Heating, Ventilation, Air Conditioning, and Refrigeration II

8504 36 weeks / 280 hours

Table of Contents

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Course Description

Suggested Grade Level: 11 or 12
Prerequisites: 8503

This instructional program teaches students to professionally install, repair, and maintain the operating conditions of heating and cooling systems. Students also explore emerging technologies, Environmental Protection Agency (EPA) regulations, energy conservation techniques, and systems with exempt and non-exempt refrigerants. Completion of this sequence will prepare students for employment in a variety of heating, ventilation, air-conditioning, and refrigeration (HVACR) occupations.

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	8504	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	⊕	Identify emergency first-aid procedures.
43	⊕	Explain safe working practices around electrical hazards.
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.

Task Number	8504	Tasks/Competencies
49	⊕	Report personal injuries, environmental issues, and equipment safety violations to the appropriate authority.
50	⊕	Demonstrate lockout and tagout procedures.
51	⊕	Pass a safety test for lab/site safety and for specific tool use.
Understanding Motors and Controls		
52	⊕	Install a magnetic coil in the motor starter.
53	⊕	Identify different types of motors.
54	⊕	Remove or replace the fan motor, blower wheel, and motor.
55	○	Set the V-belt tension or replace.
56	⊕	Check motor current (i.e., amps).
57	○	Lubricate bearings.
Servicing and Maintaining Fossil Fuel Heating Systems		
58	⊕	Describe different ignition methods in a fossil fuel heating system.
59	⊕	Interpret customer heating complaints.
60	⊕	Determine furnace efficiency through combustion analysis.
61	⊕	Clean furnace and components.
62	⊕	Test oil and gas safety controls.
63	○	Adjust the burner primary air on an oil furnace.
64	⊕	Adjust the oil pump pressure.
65	⊕	Identify the basic sequence of operation of a gas furnace.
66	⊕	Replace an oil burner (chassis and air tube).
67	⊕	Replace the oil burner motor.
68	⊕	Replace the burner nozzle.
69	⊕	Replace the fuel oil pump.
70	⊕	Replace the oil filter cartridge.
71	⊕	Adjust gas pressure.
72	⊕	Test for gas leaks.
73	⊕	Replace the gas orifice and gas burner.
74	⊕	Replace the gas valve.
75	⊕	Convert natural gas components to propane components, using a conversion kit.
Servicing and Maintaining Alternative Fuel Heating Systems		
76	⊕	Summarize the concepts of electric heat, heat pump, and hydronics heating systems.
77	⊕	Calculate cubic feet per minute (CFM), using the temperature-rise method.
78	⊕	Identify the components of each alternative system.
79	○	Purge air from a hydronics system (e.g., radiators).
Servicing and Maintaining Cooling Systems		
80	⊕	Interpret customer cooling complaints.
81	⊕	Read various tools and instruments needed for checking, testing, operating, and troubleshooting air-conditioning systems.
82	⊕	Measure the temperature difference across a coil.
83	⊕	Describe the process for installing a condensing unit.

Task Number	8504	Tasks/Competencies
84	⊕	Describe the process for installing an air-handler unit.
85	⊕	Describe methods of charging the air-conditioning system, using various methods.
86	⊕	Check the external components of the system.
Sizing and Installing Duct Systems		
87	⊕	Modify existing plenum for evaporator installation.
88	⊕	Describe the installation of the branch duct takeoff from the main, using round metal duct and fittings.
89	⊕	Describe the installation of a rectangular metal duct and fittings.
90	⊕	Describe the installation of a round duct and fittings.
91	⊕	Describe the installation of the main duct (rectangular rigid fiberglass) and fittings.
92	⊕	Determine the optimal air flow based on the size of the unit/equipment and the duct.
Complying with EPA Laws and Regulations		
93	⊕	Identify regulations affecting ozone depletion and global warming.
94	⊕	Identify the evacuation requirements for small appliances.
95	⊕	Detect noncondensables, using the pressure and temperature relationship (i.e., the P/T chart).
96	⊕	Install both high- and low-side access valves when recovering refrigerant from small appliances with inoperative compressors.
97	⊕	Recover refrigerants with system-dependent (passive) and self-contained (active) recovery methods.
98	⊕	Remove the solderless access fitting at the conclusion of service.
99	⊕	Identify annual leak rates for commercial and industrial process refrigeration and for other appliances containing more than 50 pounds of refrigerant.
100	⊕	Identify high-pressure and low-pressure recovery techniques and requirements.
101	⊕	Identify the components of high-pressure and low-pressure appliances and state of refrigerant.
102	⊕	Identify pressure-temperature relationships of high-pressure and low-pressure refrigerants.
103	⊕	Identify EPA recordkeeping requirements for refrigerant handling and disposal.
104	⊕	Obtain the EPA Section 608 certification.
Exploring Emerging HVACR Technologies and Industry Considerations		
105	⊕	Describe design choices for a proposed HVACR project that reflect an efficient use of energy.
106	⊕	Describe design choices for a proposed HVACR system that reflect an efficient use of water.
107	⊕	Describe design choices that can affect indoor air quality for proposed HVACR projects.

