



# Heating, Ventilation, Air Conditioning, & Refrigeration

## Study Guide

### Assessments:

**3401 HVACR Technician**

**3402 Process Piping Technician**

**3403 Refrigeration Technician**

**3404 Sheet Metal Technician**

Aligned to PAHRA Technical  
Program Requirements,  
Oklahoma Construction  
Industries Board, & NCCER  
National Standards

Endorsed by the Air  
Conditioning, Heating, and  
Refrigeration Institute



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The logo for Oklahoma Works. It features a stylized graphic of three overlapping shapes in orange, blue, and yellow, resembling a 'W' or a mountain range. Below the graphic, the words "OKLAHOMA" and "WORKS" are stacked in a bold, blue, sans-serif font.

## Overview

This study guide is designed to help students prepare for the HVACR assessments which include the following: HVACR Technician, Process Piping Technician, Refrigeration Technician, and Sheet Metal Technician. It not only includes information about each assessment in the series, but also the skill standards upon which the assessments are based, resources that can be used to prepare for the assessments, and test taking strategies.

Each of the four sections in this guide provides useful information for students preparing for the HVACR assessments and the industry-level certifications through the Partnership for Air Conditioning, Heating, Refrigeration Accreditation (PAHRA) for 3401 HVAC Technician, Oklahoma Construction Industries Board (OCIB) (3402-3404) and the National Center for Construction Education and Research (NCCER) HVAC modules.

- CareerTech and Competency-Based Education: A Winning Combination
- HVACR assessments
  - ▶ Assessment Information
  - ▶ Standards and Test Content
  - ▶ Sample Questions
  - ▶ Textbook/Curriculum Crosswalk
  - ▶ Additional Resources
  - ▶ Abbreviations, Symbols, and Acronyms
- Strategies for Test Taking Success
- Notes

The HVACR Technician (3401) was developed and aligned to the PAHRA Technical Program Requirements and to align to the ICE exam for Residential Air Conditioning and Heating. PAHRA is a third party organization that is a partnership between HVACR educators and the HVACR industry that will award accreditation to programs that have met and/or exceeded industry validated standards.

The Process Piping Technician (3402), Refrigeration Technician (3403), and Sheet Metal Technician (3404) were developed and aligned with the OCIB industry-recognized licensure assessments. The OCIB regulates the licensing of plumbers, electricians and mechanical trades in the state of Oklahoma.

All four assessments and associated standards are endorsed by the Air Conditioning, Heating, and Refrigeration Institute (AHRI). AHRI is a trade association representing manufacturers of HVACR and water heating equipment within the global industry. AHRI is viewed as a resource for industry shipment data, education, and workforce information and research. **[www.ahrinet.org](http://www.ahrinet.org)**

All four assessments in the series have also been crosswalked to the NCCER HVAC modules for certification. NCCER develops standardized construction and maintenance curricula and assessments with portable credentials.

The HVACR assessments measure a student's ability to apply knowledge and skills in HVACR related careers. The HVACR assessments are designed to prepare a student for the industry-recognized credentialing assessments mentioned above.

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# CareerTech and Competency-Based Education: A Winning Combination

Competency-based education uses learning outcomes that emphasize both the application and creation of knowledge and the mastery of skills critical for success. In a competency-based education system, students advance upon mastery of competencies, which are measurable, transferable outcomes that empower students.

Career and technology education uses industry professionals and certification standards to identify the knowledge and skills needed to master an occupation. This input provides the foundation for development of curriculum, assessments and other instructional materials needed to prepare students for wealth-generating occupations and produce comprehensively trained, highly skilled employees demanded by the work force.

## Tools for Success

CareerTech education relies on three basic instructional components to deliver competency-based instruction: skills standards, curriculum materials, and competency assessments.

**Skills standards** provide the foundation for competency-based instruction and outline the knowledge and skills that must be mastered in order to perform related jobs within an industry. Skills standards are aligned with national skills standards and/or industry certification requirements; therefore, a student trained to the skills standards is equally employable in local, state and national job markets.

**Curriculum materials and textbooks** contain information and activities that teach students the knowledge and skills outlined in the skills standards. In addition to complementing classroom instruction, curriculum resources include supplemental activities that enhance learning by providing opportunities to apply knowledge and demonstrate skills.

**Certification Assessments** test the student over material outlined in the skills standards and taught using the curriculum materials and textbooks. When used with classroom performance evaluations, certification assessments provide a means of measuring occupational readiness.

Each of these components satisfies a unique purpose in competency-based education and reinforces the knowledge and skills students need to gain employment and succeed on the job.

## Measuring Success

Evaluation is an important component of competency-based education. Pre-training assessments measure the student's existing knowledge prior to receiving instruction and ensure the student's training builds upon this knowledge base. Formative assessments administered throughout the training process provide a means of continuously monitoring the student's progress towards mastery.

Certification assessments provide a means of evaluating the student's mastery of knowledge and skills. Coaching reports communicate assessment scores to students and provide a breakdown of assessment results by standard area. The coaching report also shows how well the student has mastered skills needed to perform major job functions and identifies areas of job responsibility that may require additional instruction and/or training.

# HVACR

## Assessments Information

### What are the HVACR assessments?

The HVACR assessments are end-of-program assessments for students in HVACR-related programs. The assessments provide an indication of student mastery of knowledge and skills necessary for success in careers in the HVACR industry.

### How were the assessments developed?

The assessments were developed by the CareerTech Testing Center in alignment with PAHRA Technical Program Requirements, OCIB industry-recognized credentialing exams, and NCCER National Craft Assessment and Certification Program Specifications. A committee of industry representatives and educators validated the areas covered on the assessments. The content on each assessment was developed and reviewed by a committee of subject matter experts from the respective crafts.

The committee assigned frequency and criticality ratings to each skill, which determines the significance of each task for test development:

**Frequency:** represents how often the task is performed on the job. Frequency rating scales vary for different occupations. The rating scale used in this publication is presented below:

1 = less than once a week      2 = at least once a week      3 = once or more a day

**Criticality:** denotes the level of consequence associated with performing a task incorrectly. The rating scale used in this publication is presented below:

1 = slight                                      2 = moderate                                      3 = extreme

### What do the assessments cover?

The assessments are aligned to the various credentialing requirements. The areas of emphasis are as follows for each assessment in the HVACR Series:

#### 3401 – HVACR Technician (100 questions)

HVACR Industry	2%	Heating Systems	7%
Thermodynamics & Heat Transfer Principles	6%	Commercial Refrigeration	4%
Safety Skills	4%	Air Handling	6%
Tools and Equipment	8%	System Installation and Start-Up	4%
Piping Principles and Practices	5%	System Servicing and Troubleshooting	9%
Electricity	7%	Indoor Air Quality	1%
Controls	6%	Preventative Maintenance	2%
Solid State Electronics	1%	Refrigerant Recovery	4%
Load Calculations	3%	Refrigerant Retrofits	0%
Refrigerant System Components	9%	Refrigerants and Lubricants	2%
Air-Conditioning Systems	1%	Comply with Industry Regulations	5%
Heat Pump Systems	3%	Professional Service	1%

### **3402 – Process Piping Technician (55 questions)**

Safety and Environmental Skills	14%	Piping Principles and Practices	29%
DC Circuits	7%	Natural Gas Piping	50%

### **3403 – Refrigeration Technician (60 questions)**

Safety and Environmental Skills	7%	Refrigeration System Controls	3%
DC Circuits	15%	Piping Principles and Practices	13%
AC Circuits	10%	Refrigeration Cycle	12%
Electric Motors	18%	Refrigeration Systems	22%

### **3404 – Sheet Metal Technician (55 questions)**

Safety and Environmental Skills	16%	Vents and Chimneys	13%
Air Distribution Systems	71%		

## **What are the benefits of using these assessments?**

Students receive a certificate for each assessment that he/she passes. This certificate may be included in his/her portfolio and used to communicate the student's mastery of the subject matter to potential employers.

## **When should the assessments be taken?**

The CareerTech Testing Center recommends that students take an assessment as soon as possible after receiving all standards-related instruction, rather than waiting until the end of the school year.

## **Are the assessments timed?**

No. Although students may take as long as they need, most finish an assessment within one hour.

## **What resources can students use on these assessments?**

Students are allowed to use calculators and scratch paper on CTTC assessments; however, these items must be provided by the testing proctor and returned to the proctor before the student's exam is submitted for scoring. Calculator apps on cell phones and other devices may not be used on these assessments.

Students taking these assessments may also use publisher-bound copies of the International Mechanical Code, the International Fuel Gas Code, and the International Plumbing code as long as they are free of markings and do not hold loose papers.

Students may also access the following charts during testing:

*Pressure Temperature Chart & Formulas*

[http://www.okcareertech.org/educators/assessments-and-testing/testing/resources/PressureTemperatureFormulachart\\_05742015.pdf](http://www.okcareertech.org/educators/assessments-and-testing/testing/resources/PressureTemperatureFormulachart_05742015.pdf)

*Static Pressure Chart*

[http://www.okcareertech.org/educators/assessments-and-testing/testing/resources/StaticPressureChart\\_05072015.pdf](http://www.okcareertech.org/educators/assessments-and-testing/testing/resources/StaticPressureChart_05072015.pdf)

## What accommodations can be made for students with Individualized Education Plans (IEPs)?

Accommodations are allowed for students with an Individualized Education Plan. Examples of allowable accommodations include:

- Extended time — This assessment is not timed, therefore students may take as much time as needed to finish. The assessment must be completed in one testing session.
- Readers — A reader may be used to read the assessment to a student who has been identified as needing this accommodation.
- Enlarged text — Students needing this accommodation can activate this feature by clicking the **AA** icon in the upper right corner of the screen.

## What can students expect on Test Day?

All CTTC assessments are web-based and delivered exclusively by a proctor in the school's assessment center. The proctor **cannot** be an instructor or anyone who was involved with the student during instruction.

Assessments are delivered in a question-by-question format. When a question is presented, the student can select a response or leave the question unanswered and advance to the next question. Student may also flag questions to revisit before the test is scored. All questions must be answered before the test can be submitted for scoring.

After the assessment is scored, the student will receive a score report that not only shows the student's score on the assessment, but also how the student performed in each standard area.

## Can students retake the test?

Students may retake the test unless their school or state testing policies prohibit retesting. Students who can retest must wait at least three days between test attempts.



# Standards and Test Content

## HVACR Industry

### 1. Introduction to Refrigeration (1/1)

- Explain the history of air conditioning and refrigeration
- Define air conditioning and refrigeration
- Explain the differences between air conditioning and refrigeration
- Determine career opportunities in the HVACR industry
- Describe the role of Trade Association

### 2. Introduction to Air Conditioning (1/1)

- Understand the historical development of air conditioning
- Define "air conditioning" and relate to human comfort conditions
- Discuss the differences between air conditioning and heating
- Discuss the various systems of air conditioning
  - mechanical compression cycle
  - evaporative cooling
  - desiccant dehumidification
  - absorption cycle
- Explain why ventilation is often inadequate

### 3. Introduction to Heating (1/1)

- Define heating
- Discuss the differences between air conditioning and heating
- Explain the various heating systems
  - gas
  - oil
  - heat pump
  - electric resistance
  - hydronics
  - solar



## Thermodynamics and Heat Transfer Principles

### 1. Matter and Heat Behavior (3/3)

- Define matter and heat
- Explain the direction and rate of heat flow
- Describe the three methods of heat transfer
- Identify the reference points of temperature
  - boiling point
  - freezing point
  - critical temperature
  - absolute zero
- Explain the difference between heat and temperature
- Explain the difference between latent and sensible heat
- Explain the change of state of matter
- Explain heat/cool storage



- Define specific heat
- Define sensible heat
- Define latent heat of fusion
- Define latent heat of vaporization
- Define enthalpy
- Define saturation temperature (dew point temperature)
- Define water vapor pressure
- Explain the direction and rate of moisture transfer
- Calculate total heat (in BTU's) a pound of any substance contains

## 2. Fluids and Pressures (3/3)

- Explain the relationship of pressures and fluids at saturation temperatures
- Identify the relationship between temperature and pressure using the P/T Chart
- Define pressure
- Explain atmospheric pressure
- Explain compound gauges
- Explain bourdon tubes
- Explain barometric pressure
- Explain absolute pressure
- Explain gauge pressure
- Explain inches of mercury absolute
- Explain micron



## 3. Refrigeration Cycle/Diagrams (3/3)

- Identify the four major components of the vapor compression refrigeration system
- Describe the state and conditions of the refrigerant during a cycle
- Explain the effects of:
  - superheating the suction gases
  - increasing the condensing pressure
  - subcooling the liquid
- Explain the importance of superheat and subcooling
- Define refrigeration
- Explain the functions of the four major components of a refrigeration system
 

▸ compressor	▸ metering device
▸ condenser	▸ evaporator
- List the components which separate the high side from the low side of the system
- Describe the Temperature/Enthalpy (T-H) Diagram
- Calculate problems using Pressure/Enthalpy (P-H) Diagram
- Label the line which represents each of the four basic components on a Pressure/Enthalpy (P-H) Diagram

#### 4. Measurement Systems (2/2)

- Explain units of heat, power, velocity, mass and length
- Identify U.S. and S.I. units
- Convert from U.S. to metric units
  - length
  - area
  - volume
  - mass
  - force
  - velocity
  - density
  - pressure
  - temperature
  - energy
  - power
  - specific heat
  - volume flow rate
  - capacity
- Convert pounds to ounces
- Convert cooling capacity from tons of refrigeration to kW and BTUH to kW

