Heating, Ventilation, Air Conditioning, and Refrigeration I

8503 36 weeks / 140 hours

Table of Contents

Acknowledgments

The components of this instructional framework were developed by the following curriculum development panelists:

Steven Allen, Accreditation Specialist, HVAC Excellence, Detroit, MI
Anthony Lann, Instructor, Spotsylvania Career and Tech Center, Spotsylvania County Public Schools
Joyce Price, Director, SkillsUSA Virginia, Blacksburg
Daniel Ramos, Jr., Instructor, Virginia Beach Technical and Career Education Center,

Virginia Beach City Public Schools
Wade Saxton, Commissioning and Startup Manager, Atlantic Constructors, Richmond
Bernie Sisson, Technical and Skills Manager, Michael and Son Services, Alexandria
Tim Southern, Special Projects Manager and Safety Director, L.A. Lacy, Charlottesville
Robert Stringham, Instructor, Edison Academy, Fairfax County Public Schools
Alfred Wheeling, Instructor, Franklin County High School, Franklin County Public Schools
Frank Willis, Instructor, Chesterfield Career and Technical Center at Courthouse, Chesterfield County Public Schools

Correlations to the Virginia Standards of Learning were reviewed and updated by:

Leslie R. Bowers, English Teacher (ret.), Newport News Public Schools
Vickie L. Inge, Mathematics Committee Member, Virginia Mathematics and Science Coalition
Anne F. Markwith, New Teacher Mentor (Science), Gloucester County Public Schools
Michael Nagy, Social Studies Department Chair, Rustburg High School, Campbell County Public Schools

The framework was edited and produced by the CTE Resource Center:

Nathan K. Pope, Writer/Editor
Kevin P. Reilly, Administrative Coordinator

Virginia Department of Education Staff

J. Anthony Williams, Specialist, Trade and Industrial Education and Related Clusters

J. Anthony Williams, Curriculum and Instruction Coordinator
Dr. David S. Eshelman, Director, Workforce Development and Initiatives
George R. Willcox, Director, Operations and Accountability

Office of Career, Technical, and Adult Education
Virginia Department of Education

Course Description

Suggested Grade Level: 10 or 11

In this first course of the instructional program, students are taught to professionally install, repair, and maintain the operating conditions of heating, ventilation, air-conditioning, and

refrigeration (HVACR) systems. Students work with piping and tubing, study the principles of heat and electricity, install duct systems, and comply with U.S. Environmental Protection Agency (EPA) regulations. Successful completion of the two-course sequence may prepare students for a career as a HVACR technician.

Legislation enacted in the 2015 Virginia General Assembly (HB1616) requires each sequence of courses constituting a career and technical education (CTE) program completion to be aligned with state or national program certification and accreditation standards, if such standards exist. To comply with this requirement all Heating, Ventilation, Air Conditioning, and Refrigeration programs must be accredited by HVAC Excellence.

As noted in Superintendent's Memo #058-17 (2-28-2017), this Career and Technical Education (CTE) course must maintain a maximum pupil-to-teacher ratio of 20 students to one teacher, due to safety regulations. The 2016-2018 biennial budget waiver of the teacher-to-pupil ratio staffing requirement does not apply.

Task Essentials Table

- Tasks/competencies designated by plus icons (⊕) in the left-hand column(s) are essential
- Tasks/competencies designated by empty-circle icons (○) are optional
- Tasks/competencies designated by minus icons (⊖) are omitted
- Tasks marked with an asterisk (*) are sensitive.

Task Number	8503	Tasks/Competencies
Applying Basic Construction Safety Standards (Core Safety)		
39	⊕	Comply with federal, state, and local safety requirements.
40	⊕	Identify personal protective equipment (PPE) requirements.
41	⊕	Maintain a safe working environment.
42	⊕	Explain safe working practices around electrical hazards.
43	⊕	Identify emergency first-aid procedures.
44	⊕	Identify the types of fires and the methods used to extinguish them.
45	⊕	Inspect course-specific hand and power tools to visually identify defects.
46	⊕	Demonstrate lifting and carrying techniques.
47	⊕	Demonstrate safe laddering techniques.
48	⊕	Demonstrate safe scaffolding techniques.
49	⊕	Report personal injuries, environmental issues, and equipment safety violations to the appropriate authority.
50	⊕	Demonstrate lockout and tagout procedures.
51	○	Earn the Construction Industry OSHA 10 card.
52	⊕	Pass a safety exam for lab/site safety and the use of tools and equipment specific to the construction industry.
Understanding the Theory of Heat		
53	⊕	Describe the changing states of matter.
54	⊕	Describe the refrigeration process and the basic refrigeration components.

Task Number	8503	Tasks/Competencies
55	⊕	Describe the relationship of pressures and fluids at saturation temperatures.
Working with Piping and Tubing		
56	⊕	Demonstrate torch safety.
57	⊕	Connect pipe, using threaded joint.
58	⊕	Connect pipe, using cemented joint.
59	⊕	Connect tubing, using compression fitting.
60	⊕	Connect tubing, using flare fitting.
61	⊕	Connect tubing and fitting, using a soft solder joint.
62	⊕	Connect tubing, using a swaged, brazed joint and nitrogen.
63	⊕	Shape tubing run with offset and corner, using the bending tool.
64	⊕	Identify the British thermal unit (BTU) and types of heat.
Understanding Basic Electricity		
65	⊕	Interpret a schematic diagram.
66	⊕	Draw a schematic diagram.
67	⊕	Calculate voltage, amperage, and resistance in series and parallel circuits.
68	⊕	Determine the appropriate wire size, based on equipment load amperage.
69	⊕	Measure voltages in electrical circuits.
70	⊕	Measure amperage in electrical circuits.
71	⊕	Measure resistance in electrical circuits.
72	⊕	Test electrical circuits for continuity.
73	⊕	Test equipment and motor windings for grounds, opens, and shorts.
74	⊕	Measure capacitance of a capacitor.
75	⊕	Make electrical connections.
76	⊕	Install electrical components.
77	⊕	Troubleshoot high-voltage and low-voltage electrical systems.
Servicing and Maintaining Refrigeration Systems		
78	⊕	Perform routine preventive maintenance on refrigeration systems.
79	⊕	Compare electrical problems to those that are mechanical.
80	⊕	Demonstrate use of a refrigeration manifold gauge.
81	⊕	Measure superheat and subcooling.
82	⊕	Locate a leak in charged refrigerant circuits, using various leak detection methods.
83	⊕	Locate a leak in an uncharged refrigerant circuit, using nitrogen pressurization or trace gas.
84	⊕	Replace a filter-drier.
85	⊕	Evacuate and charge a refrigeration circuit (new or contaminated system).
86	⊕	Repair a leak in a refrigerant circuit.
87	⊕	Identify various types of compressors.
88	⊕	Add oil to a compressor.
89	⊕	Adjust pressure to turn on an operating refrigeration system.
90	⊕	Adjust the temperature switch.
91	○	Adjust defrost cycle.
92	○	Attempt to start a stuck hermetic (single-phase) compressor.

