:

- safety legislation
- protective clothing, equipment and gear
- job documentation
- capacity of material handling equipment
- type and distance of move
- size of workpiece
- load control
- speed and travel
- turning and positioning load
- load or travel pathway
- operators keep to the back end of the load
- use of hand signals
- documentation of moving loads

Identify procedures for setting down loads including:

- safety legislation
- job documentation
- work or job site is clear
- supports placed and aligned
- lowering speed requirements
- stopping the set down before placing down the load
- sounding the alarm confirming “all clear for down
- materials
  - placed
  - located
  - balanced
  - aligned
  - secured
- set down procedures