## Safety Skills

#### 1. Personal Safety and Work Practices (1/3)

- Explain clothing and safety equipment
- Review OSHA standards
- Explain the effects of substance abuse on safety
- Review safe driving practices
- Identify, handle, use, and dispose of hardware material
- Wear appropriate clothing
- Use safety equipment (e.g., footwear, hearing protection, hard hat, goggles, gloves)
- Demonstrate good housekeeping practices in the lab
- Demonstrate proper ladder safety
  - wooden
  - aluminum
  - fiberglass
  - scaffolding
- Demonstrate proper lifting procedures
- Pass safe driving course
- Use appropriate fire extinguishers
- Conduct routine safety inspections

#### 2. Handling of Pressurized Fluids (2/3)

- List safety requirements
- Explain application of pressure relief devices
- Explain proper storage and handling of refrigerants
- Explain proper storage and handling of oxygen, nitrogen and acetylene bottles
- Explain the effects of mixing oxygen and oil
- Follow procedures specified on the Safety Data Sheet (SDS)
- Store and dispose of hazardous material according to EPA specifications
- Explain ASHRAE Refrigerant Safety Classification of Refrigerants for Toxicity and Flammability
- Properly fill and label a refrigerant cylinder
- Determine if a refrigerant cylinder needs retesting



### 3. Handling Hazardous Substances (2/3)

- Explain use of Safety Data Sheets (SDS)
- Define difference between hazardous materials, substances and wastes
- Explain use of hazardous material manifest
- Locate SDS and identify particular effect
- Demonstrate use of proper clothing and equipment
- Demonstrate basic first aid procedure

### 4. Electrical Safety (2/3)

- Explain importance of GFCI
- Explain the use of power tools and accessories
- Discuss work habits
- Explain environmental safety practices
- Explain proper procedures when working with hands on live equipment
- Fault a ground fault interrupter
- Demonstrate the use of lockout/tagout equipment

## Tools and Equipment

### I. Hand Tools and Accessories (3/3)

- Identify basic tools
  - ▶ adjustable wrenches
  - ▶ allen (hex) wrenches
  - ▶ crimpers
  - ▶ diagonal cutting pliers (dikes)
  - ▶ flare nut wrenches
  - ▶ general-use pliers
  - ▶ hack saw
  - ▶ hand saw
  - ▶ lineman pliers (sidecutters)
  - ▶ nutdrivers
  - ▶ open & box end wrenches
  - ▶ pipe wrenches
  - ▶ pulley & gear pullers
  - ▶ punches
  - ▶ scratch awl
  - ▶ sheet metal snips
  - ▶ socket wrenches
  - ▶ torque wrenches
  - ▶ various hammers
  - ▶ various screwdrivers
  - ▶ wire strippers
  - ▶ tape measure
  - ▶ solder gun
  - ▶ Schrader valve
- Identify power tools
  - ▶ general-purpose drills
  - ▶ hammer drill
  - ▶ power screwdriver
  - ▶ reciprocating saws
  - ▶ screwgun
- Identify fasteners
  - ▶ bolts
  - ▶ conduit, pipe & cable clamps
  - ▶ masonry anchors
  - ▶ nails
  - ▶ screws
  - ▶ various electrical connectors
  - ▶ pop rivets



- Identify pipe and tubing tools
    - benders
    - flaring tools
    - pipe cutters, reamers and threaders
    - pipe vises
    - swaging tools
    - tubing cutters and reamers
  - Describe lubrication methods using different types of circuits
    - grease guns
    - oilers
    - spray
  - Show the proper use of a pipe cutter
  - Show the proper use of a threader
  - Demonstrate how to make a flared tubing joint
2. Electrical Testing Devices/Meters **(3/3)**
- Define amps, volts, ohms and watts
  - Demonstrate understanding of the basic types of electrical measurement
  - Measure voltage with digital and analog voltmeters
  - Measure AC current with a clamp-on ammeter
  - Measure resistance with an ohmmeter
  - Check winding insulation with megohmmeter
  - Check voltage with a voltage tester
  - Use a continuity tester to determine whether an open circuit or dead short exists
  - Use a capacitance meter to measure capacitance of run and start capacitors
  - Calculate capacitance
  - Wire and measure resistance of different types of circuits
    - series
    - parallel
    - unequal
    - series – parallel
3. Refrigeration: Servicing and Testing Equipment **(3/3)**
- Measure pressures with the refrigeration gauge manifold
  - Evacuate systems with a two-stage vacuum pump
  - Measure vacuums with a thermistor vacuum gauge
  - Measure temperatures with electronic thermometers
  - Measure temperatures with bimetal, thermocouple or glass stem thermometer
  - Charge a system with a charging cylinder
  - Charge a system with an electronic charging scale
  - Check for leaks with electronic leak detector and halide torch
  - Use nitrogen with trace of R-22 for leak detection
  - Compare readings to manufacturers' specifications
  - Determine refrigerant amount and type
  - Charge a system to manufacturers' specification



#### 4. Heating: Servicing and Testing Equipment (2/3)

- Measure chimney draft with a gauge
  - measure draft over fire
  - measure draft at the chimney breaching
- Perform an efficiency test on an oil-gas burner
  - smoke test
  - CO<sub>2</sub> test
  - O<sub>2</sub> test
  - check draft
  - series – check stack temperature
- Determine effectiveness of an oil pump using
  - vacuum gauge
  - pressure gauge
- Determine relative humidity using a sling psychrometer
  - find the relative humidity and dew point using psychrometric chart
- Measure gas pressure with the following equipment:
  - u-tube manometer
  - pressure gauge
- Calculate proper size of chimney for both 80 and 90+ furnaces
- Determine what to do with an "orphaned" water heater
- Check wall thermostat and anticipator
  - cooling system (fan on-automatic)
- Check electronic pilot system
- Check and adjust blower system
- Check and adjust fan control
- Check limit and safety controls

#### 5. Air Flow: Measuring and Testing Equipment (2/2)

- Determine air velocity within a duct via:
  - pitot tube
  - inclined manometer
  - electronic velometer
  - u-tube manometer
- Determine air velocity at grilles and diffusers via:
  - deflecting vane anemometer
  - velometer
  - hot wire anemometer
  - pitot tube
  - rotating vane anemometer
- Measure pressure drop with a magnahelic gauge
- Determine CFM
- Use manufacturers' airflow data sheets
- Solve problems using friction loss chart



# Piping Principles and Practices

## 1. Piping Material and Fabrication (2/3)

- Identify types of pipe and tubing used in HVACR industry
- Identify various types of fittings or valves for specific applications
- Describe methods of insulating pipe and tubing
- Identify soldering and brazing alloys used in HVACR
- Explain applications of soldering and brazing alloys
- Describe heat sink methods
- Describe heat exchange techniques
- Describe the applications and installation of vibration eliminators
- Identify types of torches used for cutting and welding
- Flare copper tubing
- Swage copper tubing
- Bend copper tubing
- Solder and braze copper tubing
- Cut and thread steel/iron pipe
- Braze aluminum tubing
- Thread pipe used in pipe operations

## 2. Pipe Sizing and Troubleshooting (2/2)

- Explain capacities of refrigerant lines
- Explain effects of refrigerant velocity in lines
- Explain equivalent lengths of piping for fittings
- Explain use of traps in vapor risers
- Explain the effects of pressure drop in the refrigeration system
- Explain gas piping
- Calculate total effective length of pipe runs
- Calculate amount of refrigerant in lines
- Size piping using manufacturers' installation instructions
- Calculate pressure drop in liquid line risers
- Size liquid and vapor lines
- Calculate gas piping sizes to multiple units, fed from a single meter

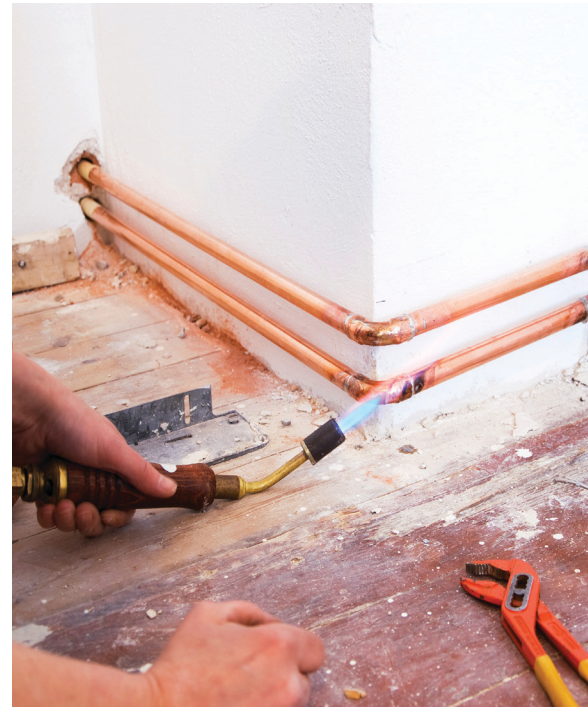
## 3. Sheetmetal (2/2)

- Explain use of bending tools
- Explain use of cutting tools
- Explain the types of ductwork and fittings
- Demonstrate use of tin snips left, right and straight
- Identify the different pressures of ductwork
- Identify the different types of connections



## Natural Gas Piping

1. Demonstrate knowledge of/apply principles of natural gas piping systems **(3/3)**
  - Pipe materials
  - Pipe size
  - System design
  - Installation
  - Pipe auxiliary accessories
  - Code regulations
2. Design and install a natural gas piping system **(2/3)**
3. Identify/select specified natural gas piping, valves, connectors, and accessories **(3/3)**
4. Read and interpret piping layouts **(3/3)**
  - Schematics
  - Trains
  - Blueprints
  - Diagrams
  - Charts
  - Engineering specifications
5. Perform metallic tubing operations **(3/3)**
  - Cleaning
  - Pipe fitting
  - Set up soldering/brazing system
  - Cutting
  - Flaring
  - Mechanical joints
  - Soldering
  - Brazing
  - Bending
  - Swaging
  - Reaming
6. Perform metallic pipe operations **(3/3)**
  - Cutting
  - Reaming
  - Threading
  - Mechanical joints
  - Welding
  - Fitting
7. Perform non-metallic pipe operations **(3/3)**
  - Cutting
  - Fitting
  - Cleaning
  - Reaming
  - Threading
  - Mechanical joints
  - Fusion
  - Solvent cementing
  - Bending
8. Perform welding **(2/2)**
  - Set up welding system
  - Arc welder
  - MIG welder
  - TIG welder
  - Oxyfuel welder
  - Fusion equipment
9. Test for leaks **(3/3)**



## Electricity

1. Basic Electricity **(3/3)**
  - Define watts, ohms, volts, and amps
  - Define and compare single- and three-phase voltage and current
  - Identify types of electrical loads (i.e., capacitive, inductive and resistive)
  - Analyze applications of magnetism in electricity
  - Apply magnetic principles to electrical theory

- Compare conducting and insulating materials
- Identify principles of solid-state switching devices
- Demonstrate proper use of ammeter, ohmmeter, voltmeter and wattmeter
- Use Ohms Law to solve circuit problems and calculate circuit loads
- Use appropriate meters to check basic electrical components
- Determine the electrical characteristics of both series and parallel circuits
- Demonstrate algebra/math skills
- Determine the equivalent resistance in a parallel and series circuit
- Determine the equivalent capacitance in a parallel and series circuit
- Construct and analyze:
  - series circuit
  - parallel circuit
  - series-parallel circuit

## 2. Electrical Generation and Distribution (2/2)

- Explain basic generator principle
- Explain how electricity is produced and distributed
- Define Wye (Y) and Delta ( $\Delta$ ) distribution systems
- Draw and identify power transformer types
- Use electrical meters appropriately to test and identify voltages in both single- and three-phase systems
- Size/test fuses/breakers and safely replace them
- Use National Electrical Code (NEC) tables to check wire size and conduit size for connected equipment
- Determine correct wire size and voltage drops for electrical circuits
- Determine whether existing load centers are adequate to supply desired load addition

## 3. Electrical Components (3/3)

- Define magnetic theory
- Define and explain the use or function of:
 

▸ aquastats	▸ potentiometers
▸ capacitors	▸ pressure controls
▸ contactor/starters	▸ relays
▸ crankcase heaters	▸ rheostats
▸ current relays	▸ sail Switches
▸ damper actuators	▸ sequencers
▸ defrost timers	▸ solenoids
▸ fan/limit controls	▸ solid state time delays
▸ oil pressure safety	▸ thermostats
▸ overloads	▸ water valves
▸ positive temperature co-efficient (PTC)	▸ zone valves
- Demonstrate proper use of test equipment for testing the above items

## 4. Electrical Circuits and Controls (3/3)

- Interpret detailed instructions for wiring circuits
- Draw electrical circuits that conform to standard industry logic and symbols using appropriate loads and controls



- Wire actual electrical circuits from wiring diagrams
- Demonstrate use and understanding of basic electrical meters in actual wiring and testing of circuits
- Identify and draw all electrical symbols used by the HVACR industry in diagrams
- Size an electric motor circuit, single and multiple, including overcurrent protection in accordance with National Electrical Code (NEC)