Task Number	8503	Tasks/Competencies
93	○	Test refrigerant system for acid.
94	⊕	Replace a compressor.
Understanding Motors and Controls		
95	⊕	Connect single-phase motors.
96	⊕	Reverse the rotation of a single-phase motor.
97	⊕	Troubleshoot the starting components of a single-phase motor.
98	⊕	Install a hard-start kit on a hermetic compressor.
99	⊕	Install a motor contactor.
100	⊕	Replace a start or a run capacitor.
101	⊕	Replace a starting relay.
102	⊕	Replace a motor overload protector.
Complying with EPA Laws and Regulations		
103	○	Identify regulations affecting ozone depletion.
104	○	Identify the evacuation requirements for small appliances.
105	○	Detect noncondensables, using the pressure and temperature relationship (i.e., the P/T chart).
106	○	Install high-side and low-side access valves when recovering refrigerant from small appliances with inoperative compressors.
107	○	Recover refrigerants with system-dependent (passive) and self-contained (active) recovery methods.
108	○	Remove the solderless access fitting at the conclusion of service.
109	○	Identify annual leak rates for commercial and industrial process refrigeration and for other appliances containing more than 50 pounds of refrigerant.
110	○	Identify high-pressure and low-pressure recovery techniques and requirements.
111	○	Identify the components of high-pressure and low-pressure appliances and the state of refrigerant.
112	○	Identify pressure-temperature relationships of high-pressure and low-pressure refrigerants.
113	○	Obtain the EPA Section 608 certification.

Legend: ⊕Essential ○Non-essential ⊖Omitted

Curriculum Framework

Applying Basic Construction Safety Standards (Core Safety)

Task Number 39

Comply with federal, state, and local safety requirements.

Definition

Compliance should include

- understanding the roles of the Occupational Safety and Health Administration (OSHA), Virginia Occupational Safety and Health (VOSH), and the Environmental Protection Agency (EPA)
- identifying the OSHA Hazard Communication Standard (HazCom)
- interpreting the information included on safety data sheets (SDS)
- describing the responsibilities of employers and employees under HazCom.

Process/Skill Questions

- Where should hazardous materials be stored?
- What information can be found on an SDS?

Task Number 40

Identify personal protective equipment (PPE) requirements.

Definition

Identification could include procedures for inspecting, wearing, and removing

- eye protection
- respirator
- hard hat
- gloves
- safety harness
- hearing protection
- safety shoes.

Identification should also include explaining when particular PPE is required.

Process/Skill Questions

- What are some dangerous effects of sun exposure, and how can these risks be mitigated?
- Why is wearing jewelry prohibited while in the lab or on the job site?

Task Number 41

Maintain a safe working environment.

Definition

Maintaining safety should be an ongoing process and should result in identifying potential hazards on a job site or in the lab, such as unstable or improperly erected scaffolding, electrical hazards, job-site debris, improperly stored materials, and air quality hazards. When present, hazards must be remedied by appropriate measures, in compliance with school and instructor guidelines.

Process/Skill Questions

- What are examples of job-site hazards?
- Why is it important to use good housekeeping standards on a job site?
- Why is it important to store materials and tools in their proper places?

Task Number 42

Explain safe working practices around electrical hazards.

Definition

Explanation should include

- identifying equipment used to test electrical circuits
- describing safe working conditions (e.g., grounding, using ground-fault circuit interrupters [GFCIs] and cords)
- demonstrating safe work habits.

Process/Skill Questions

- What is the definition of *proximity work*?
- What are safe working clearances, according to the National Electrical Code (NEC)?
- What are considered safe working conditions and safe work habits?
- What is the unseen hazard with electrical work?
- What are some common electrical workplace issues?

Task Number 43

Identify emergency first-aid procedures.

Definition

Identification should include standard first-aid procedures and school policies regarding incidents involving

- bodily fluids
- electrical injuries
- eye injuries
- falls
- burns.

Process/Skill Questions

- What are the steps that should be followed after an accident?
- Why is knowing cardiopulmonary resuscitation (CPR) an important skill in the construction trades?
- Why is it important to be certified to administer first aid?
- What are the different degrees of electrical burns?

Task Number 44

Identify the types of fires and the methods used to extinguish them.

Definition

Identification should include classifications of fires (e.g., Classes A, B, C, and D), causes and prevention of fires, types of extinguishers, and, when possible, the demonstrated use of a fire extinguisher, in accordance with government regulations and instructor guidelines.

Process/Skill Questions

- Why do fires have different classifications, and what are they?
- What is the fire triangle and the fire tetrahedron?
- What are the three things necessary to start a fire?
- Why is it important to know the classification of fire when trying to extinguish it?
- Why should extinguishers be inspected, and how often should they be inspected?
- What are the classifications of extinguishers?

Task Number 45

Inspect course-specific hand and power tools to visually identify defects.