Task Number	8504	Tasks/Competencies
108	○	Describe the history and definition of direct digital control (DDC) systems.
109	⊕	Install a programmable controller.
110	⊕	Describe emerging technology and energy-management options in the industry.
Exploring R-410A		
111	⊕	Distinguish between an R-22 and an R-410A system and the requirements of each.
112	⊕	Describe the safety issues related to working with R-410A systems and components.
113	⊕	Identify the benefits of R-410A systems.

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

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 43

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 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 heating, ventilation, air-conditioning, and refrigeration (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

Pass a safety test for lab/site safety and for specific tool use.

Definition

Passing should be required

- to measure participation in safety training programs (e.g., NCCER)
- to document attendance at safety meetings
- to demonstrate knowledge and skills gained from program topics (e.g., interpretation of SDS).

Process/Skill Questions

- How often should technicians participate in safety training programs? Why?
- How does insurance impact the requirement of continuous retraining for safety?
- What is workers' compensation?

Understanding Motors and Controls

Task Number 52

Install a magnetic coil in the motor starter.

Definition

Installation should include

- identifying the functions of the four basic components:
    - compressor
    - condenser coil
    - metering device
    - evaporator coil
- checking voltage on the starter
- checking amperage on the motor.

Process/Skill Questions

- What is the voltage of the magnetic coil?
- What safety procedures should be followed?
- What is the National Electrical Code (NEC)?

Task Number 53

Identify different types of motors.

Definition

Identification should include

- shaded pole
- permanent split capacitor (PSC)
- electronically commutated motor (ECM)
- variable speed.

Process/Skill Questions

- How might each type of motor be checked?
- What testing equipment should be used to check each type of motor?

Task Number 54

Remove or replace the fan motor, blower wheel, and motor.

Definition

Replacement should follow the steps for troubleshooting and replacing single-phase fan motors:

- Follow motor wires to the terminal block and remove them.
- Remove the mounting screws.

- Remove the assembly.
- Remove the fan blade.
- Take the fan blade and rubber washer off the motor shaft and install them on the new motor.
- Reinstall the fan assembly.
- Attach wires to the terminal block.
- Test operation.

Process/Skill Questions

- Where are the manufacturer specifications located?
- How can the fan motor be tested prior to full replacement?

Task Number 55

Set the V-belt tension or replace.

Definition

Setting the tension should include checking the V-belt for wear, assessing and adjusting for proper tension, and determining the need for replacement.

Process/Skill Questions

- How is the pulley alignment checked?
- How is the tension checked?

Task Number 56

Check motor current (i.e., amps).

Definition

Checking the motor current requires using an ammeter and describing the desired range for readings.

Process/Skill Questions

- What meter checks motor amps?
- What is the nameplate used for?

Task Number 57

Lubricate bearings.

Definition

Lubrication should include following the procedures for examining and lubricating motor bearings, using the wick system or the slip-ring system.

Process/Skill Questions

- What type of bearing cannot be lubricated?
- What types of lubricants should be used?

Servicing and Maintaining Fossil Fuel Heating Systems

Task Number 58

Describe different ignition methods in a fossil fuel heating system.

Definition

Description may include one or more of the following:

- Burner air on a gas furnace
- Thermocouple adjustment
- Pilot igniter
- Spark igniter gap adjustment

Process/Skill Questions

- What is the process of ignition in a fossil fuel system?
- What is a spark igniter?

Task Number 59

Interpret customer heating complaints.

Definition

Interpretation should be formed by listening to the customer, deciding whether the problem is electrical or mechanical, and pinpointing the problem by process of elimination.

Process/Skill Questions

- What is the most important procedure when fielding customer complaints?
- What is the general-diagnosis procedure?