## Electric Motors

1. Explain electric motor theory (i.e., magnetism, electromotive force, etc.) **(3/3)**
2. Explain the operation, application, disassembly and reassembly of: **(3/3)**
  - Capacitor start/induction run motor (CSIR)
  - Capacitor start/capacitor run motor (CSCR)
  - Electronically controlled motor (ECM)
  - Modulating motor (economizers)
  - Multi-speed motor
  - Permanent split capacitor (PSC)
  - Shaded-pole
  - Split-phase motor (RSIR)
  - Three-phase motor
  - Variable-speed motor
3. Describe starting components associated with single-phase and three-phase motors **(3/3)**
4. Demonstrate knowledge of the operation/replacement of electric motor protection devices **(3/3)**
5. Explain the significance of power factor **(3/3)**
6. Determine characteristics and specifications of a motor – type, wattage, power, rpm, size, application **(3/3)**
7. Demonstrate proper use of testing equipment for motors **(3/3)**
8. Troubleshoot electric motors and motor circuits **(3/3)**
9. Determine physical conditions/alignment/replacement of motor bearings, rotors, belts, and pulleys **(3/3)**
10. Troubleshoot/replace starting components and relays for various types of motors **(3/3)**
11. Troubleshoot the resistance of windings in single-phase and three-phase motors **(3/3)**
12. Replace motor controls **(3/3)**
  - Pressure
  - Temperature
  - Electric
  - Pneumatic
13. Replace air-moving devices including fan blades and blower wheels **(3/3)**
14. Install/align shafts with motor-driven components **(3/3)**
15. Draw and explain the starting and run circuit for a single-phase CSIR compressor using a current type starting relay **(3/3)**
16. Draw and explain the starting and run circuit for a single-phase CSCR compressor using a potential type starting relay **(3/3)**
17. Draw and explain the circuit for a PSC compressor **(3/3)**



## DC Circuits

1. Identify properties of a DC circuit **(3/3)**
2. Identify DC sources **(3/3)**
3. Define voltage, current, resistance, power, and energy **(3/3)**
4. Apply Ohm's Law **(3/3)**
5. Measure DC circuits and components using VOA meter **(3/3)**
6. Troubleshoot circuits – series, parallel, and series-parallel **(3/3)**
7. Troubleshoot maximum power transfer theory **(2/2)**
8. Define magnetic properties of circuits and devices **(2/2)**
9. Describe physical and electrical characteristics of electronic components **(3/3)**
10. Set up and operate for DC circuits **(3/3)**
  - VOA meter
  - Specific equipment analyzers
11. Construct and interpret schematics and diagrams **(3/3)**
  - Pictorial
  - Line
  - Ladder
12. Check anodes (electrolysis) **(3/3)**
  - Millivolt meter

## AC Circuits

1. Identify properties of an AC circuit **(3/3)**
2. Identify AC sources **(3/3)**
3. Troubleshoot AC circuits **(3/3)**
  - Capacitive
  - Inductive
  - Completed
  - Open
  - Short
  - Grounded
  - Series
  - Parallel
  - Complex
  - Ampacity
4. Troubleshoot, analyze, and apply principles of transformers to AC circuits **(3/3)**
  - Step up
  - Step down
5. Troubleshoot circuits – series, parallel resonant, polyphase **(2/3)**
6. Demonstrate knowledge of basic electrical theory and operation of loads **(3/3)**
7. Set up and operate for AC circuits **(3/3)**
  - VOA meters
  - Specific equipment analyzers
8. Construct and interpret schematics and diagrams **(3/3)**
  - Pictorial
  - Line
  - Ladder

## Controls

### 1. Gas Valves (3/3)

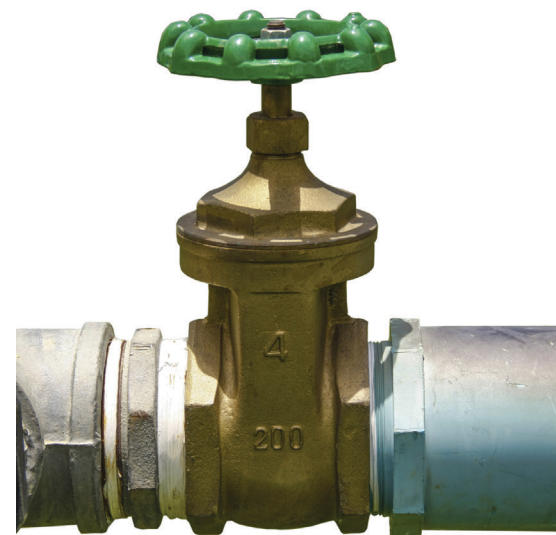
- Identify types of gas valves
  - low voltage
  - line voltage
  - redundant
  - two-stage
  - modulating
- Explain the operation of solenoid valves used to control gas flow
- Describe function and application of regulators
- Describe the methods of pilot/burner ignition:
  - standing pilot thermocouple
  - glow coil pilot ignition
  - intermittent spark pilot ignition
  - direct spark burner ignition
  - hot surface burner ignition
- Describe methods of fan control for the three categories of gas furnaces:
  - low-efficiency - 60-70% efficient
  - mid-efficiency - 78-80% efficient
  - high-efficiency - 90%+ efficient
- Describe the sequence of operation for 78-80% efficient gas furnaces
- Identify the components used in all types of gas furnaces:
  - low-efficiency - 60-70% efficient
  - mid-efficiency - 78-80% efficient
  - high-efficiency - 90%+ efficient
- Explain the operation of a redundant gas valve
- Check gas valve operation
- Check flame sensing current of flame sensing device
- Check and adjust inlet and outlet pressure of a gas valve
- Perform conversion on gas valve from natural gas to liquified petroleum (LP) or reverse
- Check the operation of an induced draft blower by blocking flue outlet

### 2. Fuel Control (3/3)

- Explain the operation of ignition and pilot proving devices
- Explain operation of an oil delay valve
- Test and change a thermocouple flame sensor
- Test spark ignition modules
- Perform safety lockout procedures for burners
- Measure resistance of cad cell

### 3. Residential Control Systems—Heating/Cooling (3/3)

- Identify residential heating and cooling thermostats
- Identify controls for heating and cooling
- Explain heat and cooling anticipators
- Install and test a fan/limit control to identify set point of control
- Wire a complete heating system - line and low voltage
- Wire a humidistat into electrical circuit
- Wire an electronic air cleaner into an electrical circuit



- Program a programmable thermostat for heating, cooling and heat pump operation including set-up and set back
- Set heat anticipator on system thermostat
- Install residential heating and cooling thermostats

#### 4. Heat Pump Controls **(3/3)**

- Explain the operation and function of a reversing valve
- Identify the main types of defrost controls
- Identify and explain the operation of each type of defrost control
- Identify and explain the operation of flow and safety control for geothermal system
- Describe the purpose and function of outdoor thermostats
- Describe the sequence and purpose of emergency heat controls
- Identify and explain the operation of check valves in heat pumps
- Describe the sequence between first stage and second stage heating thermostat
- Describe the auxiliary heat controls
- Select and install appropriate system thermostat
- Wire the control circuit of a heat pump system
- Install or replace a heat-sequencing relay
- Perform tests on reversing valve to determine if mechanical or electrical failure

## Solid State Electronics

### I. Solid State Components **(1/1)**

- Explain the function and/or application in HVACR circuits and controls of:
  - amplifiers
  - bilateral switches
  - capacitors
  - diodes
  - direct digital control/system (DDC/DDS)
  - effects of heat and moisture
  - photoelectric Cell
  - rectifiers
  - resistors
  - semiconductors
  - shielded wiring
  - sensors
  - silicon controlled rectifiers (SCR)
  - thermistors
  - transducers
  - transistors
  - triacs
- Explain the role computers are now playing in the HVACR industry
- Measure resistive value of various sensors
- Measure operability of various boards
- Test electronic air cleaners

## Refrigeration System Controls

### I. Demonstrate knowledge of principles of safety and operating control devices **(3/3)**

- Pressure
- Temperature
- Electric
- Pneumatic
- DDC

## 2. Install/service/troubleshoot electro-mechanical control devices **(3/3)**

- Relays
- Contactors
- Magnetic starters
- Timers
- Sequencers
- Thermostats
- Pressure switches
- Solid state ignition modules

## 3. Install/service/troubleshoot pneumatic control devices **(2/3)**

- Thermostats
- Actuators
- Switches
- Relays

## 4. Troubleshoot DDC **(2/3)**

# Load Calculations

## 1. Refrigeration Loads **(1/1)**

- Define "U" value: (Btu/hr • ft<sup>2</sup> • °F)
- Define "R" value: (hr • ft<sup>2</sup> • °F/Btu)
- Interpret heat transfer tables ("U," "K," "C," "R")
- Explain the heat load sources:
  - conduction
  - infiltration (sensible and latent)
  - product
  - miscellaneous loads (people, motors, equipment, sensible and latent)
  - radiation
- Explain the purpose of vapor barriers
- Interpret tables of specific heat values, latent heat, and heat of respiration
- Calculate total heating transfer value of any surface (R) - (U)
- Define "K" value: (Btu/hr • ft<sup>2</sup> • °F)
- Define "C" value: (Btu/hr • ft<sup>2</sup> • °F)

## 2. Psychrometrics **(1/2)**

- Identify the following on a psychrometric chart:
  - dry bulb line (DB)
  - wet bulb line (WB)
  - relative humidity (RH)
  - specific humidity (grains of moisture) or (lbw/lbda)
  - enthalpy (h)
  - apparatus dew point
  - dew point (DP)
- Explain:
  - specific humidity
  - apparatus dew point
  - contact factor
  - relative humidity
  - dry bulb
  - wet bulb
  - dew point
  - enthalpy
  - specific volume
- Calculate:
  - refrigeration sensible heat ratio
  - latent heat ratio
  - contact factor
  - latent heat
  - sensible heat
  - total heat
  - water removal
  - mixed air condition

- On a psychrometric chart, plot the following:
  - sensible heating
  - sensible cooling
  - heating and humidifying
  - heating and dehumidifying
  - cooling and humidifying
  - cooling and dehumidifying
  - humidifying
  - dehumidifying
  - cooling cycle
  - mixed air process
  - cooling and reheat

### 3. Heating Loads (1/2)

- Interpret structure design data
- Interpret building prints - size of rooms, etc
- Determine total resistance to heat flow ("R"), ("U")
- Calculate conduction loss:
  - walls
  - roofs
  - floors
  - basement (walls, floor)
  - unconditioned space
  - windows
- Calculate infiltration:
  - doors
  - windows
- Calculate ventilation load
- Calculate duct loss
- Calculate effects of bath and kitchen exhaust
- Calculate effects of power roof ventilators
- Calculate total heating load

### 4. Cooling Loads (1/2)

- Interpret structure design data
- Calculate "U" values for building material
- Calculate Cooling Load Temperature Difference (CLTD)
- Make corrections for CLTD
- Calculate conduction loads:
  - walls
  - roofs
  - windows
  - doors
  - unconditioned space
  - floors
- Calculate lighting load
- Calculate equipment load
- Calculate infiltration and ventilation load:
  - heat load
  - moisture loads
- Calculate duct gain
- Calculate refrigeration sensible heat ratio
- Calculate storage factor
- Calculate effects of bath and kitchen exhaust
- Calculate effects of power roof ventilators
- Calculate total cooling load:
  - sensible loads
  - latent loads

# Refrigerant System Components

## 1. Metering Devices (2/3)

- Define types of metering devices:
  - capillary tubes
  - thermal expansion valve
  - automatic expansion valve
  - low side float
  - high side float
  - hand expansion valve
  - restrictor orifices
  - electronic expansion valve
  - solid state expansion valve
- Evaluate system performance when using different types of flow control devices
- Explain how to size expansion valves
- Explain how to size a thermal expansion valve
- Explain how to size an automatic expansion valve
- Adjust and size metering devices when and where appropriate
- Check and adjust superheat and/or subcooling to manufacturers' specifications
- Install capillary tube

## 2. Evaporators (1/1)

- Identify types of evaporators:
  - bare-tube
  - finned – internal and external
  - plate
  - unit coolers
  - chillers
- Determine the Mean Effective Temperature Difference (METD)
- Adjust for proper coil air flow
- Check coil performance
- Select and size evaporator based on compressor capacities

## 3. Compressors (2/2)

- Identify types of compressors:
  - hermetic
  - semi-hermetic
  - open type
- Identify methods of compression:
  - centrifugal
  - rotary
  - screw
  - scroll
  - reciprocating
- Explain the methods of compression
- Explain methods of capacity control:
  - cylinder unloading
  - variable speed compressors
  - hot gas bypass
  - multiple compressors
- Select the compressor based on cooling load
- Determine the system balance based on the selected components



#### 4. Condensers (3/3)

- Define the types of condensers:
  - air-cooled
  - water-cooled
  - evaporative-cooled
- Determine proper air and water flow
- Describe maintenance of a condenser
- Describe maintenance of a cooling tower
- Explain the operation and performance of a condenser
- Explain the terms "range" and "approach" related to cooling towers
- Explain purpose of heat reclaim
- Adjust the air flow for proper temperature difference
- Adjust water flow for proper gallons per minute (GPM) and temperature difference
- Size a cooling tower
- Select and size an air-cooled condenser

#### 5. Accessories (3/3)

- Identify the proper location of all accessories:
  - accumulators
  - crankcase heaters
  - crankcase pressure regulating valves
  - defrost timers
  - driers/filters
  - evaporator pressure regulating valves
  - head pressure controls
  - heat exchangers
  - hot gas bypass
  - low pressure controls
  - low ambient controls
  - mufflers
  - oil separators
  - receivers
  - solenoid valves
  - suction filters
  - unloaders
  - vibration eliminators
  - check valves
  - water regulating valve
  - liquid sight valve-refrigerant and oil
  - relief valve
- Determine appropriate accessories for systems application
- Explain the operation of the above listed accessories
- Replace a drier/filter
- Adjust a crankcase pressure regulating valve