Definition

Inspection of tools should include

- identifying components of machinery (e.g., guards, blades, moving parts, start/stop switches)
- identifying standard safety procedures (i.e., lab practices and manufacturer recommendations)
- observing a demonstration of the safe operation and use of each piece of machinery in the lab
- identifying tool defects.

Process/Skill Questions

- What are some of the basic power tools used in construction?
- What are the proper actions to take before using a circular saw?
- Why should a power tool always be grounded?

Task Number 46

Demonstrate lifting and carrying techniques.

Definition

Demonstration should include lifting and carrying materials and equipment, based on the principles of

- lifting with the legs
- keeping the back straight
- holding the load close to the body
- getting help, if necessary.

Process/Skill Questions

- What are common injuries associated with improper lifting techniques?
- What can be done to prevent injury?
- How does positioning affect technique?

Task Number 47

Demonstrate safe laddering techniques.

Definition

Demonstration should include using appropriate conduct and safety procedures while

- using aluminum ladders (e.g., three-point contact)
- carrying ladders (e.g., two people at all times)
- erecting and setting ladders (e.g., use the 4:1 rule)
- identifying types of ladders and the components and safety features of each (e.g., wall or straight, extension, roof, stepladder, attic, special-purpose, solid-beam, aluminum, wood/aluminum truss ladder, fiberglass).

Process/Skill Questions

- Why are ladders rated for certain weights?
- Why is the apex (highest point) of a stepladder not considered a step?
- What other methods are used to adjust ladders?

Task Number 48

Demonstrate safe scaffolding techniques.

Definition

Demonstration should include inspecting settings, duty ratings, and safety tags.

Process/Skill Questions

- How can the safe weight limit of any particular scaffolding be determined?
- In which situations is scaffolding preferred or required?

Task Number 49

Report personal injuries, environmental issues, and equipment safety violations to the appropriate authority.

Definition

Report should include

- providing a verbal or written statement
- identifying the violation
- documenting the date when the incident or behavior was observed
- following the protocol for submitting the report to the instructor, the supervisor, or the local OSHA inspectors.

Process/Skill Questions

- What ethical considerations might be involved when reporting coworkers?
- Why is it important to follow reporting procedures?
- What is *liability*?

Task Number 50

Demonstrate lockout and tagout procedures.

Definition

Demonstration should include lockout and tagout procedures when using any piece of HVACR equipment connected to any power source.

Process/Skill Questions

- Who keeps the key to the lock?
- Whose name goes on the tag?
- If more than one person is working on the equipment, who should have a lock and key?

Task Number 51

Earn the Construction Industry OSHA 10 card.

Definition

Earning a Construction Industry OSHA 10 card

- will recognize that one has acquired 10 hours of safety instruction
- will help teach national standards for personal safety within a lab environment
- will validate safety skills to the industry
- will help workers become more safety conscious and responsible.

Process/Skill Questions

- What are the benefits of earning the Construction Industry OSHA 10 card?
- What is OSHA, and how are its standards validated?
- Why was OSHA established, and how has it evolved?

Task Number 52

Pass a safety exam for lab/site safety and the use of tools and equipment specific to the construction industry.

Definition

Assessment must measure participation in safety training programs, including attending safety meetings and periodically demonstrating knowledge and skills gained from program topics (e.g., interpretation of SDS).

Process/Skill Questions

- How often should one participate in safety training programs? Why?
- Why are retraining programs relevant to a company's insurance policy?
- What is workers' compensation?

Understanding the Theory of Heat

Task Number 53

Describe the changing states of matter.

Definition

Description should include

- the effects of heat on evaporation, condensation, and sublimation
- Charles's law
- Dalton's law
- Boyle's law.

Process/Skill Questions

- How many states of matter are there?
- At what temperature does water freeze?

- At what temperature does water boil?

Task Number 54

Describe the refrigeration process and the basic refrigeration components.

Definition

Description should include identification of

- the mechanical refrigeration system
- its components (e.g., compressor, condenser coil, metering device, evaporator coil)
- details related to evaporation, condensation, and compression.

Process/Skill Questions

- What is *evaporation*?
- What is *condensation*?
- What is *compression*?
- What is the name of the component where heat is absorbed?
- What is the name of the component where heat is released?
- What is a piston-in-cylinder compressor?
- Which compressor works like a fan?
- Which compressor works like a screw?

Task Number 55

Describe the relationship of pressures and fluids at saturation temperatures.

Definition

Description should include

- using a pressure/temperature (P/T) chart
- explaining why these values are important to HVACR technicians.

Process/Skill Questions

- What is the saturation temperature of R-22 at 50 psig?
- When do temperature and pressure correspond?
- What is the temperature-pressure relationship?

Working with Piping and Tubing

Task Number 56

Demonstrate torch safety.

Definition

Demonstration should include following appropriate procedures when setting up, lighting, and shutting off torches.

Process/Skill Questions

- What is an unstable pressure for acetylene gas?
- Should oxy and acetylene passages be purged before lighting torches? Why, or why not?
- Which tool is used to light the torch? Why?

Task Number 57

Connect pipe, using threaded joint.

Definition

Connection should be made so that the finished assembly will maintain specified pressure and be free of leaks.

Process/Skill Questions

- What kinds of pipe can be threaded?
- How are threaded joints sealed?
- What are the thread requirements for explosive gases?

Task Number 58

Connect pipe, using cemented joint.

Definition

Connection should be made by cementing PVC, fittings, and pipe together so that the assembly will carry fluid and be free of leaks.

Process/Skill Questions

- What adhesive is used during installation? Why?
- Should the pipe be cleaned prior to gluing? Why, or why not?
- What kind of pipe can be cemented?

Task Number 59

Connect tubing, using compression fitting.

Definition

Connection should be made by using proper wrenches and compression fittings to join tubing so that the finished assembly is free of leaks.

Process/Skill Questions

- What type of tubing is used with compression fittings?
- Why should pipe be cleaned prior to compression fitting?
- What are the parts of a compression fitting?

Task Number 60

Connect tubing, using flare fitting.

Definition

Connection should be made by selecting tubing, flare fittings, and tools that will connect tubing so that the finished assembly is free of leaks.

Process/Skill Questions

- At what angle should the flare be set?
- What types of materials can be flared?

Task Number 61

Connect tubing and fitting, using a soft solder joint.

Definition

Connection should be made by selecting the appropriate tubing, fittings, solder, and torch and by demonstrating soldering of a joint so that the finished assembly is free of leaks.

Process/Skill Questions

- Should the tubing be sanded? Why, or why not?
- At what temperature does a soft solder melt?
- What flux is used?

Task Number 62

Connect tubing, using a swaged, brazed joint and nitrogen.

Definition

Connection should be made by using a low-pressure nitrogen brazing and applying appropriate tools and materials so that the finished assembly is free of leaks.

Process/Skill Questions

- What kind of tubing can be swaged?
- What are the proper tools to be used for swaging?
- What is the brazing material called?

Task Number 63

Shape tubing run with offset and corner, using the bending tool.

Definition

Shaping should include using the bending tool and running tubing with an offset and corner.

Process/Skill Questions

- What types of material can be bent?
- What tools should be used to bend materials?
- What are the parts of the bender?

Task Number 64

Identify the British thermal unit (BTU) and types of heat.

Definition

Identification should include

- HVACR applications of BTUs, or the standard measuring unit of energy (i.e., equal to the amount of energy needed to heat or cool one pound of water by one degree Fahrenheit)
- the difference between latent and sensible heat
- heat transfer.

Process/Skill Questions

- What is a BTU? Why is it important to HVACR?
- What are the differences between latent and sensible heat?
- How might the enthalpy of water be graphed?

Understanding Basic Electricity

Task Number 65

Interpret a schematic diagram.

Definition

Interpretation should include

- a demonstrated understanding of the symbols used in drawings

- an accurate correlation between the flow of electricity through wires and the printed drawing.

Process/Skill Questions

- What are the symbols in a schematic?
- What is the difference between a schematic and a pictorial diagram?
- In what position are schematics shown?

Task Number 66

Draw a schematic diagram.

Definition

Drawing should include

- basic electrical symbols
- a legend correlation.

Process/Skill Questions

- What are the differences between schematic and pictorial diagrams?
- What are common electrical schematic symbols?
- What is a legend, and why is it helpful?

Task Number 67

Calculate voltage, amperage, and resistance in series and parallel circuits.

Definition

Calculation requires an understanding of the mathematical and scientific concepts related to Watt's law and to power. Calculation should include

- defining the terms of the equation for Ohm's law and Watt's law:
  - Ohm's law: E = IR; I = E/R; R = E/I
  - Watt's law: P = IE; I = P/E; E = P/I
- describing the basic scientific principle that if resistance to current flow stays the same and the voltage pressure increases, the current flow rate must also increase
- using the same value components that are physically installed in the circuit
- retaining at least three significant figures (i.e., decimal places) on all measurements

- reconciling differences between computed and measured values (often attributable to rounding errors).

Process/Skill Questions

- What is the formula for calculating a series circuit?
- What is the formula for calculating a parallel circuit?
- What measuring devices enable these calculations?

Task Number 68

Determine the appropriate wire size, based on equipment load amperage.

Definition

Determination should include

- correlating correct wire sizes to identified load amperages
- correlating identified wire sizes to correct load amperages
- locating and identifying chart specifications
- confirming specifications in the National Electrical Code (NEC).

Process/Skill Questions

- What is *AWG*?
- What is the most commonly used gauge?
- How does gauge size correlate to capacity?
- What are the minimum and maximum load ratings for air-conditioning units?

Task Number 69

Measure voltages in electrical circuits.

Definition

Measurements should be checked for accuracy, using a voltmeter and observing safety procedures.

Process/Skill Questions

- What tool is used to measure voltage?
- What voltages are associated with residential power supplies?

- What is *VOM*?

Task Number 70

Measure amperage in electrical circuits.

Definition

Measurement should be checked at different locations in a circuit, using an ammeter and observing safety procedures.

Process/Skill Questions

- What is *amperage*?
- What meter is used to measure amperage?
- Where is the amperage rating found on a piece of equipment?

Task Number 71

Measure resistance in electrical circuits.

Definition

Measurement should be checked at various points on the circuit, using an ohmmeter and observing safety procedures.

Process/Skill Questions

- In what units is resistance measured?
- With what tool is resistance measured?
- What is the symbol for resistance?

Task Number 72

Test electrical circuits for continuity.

Definition

Test should check for circuit continuity, using an ohmmeter and observing safety procedures.

Process/Skill Questions

- What piece of equipment measures continuity?
- What is the difference between an open and a closed circuit?

Task Number 73

Test equipment and motor windings for grounds, opens, and shorts.

Definition

Test should check readings for grounds, opens, and shorts (checking common, start, and run terminals on a compressor), using an ohmmeter and observing safety procedures.

Process/Skill Questions

- Why should the ground, open, and short be tested?
- How should a compressor/motor for a ground, open, and short be tested?
- Why is it important to test the compressor windings?
- Where are the start, run, and common terminals located on a compressor?
- How is the resistance in the windings determined?

Task Number 74

Measure capacitance of a capacitor.

Definition

Measurement will check capacitors for proper mF and voltage, using an ohmmeter and/or capacitor checker and observing safety procedures.

Process/Skill Questions

- How is capacitance measured?
- What is the unit of measurement for capacitance?
- What kinds of capacitors are available?
- What type of meter can check a capacitor?

Task Number 75

Make electrical connections.

Definition

Connections should depend on the circuit and materials and should be tested before and after connections are made.

Process/Skill Questions

- What materials are used in connections?
- What are two types of terminals?
- What do the colors of wire nuts represent?
- Why are tight and secure connections important?

Task Number 76

Install electrical components.

Definition

Installation should include

- identifying various electrical components (e.g., circuit breaker, thermostat, transformer)
- explaining their functions in a system
- adhering to the NEC
- following safety procedures.