#### 6. Access Valves (3/3)

- Identify front and back seat valves in the:
  - operation and use of the suction and discharge service valves that service the compressor
  - application and operation of the king valve at the outlet of the receiver
  - application and operation of the queen valve where present, near the receiver
  - small system high side and low side service ports
  - front seating and Schrader valves, OEM and field installed
- Identify Schrader Type OEM and field installed in the:
  - installation and use of clamp on valves
  - installation and use of solder (in) or (on) stem valves
  - use of A/C front seating/Schrader OEM service valves
  - use of quick disconnects with Schrader-Based Valves



## Refrigeration Cycle

1. Demonstrate knowledge of the theory of heat **(3/3)**
  - Latent heat
  - Sensible heat
  - Specific heat
  - Superheat
  - Sub-cooling
  - Heat of compression
  - Heat of evaporation
2. Demonstrate knowledge of characteristics and identifications of refrigerants **(3/3)**
  - Boiling points
  - Pressure temperature relations
  - Dew points
  - Hazards
  - Maximum quantities
  - Color coding
  - Name
  - Chemical number
3. Read and interpret pressure-temperature curves and charts **(3/3)**
  - Determine pressures and temperatures of a refrigeration system **(3/3)**
  - Psychometrics
4. Demonstrate knowledge of principles and operation of the mechanical refrigeration cycle **(3/3)**
  - Compressors
  - Condensers
  - Metering devices
  - Evaporators
  - Other components
5. Evacuate a refrigeration system **(3/3)**
  - Measure vacuum
  - Triple evacuate
6. Charge a refrigeration system **(3/3)**
  - Superheat
  - Subcooling
  - Manufacturers' specifications
7. Adjust head pressure controls **(3/3)**

## Air-Conditioning Systems

1. Unitary Cooling **(3/3)**
  - Describe the sequence of the basic refrigeration cycle and operation of the various types of air-conditioning systems
  - Use and read various tools and instrumentation needed for checking, testing, and operating air-conditioning systems
2. Service and Problem Analysis **(3/3)**
  - Explain the causes of electrical problems
  - Explain the causes of mechanical problems
  - Explain the causes of hydronic problems
  - Analyze air conditioning systems and appropriately diagnose:
    - electrical problems
    - mechanical problems
    - hydronic problems

# Heat Pump Systems

## 1. Basic Principles and Components (3/3)

- Review the history of heat pumps
- Explain the basic theory of the air source heat pump system
- Explain the basic theory of the water source heat pump system
- Explain the basic theory of geothermal source heat pump system
- Identify and explain the function of the electrical and mechanical components of the heat pump systems
- Explain terms typically used for heat pumps:
  - seasonal energy efficiency ratio (SEER)
  - coefficient of performance (COP)
  - heating seasonal performance factor (HSPF)
  - balance points
  - outdoor design temperature (ODT)
  - optimizer
- Analyze and explain the refrigerant cycle in both cooling and heating — identifying the pressure and state of the refrigerant at any point in the refrigerant circuit
- Explain the different types of defrost methods
- Describe the operation of the time clock in a defrost control
- Identify which three components of a heat pump system are controlled directly during a defrost cycle
- Describe a heat pump thermostat function
- Check reversing valve for proper temperatures
- Calculate both economic and thermal balance points
- Calculate temperature settings for multiple outdoor thermostats
- Check refrigerant charge using charging chart
- Check sequence of operation of an air-to-air split system heat pump for cooling, heating, and defrost modes

## 2. Applications (3/3)

- Identify and describe different types of heat pump systems:
  - air-cooled
  - water-source
    - open loop
    - closed loop
    - air-to-water
    - water-to-water
    - geothermal
- Analyze and compare the operation and performance of the different types of Heat Pump Systems:
  - explain the integration and operation of the air-to-air heat pump with electric resistance heat
  - explain the integration and operation of the water-to-air heat pump with electric resistance heat
  - explain the integration and operation of the air-to-air heat pump with a fossil fuel unit
  - explain applications for open vs. closed loop geothermal heat pump systems
- Mechanically and electrically connect and check out:
  - air-to-air heat pump
  - water-to-water heat pump



# Heating Systems

## 1. Forced Warm Air Systems (3/3)

- Check the operation of the ignition system
- Derate or change over a gas burner
- Adjust burner flame for proper fuel/air ratio
- Check for proper temperature rise through the furnace
- Test all safety controls
- Remove, install and adjust blower motor and/or belt
- Clean pilot assembly
- Oil motor(s) and bearings
- Check and adjust heat anticipator of thermostat
- Use orifice sizing charts
- Test induced draft pressure switches
- Check all safety controls
- Check operation of sequence

## 2. Hydronic Systems (1/1)

- Identify types of hydronic piping systems
- Identify types of boilers
- Check circulator for alignment and lubrication
- Set aquastat
- Check water pressure regulating valve (PRV)
- Check the zone valve operation
- Remove air from system
- Check backflow preventer
- Check compression/expansion tank
- Check water temperature rise across the boiler
- Check and adjust water level in pressure tanks
- Check automatic air vent operation
- Wire multizone/multipump hydronic systems

## 3. Testing and Balancing Equipment (1/1)

- Perform pressure checks on air distribution system
- Perform pressure checks on fuel system
- Perform efficiency test and adjust to recommended rate:
  - check draft
  - check smoke (if applicable)
  - check stack temp
  - check CO<sub>2</sub>
  - check O<sub>2</sub>
  - check CO
- Perform balance method for an air distribution system
- Perform balance method for a hydronic system

## 4. Humidification (2/2)

- Explain importance of humidification
- Describe different types of humidifiers
- Explain factors affecting humidity in business and residence
- Select proper humidification equipment
- Check operation of humidification equipment

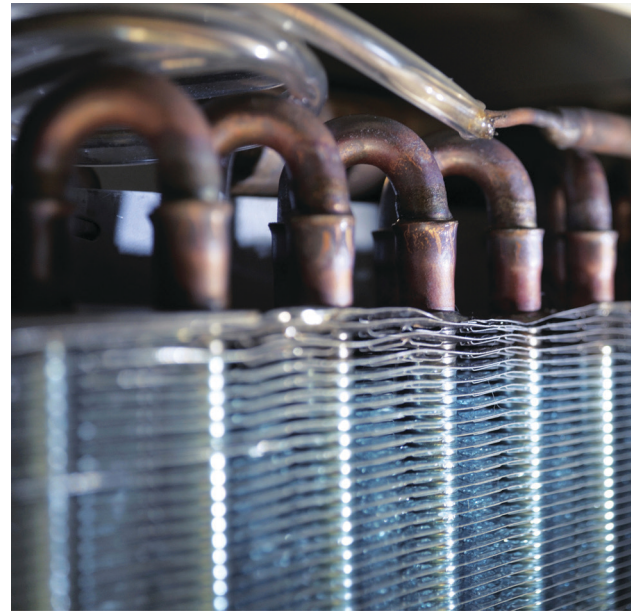


- Perform maintenance on humidification equipment
  - Determine relative humidity using a psychrometer
  - Determine dew point using a psychrometer
5. Unitary Combination Heating and Cooling Equipment **(3/3)**
    - Describe the sequence of operation of a heating system
    - Use and read various tools and instruments needed for checking and testing combination air-conditioning and heating systems
  6. Oil Furnaces **(1/1)**
    - Explain and check the sequence of operation of oil stack switches
    - Explain and check the sequence of operation of Electronic Primary Controls
    - Understand how to replace oil filters
    - Understand how to purge water from oil storage tanks
    - Understand how to oil motors
    - Replace oil nozzle and adjust electrodes
    - Perform combustion test and adjust to optimum efficiency
    - Perform safety shutdown check
    - Replace oil nozzles with proper size replacements
    - Inspect and adjust electrodes replacing when necessary
    - Test and adjust oil pumps and couplers
  7. Electric Furnaces **(3/3)**
    - Understand the use of sequencers in electric furnaces
    - Understand the effects of air flow on temperature rise
    - Inspect heating elements and insulators
    - Test thermal fuses
    - Inspect all electrical connections
    - Check for proper temperature
    - Oil motors
    - Test sequence of operation of electric furnaces

## Refrigeration Systems

1. Demonstrate knowledge of principles of refrigeration applicants **(3/3)**
  - High temperature
  - Medium temperature
  - Low temperature
  - Ultra-low temperature
2. Calculate heating and cooling loads **(2/3)**
  - Equipment sizing
3. Demonstrate knowledge of principles of refrigeration systems **(3/3)**
  - Walk-in coolers
  - Walk-in freezers
  - Self-service cooler cases
  - Self-service freezer cases
  - Multiple evaporator systems

- Packaged systems (unitary refrigeration)
  - Water coolers
4. Demonstrate knowledge of principles of electric and hot gas defrost operations **(3/3)**
  5. Demonstrate knowledge of principles of/apply principles of specific refrigeration system components **(3/3)**
    - Low ambient controls
    - Evaporator pressure regulators
    - Crankcase pressure regulators
    - Accumulators
    - Oil separators
    - Filters/dryers
    - Liquid indicators
  6. Install/service/troubleshoot/replace refrigeration systems **(3/3)**
  7. Install/service/troubleshoot/replace ice makers **(2/3)**
  8. Install/service/troubleshoot/replace water coolers **(2/3)**
  9. Troubleshoot/replace the power element **(2/2)**
  10. Service/troubleshoot/replace evaporator pressure control devices **(2/2)**
  11. Troubleshoot/replace a two-temperature valve **(2/2)**
  12. Service/adjust/troubleshoot/replace defrost components **(2/2)**
    - Electric
    - Hot gas
  13. Pump-down refrigeration system **(3/3)**
  14. Adjust high and low pressure control settings **(2/3)**
  15. Install/service/troubleshoot/replace a defrost heater/timer **(2/2)**
  16. Install/service/troubleshoot/replace solenoid valve **(2/3)**
  17. Install/service/troubleshoot/replace thermostatic motor controls **(2/3)**
  18. Troubleshoot electrical circuits of refrigeration systems **(3/3)**
  19. Test for, locate, and repair a refrigerant leak **(3/3)**
  20. Recover/recycle refrigerants **(3/3)**
  21. Analyze refrigeration system operation **(3/3)**
    - Pressure
    - Temperatures
  22. Install/service/troubleshoot/replace crankcase heater **(2/3)**
  23. Install/service/troubleshoot/replace compressor **(2/3)**
  24. Adjust superheat/subcooling **(2/2)**



# Commercial Refrigeration

## I. Single Compressor (I/I)

- Explain the importance of compressor/evaporator balance
- Describe the differences in compressor displacement between the various temperature ranges
- Explain basic low and high pressure control theory and operation
- Explain the operation of a vapor compression system and its effects on temperature and volume
- Explain the operation and components used for the pump down cycle.
- Explain the evaporator and the condenser side of a system
- Explain application and operation of evaporator pressure regulating valves
- Discuss the problems associated with compressors operating at lower evaporator temperatures:
  - decreased volumetric efficiency
  - higher discharge gas temperatures
  - potential overloading during initial temperature pull-down
- Discuss the use of different compressor designs for increased efficiency and capacity
- Describe the methods used for cycling the compressor on and off.
- Explain methods of defrost
- Explain methods of head pressure control system
- Explain heat reclaim
- Explain the lubrication methods for a compressor
- Determine the terminal identification of a single-phase compressor
- Explain how to measure the compressor lubrication oil pressure
- Explain several manufacturers' model numbering system
- Define compression ratio and the effect suction and discharge pressure have on compression ratio
- Determine compressor capacity using the compressor's curve
- Determine the correct operating amps using the compressor's curve
- Describe the different types and designs of compressors:
  - type:
    - hermetic
    - semi-hermetic
    - open drive
  - design:
    - reciprocating
    - scroll
    - screw
- Explain requirements of food preservation:
  - medium temperature
  - low temperature
- Describe supermarket display cases
- Explain the difference between an across-the-line start and a part-winding start
- Identify the different types of compressors
- Select a compressor for a particular capacity and temperature range
- Check the operation of a compressor in a particular system

- Compute the compression ratio for a particular system
- Adjust Evaporator Pressure Regulating (EPR) valve
- Check control circuits per manufacturers' specifications
- Check system charge, superheat and subcooling
- Check display case temperatures and determine if operating properly
- Set cut-in and cut-out for a special product
- Draw the wiring diagrams for an across-the-line start and a part-winding start
- Draw a ladder diagram of a system equipped with a pump down cycle
- Draw the schematic of a single-phase and a three-phase compressor motor
- Draw a ladder diagram of a system using a defrost time clock and defrost termination fan delay switch
- Measure the compressor windings and determine if they are correct
- Measure the operating amps and determine if it is correct
- Check operation of defrost cycle and adjust time clock
- Adjust head pressure controls for proper operation
- Check operation of equipment equipped for automatic pump down

## Air Handling

### 1. Air Flow Principles/Duct Design (3/3)

- Draw layout of return and supply runs
- Calculate equivalent length of trunk and branch ducts
- Calculate total effective length of duct runs
- Calculate total available static pressure
- Size trunk and branch ducts by equal friction method
- Use duct calculator to find duct size, velocity, cfm, and friction loss
- Calculate air flow factors for heating and cooling
- Size registers, grilles, and diffusers
- Fabricate fittings
- Fabricate a "HAND" pittsburg
- Fabricate "HAND" slips and drives
- Identify and use all basic hand-held sheet metal tools
- Identify and use all basic hand-held tools for duct board