Process/Skill Questions

- What precautions should be taken before installing electrical components?
- Where can the amperage be found on a circuit breaker?
- How many positions does a circuit breaker have?

Task Number 77

Troubleshoot high-voltage and low-voltage electrical systems.

Definition

Troubleshooting should include

- following the troubleshooting process
- using the appropriate electronic testing equipment
- adhering to safety precautions
- following manufacturer specifications and instructor guidelines.

Process/Skill Questions

- What selection/range should be used on the multimeter?
- How is the voltage rating determined?
- What safety precautions are necessary when measuring system voltage?

Servicing and Maintaining Refrigeration Systems

Task Number 78

Perform routine preventive maintenance on refrigeration systems.

Definition

Maintenance should include following standard procedures, including checking and adjusting superheat and subcooling on refrigeration systems.

Process/Skill Questions

- Which coils require cleaning?
- How often should the coils be cleaned?
- What other components require maintenance?

Task Number 79

Compare electrical problems to those that are mechanical.

Definition

Comparison should include

- demonstrating troubleshooting techniques for refrigeration systems
- describing electrical vs. mechanical malfunctions.

Process/Skill Questions

- What are examples of typical mechanical problems?

- What are examples of typical electrical problems?

Task Number 80

Demonstrate use of a refrigeration manifold gauge.

Definition

Demonstration should require

- connecting the gauge to the refrigeration system
- reading the gauge accurately to within +/- 1 percent
- observing safety procedures.

Process/Skill Questions

- What is the difference between a high-pressure gauge and a low-pressure gauge?
- What is the scale on a high-pressure gauge?
- What does the manifold gauge measure?

Task Number 81

Measure superheat and subcooling.

Definition

Measurement should be based on a P/T chart and adjustment should be made by

- adding or removing refrigerant in a capillary tube system
- adjusting the thermostatic expansion valve system according to manufacturer recommendations.

Process/Skill Questions

- What is the common superheat temperature for air conditioning?
- How is superheat measured?
- How is subcooling measured?

Task Number 82

Locate a leak in charged refrigerant circuits, using various leak detection methods.

Definition

Locating a leak should be based on performing one or more of the following detection methods:

- Bubble solutions
- Dye/fluorescent detection
- Halide torch
- Electronic leak detection

Process/Skill Questions

- What are three leak detection methods?
- Which leak detection method is used for large leaks?
- What can indicate a leak?

Task Number 83

Locate a leak in an uncharged refrigerant circuit, using nitrogen pressurization or trace gas.

Definition

Locating a leak in a system should include using dry nitrogen and observing safety procedures.

Process/Skill Questions

- What is the name of the refrigerant used for a trace charge with nitrogen?
- Can a trace charge be vented into the atmosphere? Why, or why not?
- Why is a regulator needed?

Task Number 84

Replace a filter-drier.

Definition

Replacement should include

- identifying the moisture capacity and size
- determining replacement by measuring delta T
- replacing the filter-drier each time the refrigeration system is opened.

Process/Skill Questions

- How is a filter drier replacement determined?
- How long should a suction filter drier be installed in a system?
- In which refrigeration line is a suction drier installed?

Task Number 85

Evacuate and charge a refrigeration circuit (new or contaminated system).

Definition

Evacuation should include using a pressure gauge and a micron gauge and demonstrating the steps required when

- charging pressure to within +/- 1 psig
- charging to weight.

Process/Skill Questions

- What evacuation methods should be used on a new or contaminated system?
- What tool is used to measure moisture?
- What is a contaminated system?

Task Number 86

Repair a leak in a refrigerant circuit.

Definition

Repair techniques should include

- brazing or soldering tubing
- repairing or replacing fittings or mechanical devices.

Process/Skill Questions

- Why is it necessary to fix a leak?
- What is the EPA, and what are its requirements regarding refrigerant leaks?

Task Number 87

Identify various types of compressors.

Definition

Identification should include an explanation of

- reciprocating, rotary, and centrifugal compressors
- hermetic, semi-hermetic, and open compressors.

Process/Skill Questions

- What is a piston-in-cylinder compressor?
- Which compressor works like a fan?
- Which compressor works like screw?

Task Number 88

Add oil to a compressor.

Definition

Adding oil to a system should include using a charging cylinder and an oil hand pump.

Process/Skill Questions

- What keeps a compressor cool?
- Are all oils compatible with all compressors/refrigerants?
- How is the oil level checked?

Task Number 89

Adjust pressure to turn on an operating refrigeration system.

Definition

Adjustments should be made to both high- and low-pressure switches to within +/- 1 psig.

Process/Skill Questions

- What are two reasons to use a pressure switch?
- How is the pressure determined?

Task Number 90

Adjust the temperature switch.

Definition

Adjustment should be made within 1 degree Fahrenheit on the following:

- A window air conditioner
- A small refrigeration system
- A wall thermostat

Process/Skill Questions

- What are two reasons to use a temperature switch?
- How is the temperature determined?

Task Number 91

Adjust defrost cycle.

Definition

Adjustment should be made by setting a defrost timer for a commercial system.

Process/Skill Questions

- Is it better to defrost at night or during the day? Why?
- How many defrost cycles does a residential refrigerator have?
- Where is the defrost timer located?

Task Number 92

Attempt to start a stuck hermetic (single-phase) compressor.

Definition

Attempting to start a single-phase compressor should require using

- a hard-start kit
- hook-up and operation of a compressor analyzer.

Process/Skill Questions

- What instrument can be used to start a stuck compressor?
- Why do compressors get stuck?

Task Number 93

Test refrigerant system for acid.

Definition

Test should be demonstrated by checking the appearance of the oil and by using an acid test kit or refrigerant system acid test kit, once the oil is removed from a burned-out compressor.

Process/Skill Questions

- What does burnt oil look and smell like?
- How often should the compressor oil be tested?
- What kind of acid kit should be used to test compressor oil?

Task Number 94

Replace a compressor.

Definition

Replacement should be made after the circuit is evacuated by

- connecting refrigeration manifold gauge to the refrigeration system
- reading gauge to within +/- 1 percent
- recharging the circuit to within +/- 1 psig.

Process/Skill Questions

- When is it time to replace a compressor?
- How should one dispose of an old compressor?

Understanding Motors and Controls

Task Number 95

Connect single-phase motors.

Definition

Connections should be made for various types of single-phase motors, referring to the manufacturer's procedures corresponding to available voltage.

Process/Skill Questions

- What are the safety precautions for connecting a single-phase motor?
- What are common voltages of single-phase motors?

Task Number 96

Reverse the rotation of a single-phase motor.

Definition

Reversal should be made by following instructions on the manufacturer's data plate.

Process/Skill Questions

- What equipment can be used to reverse rotation?
- When does the rotation need to be reversed?
- How is the original rotation determined?

Task Number 97

Troubleshoot the starting components of a single-phase motor.

Definition

Troubleshooting standard components of a single-phase motor should include checking starting relays, capacitors, and overloads, while observing safety procedures.

Process/Skill Questions

- What are the starting components?
- What meter is used?
- What troubleshooting procedure should be used?

Task Number 98

Install a hard-start kit on a hermetic compressor.

Definition

Installation should adhere to the following procedures:

1. Feed the compressor wires through the bushing at the bottom of the box.
2. Connect the wires to terminals, following the schematic and manufacturer instructions.
3. Install the cover containing the start capacitor and secure it with screws.
4. Connect the wires of the new compressor harness to the terminals.
5. Re-mount the terminal cover onto the compressor and secure it with the strap.

Process/Skill Questions

- What size hard-start kit should be installed?

- When is a hard-start kit necessary?
- Where would the wiring be installed when using a hard-start kit?

Task Number 99

Install a motor contactor.

Definition

Installation should include making all wiring connections and checking voltage and amperage while observing all safety procedures.

Process/Skill Questions

- What electrical data is needed before installing a contactor?
- Which components on a contactor go bad?

Task Number 100

Replace a start or a run capacitor.

Definition

Replacement should include using an ohmmeter and ammeter on run capacitors to check the voltage and amperage.

Process/Skill Questions

- What is the capacitance rating?
- What is the physical difference between a start and a run capacitor?
- What causes a capacitor to short out?

Task Number 101

Replace a starting relay.

Definition

Replacement should include

- testing the voltage and amperage on the device
- keeping the relay cover in place
- disconnecting power supply
- labeling each wire as it is disconnected
- mounting the thermostat to a solid surface.

Process/Skill Questions

- Which device is connected to the winding of the start relay?
- What are the types of start relays?
- When should start relays be replaced?

Task Number 102

Replace a motor overload protector.

Definition

Replacement should include using an ohmmeter and ammeter to determine when overload protector is bad or overheated.

Process/Skill Questions

- What is the function of the overload protector?
- Where is the overload protector located?

Complying with EPA Laws and Regulations

Task Number 103

Identify regulations affecting ozone depletion.

Definition

Identification should include a review of the Clean Air Act amendments.

Process/Skill Questions

- What is the Clean Air Act?
- What violations are covered under the Clean Air Act?
- What is the Montreal Protocol?

Task Number 104

Identify the evacuation requirements for small appliances.

Definition

Identification should include the procedures for checking the vacuum level and the amount of refrigerant recovered.

Process/Skill Questions

- What is the required vacuum level?
- How much refrigerant needs to be recovered?
- What is meant by a system-dependent recovery process? How does this process apply to small appliances?

Task Number 105

Detect noncondensables, using the pressure and temperature relationship (i.e., the P/T chart).

Definition

Detection should include using the gauge set and pressure temperature chart to identify the refrigerants and noncondensables.

Process/Skill Questions

- What indicates that there are noncondensables in the tank of refrigerant?
- What is a noncondensable?
- How are noncondensables prevented from entering into the recovery cylinders?

Task Number 106

Install high-side and low-side access valves when recovering refrigerant from small appliances with inoperative compressors.

Definition

Demonstration should include installing temporary access valves on small appliances.

Process/Skill Questions

- What is the difference between temporary and permanent access valves?
- What is the definition of a *small appliance*?
- How does one distinguish the high side from the low side of the system?

Task Number 107

Recover refrigerants with system-dependent (passive) and self-contained (active) recovery methods.

Definition

Recovery should include

- comparing the two methods, selecting the method most appropriate to the situation
- using the proper equipment for the passive and active recovery methods and refrigerant storage.

Process/Skill Questions

- What are the main differences between passive and active recovery?
- What is the maximum amount of refrigerant recoverable when using system-dependent recovery?
- Under what conditions is system-dependent recovery used?

Task Number 108

Remove the solderless access fitting at the conclusion of service.

Definition

Removal of temporary solderless valves should include repairing the holes in the unit after the service is completed.

Process/Skill Questions

- Are saddle-type valves considered temporary? Why, or why not?
- Why should temporary valves be removed?
- What size are the temporary valves?

Task Number 109

Identify annual leak rates for commercial and industrial process refrigeration and for other appliances containing more than 50 pounds of refrigerant.

Definition

Identification should include locating the leak rates on HVACR equipment per the type of equipment and amount of refrigerant in the equipment.

Process/Skill Questions

- What percentage of refrigerant can leak from comfort cooling appliances before a repair needs to be made?
- What percentage of refrigerant can leak from commercial industrial process refrigeration before a repair needs to be made?
- If the equipment cannot be repaired, what should be done with the equipment?

Task Number 110

Identify high-pressure and low-pressure recovery techniques and requirements.