### 2. Mechanical and Electronic Filtration (3/3)

- Identify types of mechanical filters:
  - disposable
  - permanent foam, mesh, and fiber
  - high efficiency
  - HEPA
  - electrostatic
- Describe operation of electronic air cleaners
- Install air cleaner system into existing ductwork
- Remove and clear prefilter and cells:
  - check ionizer wires
  - test power pack

### 3. Fans/Blowers (3/3)

- Identify different types of fans/blowers:
  - centrifugal
  - axial
- Determine the proper direction of rotation
- Explain the difference between tube axial and vane axial
- Identify the types of centrifugal fans/blowers:
  - forward curved
  - backward curved
  - air foil
  - radial tip
- Check for proper rotation
- Interpret the fans/blowers curve
- Select the fans/blowers via the curve
- Check fans/blowers performance via curves
- Check amp draws

## Air Distribution Systems

### 1. Demonstrate knowledge of/apply principles of air distribution systems (2/3)

- Mechanical
- Natural
- Supply
- Return
- Exhaust
- Ventilation
- Combustion
- Code requirements

### 2. Design air distribution systems (2/3)

- Duct calculator
- SMACNA

### 3. Fabricate and insulate air distribution system (2/3)

- SMACNA
- Combustible
- Non-combustible
- Hazardous

### 4. Identify/install/troubleshoot ducts, fittings, and accessories (2/3)

- SMACNA
- Return
- Supply
- Exhaust
- Intake
- Combustion
- Ventilation
- Materials
- Supports
- Connectors
- Sealants

### 5. Install/service air-cleaning devices (3/3)

- SMACNA

### 6. Install fire/smoke control, and safety devices (2/3)

- Smoke removal systems
- SMACNA
- Fire dampers



7. Install clothes dryer exhaust systems **(2/2)**

- SMACNA

8. Perform test and balance of air distribution systems **(2/3)**

- Hoods
- Manometer
- Velometer
- Anemometer
- Thermometer
- Sling psychrometer
- SMACNA

9. Read and interpret air distribution layout **(2/2)**

- Blueprints
- Drawings
- Specifications
- Calculations
- Cutting, boring, and notching (all occupations)

10. Install hoods and hood systems **(1/2)**

- Commercial kitchen
- Specialty hoods

11. Maintain indoor air quality **(2/3)**

- Duct cleaning
- Air filtration
- Humidification
- Air contaminates
- Ventilation air

## Vents and Chimneys

1. Design, fabricate, and install vents **(2/3)**

- Fossil fuel
- Solid fuel
- Manufacturers' specifications
- Clearances
- Code requirements

2. Design, fabricate, and install chimneys **(2/2)**

- Masonry
- Metal
- Low heat
- Medium heat
- High heat
- Manufacturers' specifications
- Clearances
- Code requirements



## System Installation and Start-Up

I. Heating Start-up, Checkout, and Operation **(3/3)**

- Understand the importance of manufacturers' installation and operation requirements
- Demonstrate use of tools and instruments
- Determine equipment electrical, mechanical and code requirements
- Verify equipment air flow and distribution requirements
- Check operation of all electrical control components
- Check operation of gas train components and measurements
- Check oil burner components and measurements

- Check ignition systems
- Evaluate fuel supply systems
- Test for proper combustion
- Check electrical components for operation and wiring connections
- Check for correct heating input and adjust to manufacturers' specifications

## 2. Heat Pump Start-up, Checkout, and Operation (3/3)

- Understand the importance of manufacturers' installation and operation requirements
- Understand alternative fuel methods
- Demonstrate use of tools and test equipment
- Determine equipment electrical requirements
- Verify equipment air flow and distribution
- Check operation of all electrical and mechanical components
- Check system operation in the heating, cooling and defrost modes
- Check supplementary and emergency heat
- Instruct customer on operation and maintenance of system

## 3. Air Conditioning Start-up, Checkout, and Operation (3/3)

- Understand the importance of manufacturers' installation and operation requirements
- Demonstrate use of tools and test equipment
- Determine equipment electrical requirements
- Verify equipment air flow and distribution requirements
- Check operation of all electrical and mechanical components
- Check system operation while following all safety procedures
- Pull and verify deep vacuum
- Perform leak check and make repairs
- Conform to all applicable governmental regulations



# System Servicing and Troubleshooting

## I. Mechanical System Problems (3/3)

- Develop systematic way to diagnose system problems and demonstrate method
- Identify and describe possible causes of failure and how to eliminate causes
- Demonstrate use of tools and test equipment following safety practices
- Record system data for the mechanical system operation
- Verify mechanical system operation is acceptable
- Determine cause of failure in system components
- Determine actual system air flow using the appropriate test equipment
- Determine system air flow requirements

## 2. Electrical Troubleshooting (3/3)

- Interpret electrical diagrams into sequence of operation
- Describe electrical mechanical sequence from electrical schematic
- Develop a methodical routine for electrical troubleshooting
- Analyze electrical performance of each component
- Rewire an HVACR unit using an electrical diagram:
  - air conditioner
  - heat pump
  - furnace
- Record electrical system data
- Use electrical test instruments to diagnose electrical troubles and correct electrical system performance
- Troubleshoot a faulty compressor overload protector
- Change a schematic diagram to a ladder diagram in a drawing

## 3. Heating: Service and Problem Analysis (3/3)

- Explain combustion theory for gas combustion and oil combustion
- Identify and describe possible causes of failure and how to correct problems
- Determine and measure combustion air, ventilation air and unit/system air requirements
- Develop systematic method(s) to diagnose system problems and demonstrate method
- Determine the cause of failure in a heating system
- Record data and verify system operation

## 4. Heat Pump: Service and Problem Analysis (3/3)

- Test and evaluate the operation of the refrigeration cycle in cooling and heating modes
- Test the operation of the supplementary heat component(s)
- Test the operation of the emergency heat status for the heat pump system
- Record appropriate data to evaluate complete system operation
- Test proper operation of reversing valve
- Check operation of defrost controls
- Inspect wiring and tighten connections

## 5. Air Conditioning: Service and Problem Analysis (3/3)

- Explain proper temperatures and pressures at various system locations
- Explain proper fan/blower operation
- Explain heat exchanger inspection
- Explain thermostat setting and operation
- Explain sounds that could indicate a problem
- Explain how electrical measurements could indicate a problem
- Explain value of nameplate data and service records
- Discuss the required performance checks
- Discuss the method of measuring superheat, subcooling, evaporator and condenser splits
- Discuss the proper procedures for using a voltmeter and an ammeter
- Explain normal operation of air-conditioning systems
- Explain the effects of overcharge and undercharge of refrigerant
- Explain the effects of improper airflow
- Develop a systematic approach to diagnose mechanical or electrical problems.
- Check system for system leaks
- Check and clean heat exchangers

- Check for proper refrigerant charge
- Check for proper thermostat and electrical controls
- Check oil sample for acidity
- Check and replace filter/driers
- Check available voltage and install high and low side manifold gauges
- Compare static pressure on a P/T Chart to determine unit refrigerant
- Start unit and allow to stabilize
- Measure superheat and subcooling
- Check evaporator and condenser splits
- Check amperage of each motor
- Analyze performance using manufacturers' specifications
- Check electrical component operation
- Check air flow from furnace of air handler
- Inspect electrical connections
- Troubleshoot A/C systems from electrical schematics

## Indoor Air Quality

### I. Requirement and Maintenance of Air Quality (1/1)

- Define Indoor Air Quality (IAQ) as defined by ASHRAE Std. 62.
- Explain Sick Building Syndrome (SBS) and Building Related Illness (BRI).
- Explain the different factors that make up acceptable indoor air quality:
  - pollutant levels
  - ventilation air quantities
  - air distribution effectiveness
  - occupant comfort

## Preventative Maintenance

### I. Basic Maintenance (3/3)

- Explain the various types of maintenance programs
- Explain broad tasks and frequencies for a quality maintenance program
- Explain why each step of the Preventative Maintenance Program is necessary
- Explain the benefits associated with proper equipment maintenance
- Demonstrate various maintenance tasks
- Develop a Preventative Maintenance Program for:
  - absorption cooling unit
  - electric heat system
  - gas heat system
  - heat pump system
  - hydronic systems
  - ice makers
  - oil heat system
  - package heat and cooling unit
  - refrigeration systems
  - split system condensing unit and evaporator
  - walk-in boxes
  - water-cooled centrifugal chiller
  - water-cooled reciprocating chiller
- Develop a list of tools needed to perform the Preventative Maintenance Program
- Develop a Preventative Maintenance Check Sheet

# Refrigerant Recovery

## 1. Introduction (3/3)

- Describe the environmental issues regarding refrigerant, including legislation, protocol, laws, and regulations
- Describe the basic refrigerant cycle
- Determine proper evacuation levels and leak rates
- Identify three different types of technician certification

## 2. Safety (3/3)

- Describe the problems associated with mixing of refrigerants
- Describe the methods of determining when a recovery cylinder is full
- Describe the problems associated with component isolation where unsafe hydrostatic pressures can occur
- Describe the problems associated with contaminants left in a refrigerant system after recovery

## 3. Refrigerant Recovery, Recycling, and Reclamation Methods (3/3)

- Describe how to manually pump down a system
- Describe how to isolate system components
- Describe system dependent and self-contained recovery equipment
- Describe the push-pull method
- Describe difference between recycled and reclaimed refrigerant
- Explain options in Industry Recycling Guideline (IRG-2)
- List the advantages/disadvantages, and application of liquid and vapor recovery
- List methods for decreasing recovery time

## 4. Refrigerant Recovery, Recycling and Reclamation Equipment (3/3)

- Identify proper equipment for a particular job
- Describe procedures for recovering multiple refrigerants with the same recovery unit
- Describe maintenance and efficiency testing procedures for recovery units
- Describe maintenance and testing for refrigerant recovery cylinders
- Identify recovery cylinders
- Explain when to change filter-driers in recycling equipment
- Explain methods of purging non-condensables when recycling
- Identify type of refrigerant in a given recovery cycle
- Perform procedures for recovery
- Perform procedures for recycling
- Perform maintenance on recovery machine
- Connect and operate recovery equipment

## Refrigerant Retrofits

### I. Alternative Refrigerant Retrofits (1/1)

- Determine if the alternative refrigerant and/or lubricant:
  - is applicable for retrofitting specific system
  - is on the EPA SNAP list
  - is ul listed
  - meets the equipment manufacturers' approval
- Determine the lubricant required for the alternate refrigerants
- Procure the manufacturer's changeover guidelines and follow the retrofit procedures
- Measure the residual mineral oil in a system being changed from a CFC to an HFC refrigerant

## Refrigerants and Lubricants

### I. Refrigerants (3/3)

- Explain the different classes of refrigerants:
  - CFC Refrigerants
  - HCFC Refrigerants
  - HFC Refrigerants
  - HC Refrigerants
  - Other Refrigerants
  - Azeotropic mixtures (ASHRAE 500 series)
  - Zeotropic blends (ASHRAE 400 series)
- Explain physical and chemical properties:
  - flammability and toxicity
  - materials compatibility
  - miscibility and oil return
  - pressure and temperature data
  - refrigerant temperature glide
  - environmental properties (ODP, GWP and TEWI)
  - bubble point
  - dew point
- Define pure refrigerants and azeotropic mixtures
- Define zeotropic mixtures
- Define zeotropic blends
- Identify the color and classification of refrigerants by Pantone Matching System (PMS) color number
- Explain fractionization of blends
- Look up saturation pressure and temperature:
  - single element refrigerant
  - azeotropic
  - zeotropic
  - blends
- Identify when saturation pressure and temperature do not match the refrigerant
- Calculate superheat and subcooling
- Calculate superheat and subcooling glide

### 2. Lubricants (1/2)

- Explain the function of lubricants in systems
- Explain the different types and applications of lubricants:
  - alkylbenzenes (AB)
  - mineral oils
  - polyolesters (POE)
  - polyglycols (PAG)

- Explain properties of lubricants:
  - materials compatibility
  - miscibility and oil return
  - pour point and flash point
  - viscosity
  - water absorption
  - rust and oxidation inhibitors
- Describe proper oil disposal
- Draw oil sample from system
- Demonstrate proper handling of POE's
- Use acid test kit for mineral oil and AB
- Demonstrate proper use of a refractometer or oil sample test

## Comply with Industry Regulations

### I. Codes and Standards (3/3)

- Describe the reasons for codes
- Describe the three model codes:
  - Building Officials and Code Administrators (BOCA), National Mechanical Code
  - Southern Building Code Congress International (SBCCI), Standard Mechanical Code
  - International Conference of Building Officials (ICBO), Uniform Mechanical Code
- Identify the codes and standards for the applicable area, locality and state
- Discuss the relationship between codes and manufacturers' installation instructions
- Identify pertinent standards published by the following organizations:
  - AGA
  - AMCA
  - ANSI
  - ARI
  - ASHRAE
  - IEC
  - ISO
  - SMACNA
  - UL

### 2. Regulations Affecting Ozone Depletion (3/3)

- Explain ozone depletion
- Explain significance of the Montreal Protocol
- Explain significance of the Clean Air Act
- Explain EPA requirements:
  - technician certification
  - refrigerant recover, recycle, and reclaim
  - disposal of systems
  - labeling
  - shipping
  - leak detection
  - significant new alternatives policy program (SNAP)
  - recordkeeping
- Know DOT requirements concerning transportation of refrigerants
- Determine if refrigerant container is DOT-approved and whether it needs to be retested
- Determine if recovery/recycle equipment is certified and meets requirements.
- Dispose of empty non-refillable cylinders
- Use recovery equipment and prepare system for disposal
- Obtain federal EPA technician certification