Definition

Identification should include a selection from the following, taken directly from the EPA's *Ozone Layer Protection—Regulatory Programs*:

High-pressure methods should include the following:

- Recovering liquid at beginning of recovery process speeds up process
- Other methods for speeding recovery (chilling recovery vessel, heating appliance or vessel from which refrigerant is being recovered)
- Methods for reducing cross-contamination and emissions when recovery or recycling machine is used with a new refrigerant
- Need to wait a few minutes after reaching required recovery vacuum to see if system pressure rises (indicating that there is still liquid refrigerant in the system or in the oil)

Low-pressure methods should include the following:

- Recovering liquid at beginning of recovery process speeds up process
- Need to recover vapor in addition to liquid
- Need to heat oil to 130 degrees Fahrenheit before removing it to minimize refrigerant release
- Need to circulate or remove water from chiller during refrigerant evacuation to prevent freezing
- High-pressure cut-out level of recovery devices used with low-pressure appliances

High-pressure requirements are variable depending on

- disposal needs
- major vs. non-major repairs
- leaky vs. non-leaky appliances
- appliance (or component) containing less vs. more than 200 pounds
- recovery/recycling equipment built before vs. after November 15, 1993
- definition of major and non-major repairs
- prohibition on using system-dependent recovery equipment on systems containing more than 15 pounds of refrigerant.

Low-pressure requirements include all of the high-pressure variables except for the last bullet, with the addition of

- allowable methods for pressurizing a low-pressure system for a non-major repair (controlled hot water and system heating/pressurization device such as Prevac)
- the need to wait a few minutes after reaching required recovery vacuum to see if system pressure rises (indicating that there is still liquid refrigerant in the system or in the oil).

Process/Skill Questions

- Who certifies recovery equipment?
- How often should the filter be changed on the recovery machine?
- What can minimize the loss of oil from a refrigeration unit when recovering refrigerant?

Task Number 111

Identify the components of high-pressure and low-pressure appliances and the state of refrigerant.

Definition

Identification should include the refrigeration cycle and the state of the refrigerant in the components of the high- and low-pressure system.

Process/Skill Questions

- What are the four major components?
- What are the names of the connecting lines of the components?
- What are the names of all possible refrigerant states?

Task Number 112

Identify pressure-temperature relationships of high-pressure and low-pressure refrigerants.

Definition

Identification should include the key differences between refrigerants in industrial and residential equipment.

Process/Skill Questions

- What system pressures are below atmospheric?
- What refrigerant in the low-pressure system is rated B1?
- What are the differences between low-pressure system pressures and temperatures and high-pressure system pressures and temperatures?

Task Number 113

Obtain the EPA Section 608 certification.

Definition

Preparation for the EPA examination should include using the ARI sample test and EPA reviews.

NOTE: In order to work as a technician in the HVACR field, workers must have EPA Section 608 certification.

Process/Skill Questions

- Is the EPA exam an open-book or a closed-book exam? What does that mean?
- What are the main types of HVACR certifications available in Virginia?
- What is a passing score for each certification type?

SOL Correlation by Task

Comply with federal, state, and local safety requirements.	English: 10.5, 11.5 History and Social Science: GOVT.7, GOVT.8, GOVT.9, GOVT.14, GOVT.15, GOVT.16 Science: BIO.1, CH.1
Identify personal protective equipment (PPE) requirements.	English: 10.5, 11.5
Maintain a safe working environment.	English: 10.5, 11.5
Explain safe working practices around electrical hazards.	English: 10.5, 11.5 History and Social Science: GOVT.7, GOVT.8, GOVT.9, GOVT.14, GOVT.15, GOVT.16
Identify emergency first-aid procedures.	English: 10.5, 11.5
Identify the types of fires and the methods used to extinguish them.	English: 10.5, 11.5 Science: CH.1
Inspect course-specific hand and power tools to visually identify defects.	English: 10.5, 11.5
Demonstrate lifting and carrying techniques.	
Demonstrate safe laddering techniques.	
Demonstrate safe scaffolding techniques.	
Report personal injuries, environmental issues, and equipment safety violations to the appropriate authority.	English: 10.1, 11.1 History and Social Science: GOVT.7, GOVT.8, GOVT.9, GOVT.14, GOVT.15, GOVT.16
Demonstrate lockout and tagout procedures.	
Earn the Construction Industry OSHA 10 card.	English: 10.2, 10.5, 11.1, 11.5

	History and Social Science: GOVT.1, GOVT.7, GOVT.9, GOVT.14, GOVT.15
Pass a safety exam for lab/site safety and the use of tools and equipment specific to the construction industry.	English: 10.5, 10.6, 11.5, 11.6
Describe the changing states of matter.	English: 10.5, 11.5 Mathematics: A.8, AII.3, AII.10 Science: CH.5
Describe the refrigeration process and the basic refrigeration components.	English: 10.5, 11.5
Describe the relationship of pressures and fluids at saturation temperatures.	English: 10.5, 11.5
Demonstrate torch safety.	
Connect pipe, using threaded joint.	
Connect pipe, using cemented joint.	
Connect tubing, using compression fitting.	
Connect tubing, using flare fitting.	
Connect tubing and fitting, using a soft solder joint.	
Connect tubing, using a swaged, brazed joint and nitrogen.	
Shape tubing run with offset and corner, using the bending tool.	
Identify the British thermal unit (BTU) and types of heat.	English: 10.5, 11.5
Interpret a schematic diagram.	English: 10.5, 11.5 Science: PH.11
Draw a schematic diagram.	Science: PH.11
Calculate voltage, amperage, and resistance in series and parallel circuits.	Mathematics: A.1, A.4, AII.3 Science: PH.11
Determine the appropriate wire size, based on equipment load amperage.	English: 10.5, 11.5 Mathematics: AFDA.5 Science: PH.11
Measure voltages in electrical circuits.	Science: PH.11
Measure amperage in electrical circuits.	Science: PH.11
Measure resistance in electrical circuits.	Science: PH.11
Test electrical circuits for continuity.	Science: PH.11
Test equipment and motor windings for grounds, opens, and shorts.	Science: PH.11

Measure capacitance of a capacitor.	Science: PH.11
Make electrical connections.	Science: PH.11
Install electrical components.	English: 10.5, 11.5
Troubleshoot high-voltage and low-voltage electrical systems.	English: 10.5, 11.5 Science: PH.11
Perform routine preventive maintenance on refrigeration systems.	English: 10.5, 11.5
Compare electrical problems to those that are mechanical.	English: 10.5, 11.5
Demonstrate use of a refrigeration manifold gauge.	English: 10.5, 11.5
Measure superheat and subcooling.	
Locate a leak in charged refrigerant circuits, using various leak detection methods.	
Locate a leak in an uncharged refrigerant circuit, using nitrogen pressurization or trace gas.	
Replace a filter-drier.	English: 10.5, 11.5
Evacuate and charge a refrigeration circuit (new or contaminated system).	
Repair a leak in a refrigerant circuit.	
Identify various types of compressors.	English: 10.5, 11.5
Add oil to a compressor.	
Adjust pressure to turn on an operating refrigeration system.	
Adjust the temperature switch.	
Adjust defrost cycle.	
Attempt to start a stuck hermetic (single-phase) compressor.	
Test refrigerant system for acid.	
Replace a compressor.	
Connect single-phase motors.	
Reverse the rotation of a single-phase motor.	
Troubleshoot the starting components of a single-phase motor.	English: 10.5, 11.5
Install a hard-start kit on a hermetic compressor.	
Install a motor contactor.	
Replace a start or a run capacitor.	
Replace a starting relay.	English: 10.6, 11.6
Replace a motor overload protector.	
Identify regulations affecting ozone depletion.	English: 10.5, 11.5 History and Social Science: GOVT.7, GOVT.8, GOVT.9, GOVT.14, GOVT.15, GOVT.16

Identify the evacuation requirements for small appliances.	English: 10.5, 11.5
Detect noncondensables, using the pressure and temperature relationship (i.e., the P/T chart).	
Install high-side and low-side access valves when recovering refrigerant from small appliances with inoperative compressors.	
Recover refrigerants with system-dependent (passive) and self-contained (active) recovery methods.	
Remove the solderless access fitting at the conclusion of service.	
Identify annual leak rates for commercial and industrial process refrigeration and for other appliances containing more than 50 pounds of refrigerant.	
Identify high-pressure and low-pressure recovery techniques and requirements.	English: 10.5, 11.5 History and Social Science: GOVT.7, GOVT.8, GOVT.9, GOVT.14, GOVT.15
Identify the components of high-pressure and low-pressure appliances and the state of refrigerant.	Science: CH.5
Identify pressure-temperature relationships of high-pressure and low-pressure refrigerants.	English: 10.5, 11.5 Science: CH.5, PH.7
Obtain the EPA Section 608 certification.	English: 10.5, 11.5 History and Social Science: GOVT.7, GOVT.8, GOVT.9, GOVT.14, GOVT.15

Green Building Infusion Units

The Green Building Infusion Unit (GBIU) was designed to encourage teachers to infuse instructional units on green building knowledge and skills into designated CTE courses. The infusion unit is not mandatory, and, as such, the tasks/competencies are marked as "optional," to be taught at the instructor's discretion.</

Entrepreneurship Infusion Units

Entrepreneurship Infusion Units may be used to help students achieve additional, focused competencies and enhance the validated tasks/competencies related to identifying and starting a new business venture. Because the unit is a complement to certain designated courses and is not mandatory, all tasks/competencies are marked "optional."

Appendix: Credentials, Course Sequences, and Career Cluster Information

Industry Credentials: Only apply to 36-week courses

- Air Conditioning Employment Ready Examination
- Basic Refrigeration & Charging Procedures Employment Ready Examination
- Building Science Principles Examination
- Carbon Monoxide and Combustion Analysis Employment Ready Examination
- Carbon Monoxide Safety Employment Ready Examination
- College and Work Readiness Assessment (CWRA+)
- Combustion Appliance Zone (CAZ) Employment Ready Examination
- Core: Introductory Craft Skills Entry-Level Assessment
- Customer Service Examination
- Customer Service Specialist (CSS) Examination
- Electric Heat Employment Ready Examination
- Electrical Employment Ready Examination
- EPA Technician Examinations
- Fuel Oil Combustion Employment Ready Examination
- Gas Heat Employment Ready Examination
- HBI/NAHB Residential Construction Academy (RCA) Series Student Certification Assessments
- Heat Pump Employment Ready Examination
- Heating, Electrical, Air Conditioning Technology (HEAT) Examinations
- Heating, Ventilation, Air Conditioning (HVAC) Assessment
- Heating, Ventilation, Air Conditioning and Refrigeration (HVAC/R) Assessment
- HVAC Level One Entry-Level Assessment
- ICC Certificates of Completion Examinations
- Installer (or Service) Core (HVAC/R) Examination
- International Code Council Residential Mechanical (HVAC) Inspector (M1) Examination
- Light Commercial Refrigeration Employment Ready Examination
- National Career Readiness Certificate Assessment
- Natural Gas Combustion Employment Ready Examination
- Pre-Apprenticeship Certificate Training (PACT) Core Examinations
- Professional Communications Certification Examination
- Residential & Light Commercial Hydronic Heat Employment Ready Examination
- Workplace Readiness Skills for the Commonwealth Examination

Concentration sequences: *A combination of this course and those below, equivalent to two 36-week courses, is a concentration sequence. Students wishing to complete a specialization may take additional courses based on their career pathways. A program completer is a student who has met the requirements for a CTE concentration sequence and all other requirements for high school graduation or an approved alternative education program.*

- Heating, Ventilation, Air Conditioning, and Refrigeration II (8504/36 weeks, 280 hours)

Career Cluster: Architecture and Construction	
Pathway	**Occupations**
Construction	**Construction Manager** **Electrician** **General Contractor** **Project Manager**
Design/Pre-Construction	**Cost Estimator** **Mechanical Engineer**
Maintenance and Operations	**Electrician** **General Contractor** **Project Manager** **Restoration Technician**

Career Cluster: Energy	
Pathway	**Occupations**
Energy Efficiency	**HVAC and Refrigeration Mechanic or Installer**

Career Cluster: Science, Technology, Engineering and Mathematics	
Pathway	**Occupations**
Engineering and Technology	**Industrial Engineer** **Mechanical Engineer** **Quality Technician**