### 3. Other Regulations (3/3)

- Explain global warming
- Know OSHA Work Rules
- Explain Indoor Air Quality (IAQ) standards (ASHRAE Std.62)
- Explain impact of state and local codes on system application and retrofit
- Explain proper disposal of oil, components, and other materials
- Explain state and local licensing requirements
- Explain DOT regulations

## Professional Service

### 1. Customer Relations/Communication (3/3)

- Describe methods of dealing with irate customers
- Describe methods of dealing with technician delays and scheduling realities
- Describe methods of selling service agreements and replacement equipment
- Explain service(s) performed in layman's terms
- Explain how to obtain customer satisfaction
- Explain service contracts
- Demonstrate professional/personal appearance and attitude
- Discuss customer telephone etiquette
- Describe, list, calculate and present a typical billing invoice
- Demonstrate good customer relations

### 2. Character Education (3/3)

- Discuss the following personal traits:
  - ▶ honesty
  - ▶ integrity
  - ▶ reliability
  - ▶ responsibility
  - ▶ accountability
  - ▶ character
  - ▶ conflict resolution
  - ▶ teamwork
  - ▶ ethics
  - ▶ pride
  - ▶ initiative
  - ▶ time management





## Sample Questions

- \_\_\_\_\_ 1. What type of heat changes the state of a substance without changing its pressure or temperature?
- a. latent
  - b. sensible
  - c. specific
  - d. super
- \_\_\_\_\_ 2. What type of three-way valve has two inlets and one outlet?
- a. diverting
  - b. mixing
  - c. modulating
  - d. redundant
- \_\_\_\_\_ 3. What result occurs when there is an open circuit leading to a thermostat?
- a. continuous operation of an air conditioner
  - b. continuous operation of the blower
  - c. lack of operation of an air conditioner
  - d. lack of operation of the blower
- \_\_\_\_\_ 4. What is the velocity pressure of air moving through an 8" x 8" square duct at 2500 fpm?
- a. 0.16"
  - b. 0.39"
  - c. 0.54"
  - d. 0.64"
- \_\_\_\_\_ 5. According to the International Mechanical Code, what is the minimum chimney thickness for a high heat appliance with a round diameter of 14"?
- a. 0.057"
  - b. 0.075"
  - c. 0.099"
  - d. 0.129"
- \_\_\_\_\_ 6. What condition causes an HVAC unit to run with high head pressure?
- a. broken blower belt
  - b. dirty condenser coil
  - c. low refrigerant charge
  - d. low outdoor ambient temperature

- \_\_\_\_\_ 7. What type of joint runs  $90^\circ$  to the airflow?
- a. horizontal
  - b. longitudinal
  - c. transverse
  - d. vertical
- \_\_\_\_\_ 8. What device can be used to limit low-frequency sounds in an HVAC system?
- a. dampers
  - b. duct lining
  - c. mufflers
  - d. turning vanes
- \_\_\_\_\_ 9. As the length of the gas pipe increases, the gas pressure \_\_\_\_\_.
- a. decreases
  - b. fluctuates
  - c. increases
  - d. remains the same



## Sample Questions — Key

1. What type of heat changes the state of a substance without changing its pressure or temperature?

- a. latent           Correct by definition
- b. sensible        Incorrect by definition
- c. specific         Incorrect by definition
- d. super           Incorrect by definition

2. What type of three-way valve has two inlets and one outlet?

- a. diverting        Wrong, but plausible
- b. mixing           Correct
- c. modulating     Wrong, but plausible
- d. redundant      Wrong, but plausible

3. What result occurs when there is an open circuit leading to a thermostat?

- a. continuous operation of an air conditioner   Wrong, but plausible
- b. continuous operation of the blower           Wrong, but plausible
- c. lack of operation of an air conditioner       Correct
- d. lack of operation of the blower               Wrong, but plausible

4. What is the velocity pressure of air moving through an 8" x 8" square duct at 2500 fpm?

- a. 0.16"           Wrong, but plausible
- b. 0.39"           Correct
- c. 0.54"           Wrong, but plausible
- d. 0.64"           Wrong, but plausible

5. According to the International Mechanical Code, what is the minimum chimney thickness for a high heat appliance with a round diameter of 14"?

- a. 0.057"         Correct
- b. 0.075"         Wrong, but plausible
- c. 0.099"         Wrong, but plausible
- d. 0.129"         Wrong, but plausible

6. What condition causes an HVAC unit to run with high head pressure?

- a. broken blower belt                              Wrong, but plausible
- b. dirty condenser coil                             Correct
- c. low refrigerant charge                         Wrong, but plausible
- d. low outdoor ambient temperature           Wrong, but plausible

7. What type of joint runs 90° to the airflow?

- a. horizontal                      **Incorrect by definition**
- b. longitudinal                   **Incorrect by definition**
- c. transverse                    **Correct by definition**
- d. vertical                        **Incorrect by definition**

8. What device can be used to limit low-frequency sounds in an HVAC system?

- a. dampers                        **Wrong, but plausible**
- b. duct lining                    **Correct**
- c. mufflers                       **Wrong, but plausible**
- d. turning vanes                **Wrong, but plausible**

9. As the length of the gas pipe increases, the gas pressure \_\_\_\_\_.

- a. decreases                      **Correct**
- b. fluctuates                      **Wrong, but plausible**
- c. increases                       **Wrong, but plausible**
- d. remains the same            **Wrong, but plausible**

## Curricula Crosswalk

### Crosswalk to PAHRA Technical Program Requirements, NCCER Modules, OCIB Technical Specifications, & Multistate Academic and Vocational Curriculum Consortium (MAVCC) Curriculum

The following crosswalk is intended for guidance purposes only. It does not represent all curricula or resource materials that may be used for HVACR programs. It is intended as a reference for curriculum planning and mapping standards to available curricula.

#### Curriculum/Resource Titles:

- (1) MAVCC – Fundamentals of Air Conditioning and Refrigeration
- (2) MAVCC – HVACR Electrical Systems
- (3) MAVCC – Residential HVAC System Design
- (4) MAVCC – Residential & Light Commercial HVAC
- (5) PAHRA – Technical Program Requirements
- (6) NCCER – HVAC Level 1
- (7) NCCER – HVAC Level 2
- (8) NCCER – HVAC Level 3
- (9) NCCER – HVAC Level 4
- (10) NCCER – Core Curriculum Trainee Guide

For more information about MAVCC curricula, please go to [www.okcimc.com](http://www.okcimc.com).

Module Name — Objective	Unit/Module
<b>HVAC/R Industry</b>	1) Unit 1, 13, 16 4) Unit 9-12 5) TPR 2, Subtopic 1 6) Module 03101, 03108
1. Introduction to Refrigeration	1) Unit 1 5) TPR 2, Subtopic I.A. 6) Module 03101
2. Introduction to Air Conditioning	1) Unit 1, 13, 16 5) TPR 2, Subtopic I.B. 6) Module 03101
3. Introduction to Heating	4) Unit 9-12 5) TPR 2, Subtopic I.C. 6) Module 03108

<b>Module Name — Objective</b>	<b>Unit/Module</b>
<b>Thermodynamics and Heat Transfer Principles</b>	1) Unit 1, 5, 13, 14, 16, 18 3) Unit 1, 2, 3 5) TPR2, Subtopic II 6) Module 03102, 03107
1. Matter and Heat Behavior	1) Unit 13 3) Unit 1, 2, 3 5) TPR 2, Subtopic II.A. 6) Module 03107
2. Fluids and Pressures	1) Unit 13, 16, 18 5) TPR2, Subtopic II.B.
3. Refrigeration Cycle/Diagrams	1) Unit 1, 13, 14 5) TPR 2, Subtopic II.C. 6) Module 03107
4. Measurement Systems	1) Unit 5 5) TPR 2, Subtopic II.D. 6) Module 03102
<b>Safety Skills</b>	1) Unit 2, 4, 9, 16, 17, 18 5) TPR 1, Subtopic III 10) Module 00101, 00109
1. Personal Safety and Work Practices	1) Unit 2 5) TPR 1, Subtopic III.A. 10) Module 00101
2. Handling of Pressurized Fluids	1) Unit 2, 9, 16, 17, 18 5) TPR 1, Subtopic III.B. 10) Module 00109
3. Handling Hazardous Substances	1) Unit 2 5) TPR 1, Subtopic III.C. 10) Module 00109
4. Electrical Safety	1) Unit 2, 4 5) TPR 1, Subtopic III.D. 10) Module 00101
<b>Tools and Equipment</b>	1) Unit 3, 4, 7, 8, 16, 17, 18 2) Unit 2, 3, 11, 15 3) Unit 1, 2, 4 4) Unit 10, 11 5) TPR 2, 3, 4, Subtopic IV 6) Module 03106, 03109 7) Module 03202 10) Module 00103, 00104
1. Hand Tools and Accessories	1) Unit 3, 4, 7, 8 5) TPR 2, Subtopic IV.A. 10) Module 00103, 00104
2. Electrical Testing Devices/Meters	2) Unit 2, 3, 11, 15 5) TPR 2, Subtopic IV.B. 6) Module 03106

<b>Module Name — Objective</b>	<b>Unit/Module</b>
3. Refrigeration: Servicing and Testing Equipment	1) Unit 16, 17, 18 5) TPR 2 & 3, Subtopic IV.C.
4. Heating: Servicing and Testing Equipment	4) Unit 10, 11 5) TPR 2 & 3, Subtopic IV.D. 7) Module 03202
5. Air Flow: Measuring and Testing Equipment	3) Unit 1, 2, 4 5) TPR 3 & 4, Subtopic IV.E. 6) Module 03109
<b>Piping Principles and Practices</b>	1) Unit 7-12 3) Unit 4, 6 5) TPR 2, 3, 4, Subtopic V 6) Module 03103, 103104, 03105, 03213
1. Piping Material and Fabrication	1) Unit 7-12 5) TPR 2, Subtopic V.A. 6) Module 03103, 03104, 03105
2. Pipe Sizing and Troubleshooting	1) Unit 7-12 5) TPR 3 & 4, Subtopic V.B. 6) Module 03103, 03104, 03105
3. Sheetmetal	1) Unit 4, 7, 8 3) Unit 4, 6 5) TPR 3, Subtopic V.C. 7) Module 03213
<b>Natural Gas Piping</b>	1) Unit 7, 8, 9, 10, 11, 12 5) TPR 2, 3, 4, Subtopic V 6) Module 03103, 03104, 03105
1. Demonstrate knowledge of/apply principles of natural gas piping systems	1) Unit 7, 8, 9, 10, 11, 12 5) TPR 3 & 4, Subtopic V.A. 6) Module 03105
2. Design and install a natural gas piping system	1) Unit 7, 8, 9, 10, 11, 12 5) TPR 3 & 4, Subtopic V.B. 6) Module 03105
3. Identify/select specified natural gas piping, valves, connectors, and accessories	1) Unit 7, 8, 9, 10, 11, 12 5) TPR 3 & 4, Subtopic V.B. 6) Module 03105
4. Read and interpret piping layouts	1) Unit 7, 8, 9, 10, 11, 12 5) TPR 2, Subtopic V.A. 6) Module 03105
5. Perform metallic tubing operations	1) Unit 7, 8, 9, 10, 11, 12 5) TPR 2, Subtopic V.A. 6) Module 03104
6. Perform metallic pipe operations	1) Unit 7, 8, 9, 10, 11, 12 5) TPR 2, Subtopic V.A. 6) Module 03105

<b>Module Name — Objective</b>	<b>Unit/Module</b>
7. Perform non-metallic pipe operations	1) Unit 7, 8, 9, 10, 11, 12 5) TPR 2, Subtopic V.A. 6) Module 03103
8. Perform welding	1) Unit 7, 8, 9, 10, 11, 12 5) TPR 2, Subtopic V.A. 6) Module 03105
9. Test for leaks	1) Unit 7, 8, 9, 10, 11, 12 6) Module 03103, 03105
<b>Electricity</b>	2) Unit 1-6, 8, 11, 14 5) TPR 2, Subtopic VI 6) Module 03106 7) Module 03206 8) Module 03314
1. Basic Electricity	2) Unit 1-6, 8, 11, 14 5) TPR 2, Subtopic VI.A. 6) Module 03106 7) Module 03206
2. Electrical Generation and Distribution	2) Unit 1, 3 5) TPR 2, Subtopic VI.B. 7) Module 03206
3. Electrical Components	2) Unit 6, 7, 11, 12 5) TPR 2, Subtopic VI.C. 7) Module 03206
4. Electrical Circuits and Controls	2) Unit 1-14 5) TPR 2, Subtopic VI.E. 8) Module 03314
<b>Electric Motors</b>	2) Unit 6-10, 12-14 5) TPR 2, 3, 4, Subtopic VI 7) Module 03206 8) Module 03314
1. Explain electric motor theory (i.e., magnetism, electromotive force, etc.)	2) Unit 8 5) TPR 2-4, Subtopic VI.D. 7) Module 03206
2. Explain the operation, application, disassembly and reassembly of motors	2) Unit 8-10, 12-14 5) TPR 2-4, Subtopic VI.D. 7) Module 03206
3. Describe starting components associated with single-phase and three-phase motors	2) Unit 8, 12 5) TPR 2-4, Subtopic VI.D. 7) Module 03206
4. Demonstrate knowledge of the operation/replacement of electric motor protection devices	5) TPR 2-4, Subtopic VI.D. 7) Module 03206
5. Explain the significance of power factor	2) Unit 8 5) TPR 2-4, Subtopic VI.D. 7) Module 03206



<b>Module Name — Objective</b>	<b>Unit/Module</b>
6. Determine characteristics and specifications of a motor – type, wattage, power, rpm, size, application	2) Unit 9 5) TPR 2-4, Subtopic VI.D. 7) Module 03206
7. Demonstrate proper use of testing equipment for motors	2) Unit 8 5) TPR 2-4, Subtopic VI.D. 7) Module 03206
8. Troubleshoot electric motors and motor circuits	2) Unit 8 5) TPR 2, Subtopic VI.E. 8) Module 03314
9. Determine physical conditions/alignment/replacement of motor bearings, rotors, belts, and pulleys	2) Unit 8 5) TPR 2-4, Subtopic VI.D. 8) Module 03314
10. Troubleshoot/replace starting components and relays for various types of motors	2) Unit 6 5) TPR 2-4, Subtopic VI.D. 8) Module 03314
11. Troubleshoot the resistance of windings in single-phase and three-phase motors	2) Unit 10, 14 5) TPR 2-4, Subtopic VI.D. 8) Module 03314
12. Replace motor controls	2) Unit 6, 7 5) TPR 2-4, Subtopic VI.D. 8) Module 03314
<b>DC Circuits</b>	2) Unit 1-6, 8 5) TPR 2, Subtopic VI 6) Module 03106
1. Identify properties of a DC circuit	2) Unit 3 5) TPR 2, Subtopic VI.A. 6) Module 03106
2. Identify DC sources	2) Unit 3 5) TPR 2, Subtopic VI.A. 6) Module 03106
3. Define voltage, current, resistance, power, and energy	2) Unit 1 5) TPR 2, Subtopic VI.A. 6) Module 03106
4. Apply Ohm's Law	2) Unit 1 5) TPR 2, Subtopic VI.A. 6) Module 03106
5. Measure DC circuits and components using VOA meter	2) Unit 2 5) TPR 2, Subtopic VI.A. 6) Module 03106
6. Troubleshoot circuits – series, parallel, and series-parallel	2) Unit 1, 4 5) TPR 2, Subtopic VI.A. 6) Module 03106
7. Troubleshoot maximum power transfer theory	5) TPR 2, Subtopic VI.C. 6) Module 03106

<b>Module Name — Objective</b>	<b>Unit/Module</b>
8. Define magnetic properties of circuits and devices	2) Unit 1, 6, 8 5) TPR 2, Subtopic VI.C. 6) Module 03106
9. Describe physical and electrical characteristics of electronic components	2) Unit 2, 4, 5, 6 5) TPR 2, Subtopic VI.C. 6) Module 03106
10. Set up and operate for DC circuits	2) Unit 1, 2, 6 5) TPR 2, Subtopic VI.C. 6) Module 03106
11. Construct and interpret schematics and diagram	2) Unit 4, 6 6) Module 03106
12. Check anodes (electrolysis)	2) Unit 1, 4, 6 5) TPR 2, Subtopic VI.A. 6) Module 03106
<b>AC Circuits</b>	2) Unit 1-6, 8, 11, 14, 15 5) TPR 2, Subtopic VI 6) Module 03106 7) Module 03206
1. Identify properties of an AC circuit	2) Unit 3 5) TPR 2, Subtopic VI.A. 6) Module 03106
2. Identify AC sources	2) Unit 3 5) TPR 2, Subtopic VI.A. 6) Module 03106
3. Troubleshoot AC circuits	2) Unit 1, 4, 11 5) TPR 2, Subtopic VI.A. 6) Module 03106 7) Module 03206
4. Troubleshoot, analyze, and apply principles of transformers to AC circuits	2) Unit 2, 3 5) TPR 2, Subtopic VI.B. 7) Module 03206
5. Troubleshoot circuits – series, parallel resonant, polyphase	2) Unit 1, 4 5) TPR 2, Subtopic VI.A. 6) Module 03106 7) Module 03206
6. Demonstrate knowledge of basic electrical theory and operation of loads	2) Unit 1, 11 5) TPR 2, Subtopic VI.A. 2) Unit 1, 2, 6 5) TPR 2, Subtopic VI.A. 7) Module 03206
7. Set up and operate for AC circuits	2) Unit 1, 2, 6 5) TPR 2, Subtopic VI.A. 7) Module 03206
8. Construct and interpret schematics and diagrams	2) Unit 4, 6 5) TPR 2, Subtopic VI.A.

<b>Module Name — Objective</b>	<b>Unit/Module</b>
<b>Controls</b>	2) Unit 6, 7 4) Unit 9, 14 5) TPR 3 & 4, Subtopic VII 7) Module 03211 8) Module 03209, 03314
1. Gas Valves	4) Unit 9 5) TPR 3 & 4, Subtopic VII.A. 8) Module 03209
2. Fuel Control	4) Unit 9 5) TPR 3 & 4, Subtopic VII.B. 8) Module 03209
3. Residential Control Systems—Heating/Cooling	2) Unit 6, 7 5) TPR 3, Subtopic VII.C. 8) Module 03314
4. Heat Pump Controls	4) Unit 14 5) TPR 3, Subtopic VII.E. 7) Module 03211
<b>Solid State Electronics</b>	2) Unit 6 5) TPR 3 & 4, Subtopic VII, VIII
1. Solid State Components	2) Unit 6 5) TPR 3 & 4, Subtopic VII.F, VIII.A
<b>Refrigeration System Controls</b>	2) Unit 6, 7 5) TPR 3 & 4, Subtopic VIII 8) Module 03304
1. Demonstrate knowledge of principles of safety and operating control devices	2) Unit 6 5) TPR 3 & 4, Subtopic VIII.A. 8) Module 03304
2. Install/service/troubleshoot electro-mechanical control devices	2) Unit 6, 7 5) TPR 3 & 4, Subtopic VIII.A. 8) Module 03304
3. Install/service/troubleshoot pneumatic control devices	2) Unit 6, 7 5) TPR 3 & 4, Subtopic VIII.A. 8) Module 03304
4. Troubleshoot DDC	2) Unit 6 5) TPR 3 & 4, Subtopic VIII.A. 8) Module 03304
<b>Load Calculations</b>	3) Unit 2, 3, 4, 9 4) Unit 1, 2 5) TPR 3-5, Subtopic IX 9) Module 03407
1. Refrigeration Loads	3) Unit 3 4) Unit 2 5) TPR 3-5, Subtopic IX.A. 9) Module 03407

<b>Module Name — Objective</b>	<b>Unit/Module</b>
2. Psychrometrics	3) Unit 2 4) Unit 1 5) TPR 3 & 4, Subtopic IX.B. 9) Module 03407
3. Heating Loads	3) Unit 2, 3, 4, 9 4) Unit 2 5) TPR 3 & 4, Subtopic IX.C. 9) Module 03407
4. Cooling Loads	3) Unit 2, 3, 4 4) Unit 2 5) TPR 3 & 4, Subtopic IX.D. 9) Module 03407
<b>Refrigerant System Components</b>	1) Unit 13, 14 5) TPR 2-5, Subtopic X 6) Module 03107 7) Module 03302, 03303 8) Module 03312, 03313
1. Metering Devices	1) Unit 13 5) TPR 2-5, Subtopic X.A. 7) Module 03303
2. Evaporators	1) Unit 13 5) TPR 3-5, Subtopic X.B.
3. Compressors	1) Unit 13 5) TPR 3-5, Subtopic X.C. 7) Module 03302
4. Condensers	1) Unit 13 5) TPR 3-5, Subtopic X.D.
5. Accessories	1) Unit 14 5) TPR 3-5, Subtopic X.E. 8) Module 03312, 03313
6. Access Valves	1) Unit 14 5) TPR 2-5, Subtopic X.F.
<b>Refrigeration Cycle</b>	1) Unit 13, 15, 16, 17 3) Unit 1-3 4) Unit 1 5) TPR 2-5, Subtopic II, IV, X, XIV, XXII, IX 6) Module 03107 7) Module 03301, 03302, 03303
1. Demonstrate knowledge of the theory of heat	1) Unit 13 3) Unit 1-3 5) TPR 2, Subtopic II.A, II.C. 6) Module 03107

<b>Module Name — Objective</b>	<b>Unit/Module</b>
2. Demonstrate knowledge of characteristics and identifications of refrigerants	1) Unit 15 5) TPR2, Subtopic XXII.A. 6) Module 03107 7) Module 03301
3. Read and interpret pressure-temperature curves and charts	3) Unit 2 4) Unit 1 5) TPR 3 & 4, Subtopic IX.B.
4. Demonstrate knowledge of principles and operation of the mechanical refrigeration cycle	1) Unit 13 5) TPR 2-5, Subtopic X.A, X.C, X.D. 6) Module 03107 7) Module 03302, 03303
5. Evacuate a refrigeration system	1) Unit 16, 17 5) TPR 2 & 3, Subtopic IV.C.
6. Charge a refrigeration system	5) TPR 2 & 3, Subtopic IV.C.
7. Adjust head pressure controls	5) TPR 2-5, Subtopic XIV.A. 6) Module 03107
<b>Air-Conditioning Systems</b>	1) Unit 13 5) TPR 2-5, Subtopic XI 6) Module 03107
1. Unitary Cooling	1) Unit 13 5) TPR 3, Subtopic XI.A. 6) Module 03107
2. Service and Problem Analysis	5) TPR 2-5, Subtopic XI.C.
<b>Heat Pump Systems</b>	4) Unit 14 5) TPR 3 & 4, Subtopic XII 7) Module 03211
1. Basic Principles and Components	4) Unit 14 5) TPR 3 & 4, Subtopic XII.A. 7) Module 03211
2. Applications	4) Unit 14 5) TPR 3 & 4, Subtopic XII.B. 7) Module 03211
<b>Heating Systems</b>	4) Unit 9-12, 15, 16 5) TPR 3 & 4, Subtopic XIII 7) Module 03203, 03204 8) Module 03209, 03305 9) Module 03402
1. Forced Warm Air Systems	4) Unit 9-12 5) TPR 3 & 4, Subtopic XIII.A. 8) Module 03209
2. Hydronic Systems	4) Unit 16 5) TPR 3 & 4, Subtopic XIII.B. 7) Module 03203 8) Module 03305

<b>Module Name — Objective</b>	<b>Unit/Module</b>
3. Testing and Balancing Equipment	4) Unit 15 5) TPR 3 & 4, Subtopic XIII.C. 9) Module 03402
4. Humidification	5) TPR 3 & 4, Subtopic XIII.D. 7) Module 03204
5. Unitary Combination Heating and Cooling Equipment	5) TPR 3 & 4, Subtopic XIII.E. 7) Module 03201
6. Oil Furnaces	4) Unit 11 5) TPR 3 & 4, Subtopic XIII.F. 8) Module 03310
7. Electric Furnaces	4) Unit 12 5) TPR 3 & 4, Subtopic XIII.G. 8) Module 03209
<b>Heating Systems</b>	4) Unit 9-12, 15, 16 5) TPR 3 & 4, Subtopic XIII 7) Module 03203, 03204 8) Module 03209, 03305 9) Module 03402
1. Forced Warm Air Systems	4) Unit 9-12 5) TPR 3 & 4, Subtopic XIII.A. 8) Module 03209
2. Hydronic Systems	4) Unit 16 5) TPR 3 & 4, Subtopic XIII.B. 7) Module 03203 8) Module 03305
3. Testing and Balancing Equipment	4) Unit 15 5) TPR 3 & 4, Subtopic XIII.C. 9) Module 03402
4. Humidification	5) TPR 3 & 4, Subtopic XIII.D. 7) Module 03204
5. Unitary Combination Heating and Cooling Equipment	5) TPR 3 & 4, Subtopic XIII.E. 7) Module 03201
6. Oil Furnaces	4) Unit 11 5) TPR 3 & 4, Subtopic XIII.F. 8) Module 03310
7. Electric Furnaces	4) Unit 12 5) TPR 3 & 4, Subtopic XIII.G. 8) Module 03209

Module Name — Objective	Unit/Module
<b>Refrigeration Systems</b>	1) Unit 13, 14, 16-18 3) Unit 2-4 4) Unit 2 5) TPR 1-5, Subtopic IV, X, XIII, XIV, XX, XXII, IX 6) Module 03107 7) Module 03205, 03301 8) Module 03304, 03312, 03313 9) Module 03407
1. Demonstrate knowledge of principles of refrigeration applicants	5) TPR 5, Subtopic XIV.C. 8) Module 03304
2. Calculate heating and cooling loads	3) Unit 2-4 4) Unit 2 5) TPR 3-5, Subtopic IX.A, IX.C., IX.D. 9) Module 03407
3. Demonstrate knowledge of principles of refrigeration systems	5) TPR 5, Subtopic XIV.C., XIVE. 8) Module 03304
4. Demonstrate knowledge of principles of electric and hot gas defrost operations	5) TPR 5, Subtopic XIV.C., XIVE. 8) Module 03304
5. Demonstrate knowledge of principles of/apply principles of specific refrigeration system components	5) TPR 3-5, Subtopic X.E. 8) Module 03312, 03313
7. Install/service/troubleshoot/replace refrigeration systems	5) TPR 5, Subtopic XIV.D. 8) Module 03304
7. Install/service/troubleshoot/replace ice makers	5) TPR 5, Subtopic XIV.D. 8) Module 03304
8. Install/service/troubleshoot/replace water coolers	5) TPR 5, Subtopic XIV.D. 8) Module 03304
10. Service/troubleshoot/replace evaporator pressure control devices	1) Unit 13 5) TPR 4-5, Subtopic XIV.B.
12. Service/adjust/troubleshoot/replace defrost components	5) TPR 5, Subtopic XIV.C. 8) Module 03304
13. Pump-down refrigeration system	5) TPR 2-5, Subtopic XIII.A. 8) Module 03304
15. Install/service/troubleshoot/replace a defrost heater/timer	5) TPR 5, Subtopic XIV.C. 8) Module 03304
16. Install/service/troubleshoot/replace solenoid valve	1) Unit 14
19. Test for, locate, and repair a refrigerant leak	1) Unit 16-18 5) TPR 2 & 3, Subtopic IV.C. 7) Module 03205
20. Recover/recycle refrigerants	1) Unit 17, 18 5) TPR 1 & 2, Subtopic XX.C, XX.D. 7) Module 03205
22. Install/service/troubleshoot/replace crankcase heater	1) Unit 14

<b>Module Name — Objective</b>	<b>Unit/Module</b>
23. Install/service/troubleshoot/replace compressor	5) TPR 2, Subtopic XXII.B. 7) Module 03301
<b>Commercial Refrigeration</b>	5) TPR 2-5, Subtopic XIV 8) Module 03304
1. Single Compressor	5) TPR 2-5, Subtopic XIV.A. 8) Module 03304
<b>Air Handling</b>	3) Unit 4-8 4) Unit 3, 4 5) TPR 3-4, Subtopic XV 6) Module 03109
1. Air Flow Principles/Duct Design	3) Unit 4-7 4) Unit 3 5) TPR 3-4, Subtopic XV.A. 6) Module 03109
2. Mechanical and Electronic Filtration	3) Unit 8 4) Unit 4 5) TPR 3-4, Subtopic XV.B. 6) Module 03109
3. Fans/Blowers	4) Unit 4 5) TPR 3-4, Subtopic XV.C. 6) Module 03109
<b>Air Distribution Systems</b>	1) Unit 4, 7, 8 3) Unit 1-7 4) Unit 3, 4 5) TPR 3 & 4, Subtopic IV,V, XV, XVIII 6) Module 03109 7) Module 03204, 03213
1. Demonstrate knowledge of/apply principles of air distribution systems	3) Unit 4-7 4) Unit 3 5) TPR 3 & 4, Subtopic XV.A. 6) Module 03109
2. Design air distribution systems	3) Unit 4-7 4) Unit 3 5) TPR 3 & 4, Subtopic XV.A. 6) Module 03109
3. Fabricate and insulate air distribution system	3) Unit 4-7 4) Unit 3 5) TPR 3 & 4, Subtopic XV.A. 6) Module 03109



<b>Module Name — Objective</b>	<b>Unit/Module</b>
4. Identify/install/troubleshoot ducts, fittings, and accessories	1) Unit 4, 7, 8 3) Unit 4, 6 5) TPR 3, Subtopic V.C. 7) Module 03213
5. Install/service air-cleaning devices	3) Unit 8 4) Unit 4 5) TPR 3 & 4, Subtopic XV.B. 6) Module 03109
6. Install fire/smoke control, and safety devices	7) Module 03213
8. Perform test and balance of air distribution systems	3) Unit 1, 2, 4 5) TPR 3 & 4, Subtopic IV.E. 6) Module 03109
9. Read and interpret air distribution layout	3) Unit 4-7 4) Unit 3 5) TPR 3 & 4, Subtopic XV.A. 6) Module 03109
11. Maintain indoor air quality	3) Unit 4, 8 5) TPR 4, Subtopic XVIII.A. 7) Module 03204
<b>Vents and Chimneys</b>	4) Unit 10, 11 5) TPR 3, Subtopic IV 7) Module 03202
1. Design, fabricate, and install vents	4) Unit 10, 11 5) TPR 3, Subtopic IV.D. 7) Module 03202
2. Design, fabricate, and install chimneys	4) Unit 10, 11 5) TPR 3, Subtopic IV.D. 7) Module 03202
<b>System Installation and Start-Up</b>	4) Unit 4, 8, 9-12, 14 5) TPR 3 & 4, Subtopic XVI 7) Module 03211 8) Module 03209, 03310, 03310
1. Heating Start-up, Checkout, and Operation	4) Unit 9-12 5) TPR 3 & 4, Subtopic XVI.A. 8) Module 03209, 03310
2. Heat Pump Start-up, Checkout, and Operation	4) Unit 14 5) TPR 3 & 4, Subtopic XVI. B. 7) Module 03211
3. Air Conditioning Start-up, Checkout, and Operation	4) Unit 4, 8 5) TPR 3 & 4, Subtopic XVI.C. 8) Module 03210

<b>Module Name — Objective</b>	<b>Unit/Module</b>
<b>System Servicing and Troubleshooting</b>	4) Unit 4, 8, 9-12 5) TPR 3 & 4, Subtopic XVII 8) Module 03209, 03210, 03310, 03311
1. Mechanical System Problems	5) TPR 3 & 4, Subtopic XVII.A.
2. Electrical Troubleshooting	5) TPR 3 & 4, Subtopic XVII.B.
3. Heating: Service and Problem Analysis	4) Unit 9-12 5) TPR 3 & 4, Subtopic XVII.C. 8) Module 03209, 03310
4. Heat Pump: Service and Problem Analysis	4) Unit 4 5) TPR 3 & 4, Subtopic XVII.D. 8) Module 03311
5. Air Conditioning: Service and Problem Analysis	4) Unit 4, 8 5) TPR 3 & 4, Subtopic XVII.E. 8) Module 03210
<b>Indoor Air Quality</b>	3) Unit 4, 8 5) TPR4, Subtopic XVIII 7) Module 03204
1. Requirement and Maintenance of Air Quality	3) Unit 4, 8 5) TPR4, Subtopic XVIII.A. 7) Module 03204
<b>Preventative Maintenance</b>	5) TPR 3-5, Subtopic XIX 7) Module 03215
1. Basic Maintenance	5) TPR 3-5, Subtopic XIX.A. 7) Module 03215
<b>Refrigerant Recovery</b>	1) Unit 15-18 5) TPR 1-5, Subtopic XX 7) Module 03205
1. Introduction	1) Unit 15 5) TPR 3-5, Subtopic XX.A. 7) Module 03205
2. Safety	1) Unit 16 5) TPR 1 & 2, Subtopic XX.B. 7) Module 03205
3. Refrigerant Recovery, Recycling, and Reclamation Methods	1) Unit 17 5) TPR 1 & 2, Subtopic XX.C. 7) Module 03205
4. Refrigerant Recovery, Recycling and Reclamation Equipment	1) Unit 18 5) TPR 1 & 2, Subtopic XX.D. 7) Module 03205
<b>Refrigerant Retrofits</b>	5) TPR 2, Subtopic XXI
1. Alternative Refrigerant Retrofits	5) TPR 2, Subtopic XXI.A.

<b>Module Name — Objective</b>	<b>Unit/Module</b>
<b>Refrigerants and Lubricants</b>	1) Unit 15 5) TPR 2, Subtopic XXII 7) Module 03301
1. Refrigerants	1) Unit 15 5) TPR 2, Subtopic XXII.A. 7) Module 03301
2. Lubricants	1) Unit 15 5) TPR 2, Subtopic XXII.B. 7) Module 03301
<b>Comply with Industry Regulations</b>	1) Unit 15 3) Unit 3, 6, 8, 9 5) TPR 2, Subtopic XXIII 9) Module 00109
1. Codes and Standards	3) Unit 3, 6, 8, 9 5) TPR 2, Subtopic XXIII.A.
2. Regulations Affecting Ozone Depletion	1) Unit 15 5) TPR 2, Subtopic XXIII.B.
3. Other Regulations	5) TPR 2, Subtopic XXIII.C. 9) Module 00109
<b>Professional Service</b>	4) Unit 17 5) TPR 2, Subtopic XXIV 8) Module 03316 10) Module 00108
1. Customer Relations/Communication	4) Unit 17 5) TPR 2, Subtopic XXIV.A. 8) Module 03316 10) Module 00108
2. Character Education	4) Unit 17 5) TPR 2, Subtopic XXIV.B. 10) Module 00108

## Additional Resources

For a more in-depth breakdown of objectives, job sheets, and assignment sheets for the MAVCC curriculum, please see the following crosswalks:

- (1) MAVCC – Fundamentals of Air Conditioning and Refrigeration  
[www.mavcc.com/cw/ACRcrosswalktopahra.pdf](http://www.mavcc.com/cw/ACRcrosswalktopahra.pdf)
- (2) MAVCC – HVACR Electrical Systems  
[www.mavcc.com/cw/hvacreleccrosswalktopahra.pdf](http://www.mavcc.com/cw/hvacreleccrosswalktopahra.pdf)
- (3) MAVCC – Residential HVAC System Design  
[www.mavcc.com/cw/CWNATECompetencies.pdf](http://www.mavcc.com/cw/CWNATECompetencies.pdf)

## Abbreviations, Symbols and Acronyms

The following is a list of abbreviations, symbols, and acronyms used in the HVACR study guide and on the HVACR assessments.

°	Degree
°F	Degree Fahrenheit
'	Foot/feet
”	Inch/inches
Ω	Ohms
%	Percent
A	Amps
AB	Alkylbenzenes
AC	Alternating Current
AFUE	Annual Fuel Utilization Efficiency
AGA	American Gas Association
AHRI	Air Conditioning, Heating, and Refrigeration Institute
AMCA	Air Movement & Control Association
ANSI	American National Standards Institute
APD	Air Pressure Drop
ASHRAE	American Society of Heating, Refrigeration, & Air Conditioning Engineers
BOCA	Building Officials & Code Administrators
BRI	Building Related Illness
BTU	British Thermal Unit
C	24VAC Common Terminal
CFC	Chlorofluorocarbon
CFM	Cubic Feet Per Minute
CPVC	Chlorinated Polyvinyl Chloride
CSIR	Capacitor Start/Induction Run
CSCR	Capacitor Start/Capacitor Run
CSR	Capacitor Start/Run
CSST	Corrugated Stainless Steel Tubing
CO <sub>2</sub>	Carbon Dioxide
COP	Coefficient of Performance
DC	Direct Current
DDC	Direct Digital Control
DOT	Department of Transportation
EGR	Exhaust Gas Recirculation
EMF	Electromotive Force
EPA	Environmental Protection Agency
EPR	Evaporator Pressure Regulator
ft <sup>3</sup>	Cubic Feet
GFCI	Ground Fault Circuit Interrupter
HAZCOM	Hazard Communication
HCFC	Hydrochlorofluorocarbon
HFC	Hydrofluorocarbon
HEPA	High Efficiency Particulate Air
Hg	Hectograms

HSPF	Heating Seasonal Performance Factor
HVAC	Heating Ventilation & Air Conditioning
Hz	Hertz
IEC	International Electrotechnical Commission
in <sup>2</sup>	Inches Squared
ISO	International Organization of Standardization
MIG	Metal Inert Gas
mu	Milliunits
NCCER	National Center for Construction Education and Research
NIOSH	National Institute for Occupational Safety and Health
O <sub>2</sub>	Oxygen
OCIB	Oklahoma Construction Industries Board
ODT	Outdoor Design Temperature
OEM	Original Equipment Manufacturer
OSHA	Occupation Safety and Health Act
PAG	Polyglocols
PAHRA	Partnership for Air Conditioning, Heating, Refrigeration Accreditation
PFC	Perfluorocarbon
PMS	Pantone Matching System
POE	Polyolester
PSC	Permanent Split Capacitor
PTC	Positive Temperature Coefficient
psi	Pounds Per Square Inch
psia	Pounds Per Square Inch Absolute
psig	Pounds Per Square Inch Gauge
PSP	PermaShield Pipe
PVC	Polyvinyl Chloride
R	24VAC Power Terminal
R <sub>c</sub>	24VAC Cool Call Switch Power Terminal
R <sub>h</sub>	24VAC Heat Call Switch Power Terminal
SBS	Sick Building Syndrome
SDS	Safety Data Sheet
SEER	Seasonal Energy Efficiency Ratio
SMACNA	Sheet Metal and Air Conditioning Contractor's National Association
TIG	Tungsten Inert Gas
TXV	Thermal Expansion Valve
UL	Underwriter's Laboratory
V	Volts
VAC	Volts of Alternating Current
VOA	Volts Ohms Meter
W	Watt
W <sub>2</sub>	Second Stage Heating Terminal
WC	Water Column
Y <sub>2</sub>	Second Stage Cooling Terminal

## Test Taking Strategies

This section of the study guide contains valuable information for testing success and provides a common-sense approach for preparing for and performing well on any test.

### General Testing Advice

1. Get a good night's rest the night before the test — eight hours of sleep is recommended.
2. Avoid junk food and “eat right” several days before the test.
3. Do not drink a lot or eat a large meal prior to testing.
4. Be confident in your knowledge and skills!
5. Relax and try to ignore distractions during the test.
6. Focus on the task at hand — taking the test and doing your best!
7. Listen carefully to the instructions provided by the exam proctor. If the instructions are not clear, ask for clarification.

### Testing Tips

1. Read the entire question before attempting to answer it.
2. Try to answer the question before reading the choices. Then, read the choices to determine if one matches, or is similar to your answer.
3. Do not change your answer unless you misread the question or are certain that your first answer is incorrect.
4. Answer questions you know first, so you can spend additional time on the more difficult questions.
5. Check to make sure you have answered every question before you submit the assessment for scoring — unanswered questions are marked incorrect.