Task Number 60

Determine furnace efficiency through combustion analysis.

Definition

Determination should include using a combustion analyzer.

Process/Skill Questions

- What is the ideal carbon dioxide level on an oil furnace?
- What should the temperature be in the flue?
- What is a smoke test? What does it test?

Task Number 61

Clean furnace and components.

Definition

Cleaning the furnace should include changing the oil and checking the components, according to manufacturer recommendations.

Process/Skill Questions

- How often should preventive maintenance be performed?
- What can cleaning prevent?

Task Number 62

Test oil and gas safety controls.

Definition

Testing should be conducted for each type of safety control used on oil and gas furnaces.

Process/Skill Questions

- How is the safety control tested?
- What accidents might testing prevent?

Task Number 63

Adjust the burner primary air on an oil furnace.

Definition

Adjustment should be made by observing all safety procedures and using the Bacharach test kit and the carbon dioxide (CO_2) test.

Process/Skill Questions

- Where is the adjustment located?
- What is the color of the flame for a normal oil furnace?

Task Number 64

Adjust the oil pump pressure.

Definition

Adjustment should include checking the oil pressure on a furnace, according to manufacturer information and following safety procedures.

Process/Skill Questions

- What is the ideal pressure on an oil pump for an oil furnace?
- What can cause pressure fluctuations?

Task Number 65

Identify the basic sequence of operation of a gas furnace.

Definition

Identification should include

- internal safety checks
- ignition
- blower operation.

Process/Skill Questions

- Why do certain components operate in a certain order?
- How does knowledge of the sequence help during the troubleshooting process?

Task Number 66

Replace an oil burner (chassis and air tube).

Definition

Replacement should follow manufacturer guidelines for replacing an oil burner in a gun-type oil burner.

Process/Skill Questions

- When should an oil burner be replaced?
- Why should the burner be replaced when replacing the furnace?

Task Number 67

Replace the oil burner motor.

Definition

Replacement should include

- determining whether the motor is bad
- following manufacturer guidelines and safety procedures.

Process/Skill Questions

- What is the purpose of the red button on the oil burner motor?
- How can one determine whether the motor is bad?

Task Number 68

Replace the burner nozzle.

Definition

Replacement should include

- identifying and using the proper tools and hardware for preparation of the burner nozzle assembly
- installing the assembly in a gun-type burner
- testing the nozzle for the proper fire pattern and size.

Process/Skill Questions

- How is the size of the nozzle determined?
- How is the angle of the nozzle determined?
- What are the three nozzle types?

Task Number 69

Replace the fuel oil pump.

Definition

Replacement should include

- checking pump operation (when checking pressure and vacuum on a pump with a supply-line filter, the filter must be checked first)
- adjusting the pump pressure to manufacturer specifications.

Process/Skill Questions

- What are manufacturer specifications for replacement?
- Does the pump need to be primed after replacement?

Task Number 70

Replace the oil filter cartridge.

Definition

Replacement of oil filter cartridge should include determining whether the cartridge needs replacement, and, if so, following manufacturer specifications and safety procedures.

Process/Skill Questions

- How often should the fuel filter cartridge be replaced?
- If water is in the fuel, what color is the filter?

Task Number 71

Adjust gas pressure.

Definition

Adjustment should include checking manifold pressure before and after adjusting the gas valve.

Process/Skill Questions

- What meter is used to check gas pressure?
- What are the standard ideal gas pressures for natural and propane gas?

Task Number 72

Test for gas leaks.

Definition

Test should be conducted on the gas line, using leak detection methods.

Process/Skill Questions

- What meter is used to test for gas leaks?
- What do soap bubbles indicate, when checking a leak?
- How would you describe the distinct odor associated with gas leaks? Why does it have this odor?

Task Number 73

Replace the gas orifice and gas burner.

Definition

Replacement should include

- checking the orifice for each brand name and size (British thermal units [BTU]) furnace
- identifying the orifices by type (liquid propane [LP] or natural gas system)
- replacing a gas burner (LP or natural gas system), following manufacturer guidelines.

Process/Skill Questions

- What type of gas orifice is standard on new furnaces?
- What is the gas pressure setting for the LP orifice?
- What is the gas pressure setting for the natural gas orifice?
- What causes burner failure?
- Why are burners tapered?

Task Number 74

Replace the gas valve.

Definition

Replacement should include

- following the method used for testing gas valve operation

- determining whether the gas valve is working within acceptable range
- replacing the valve.

Process/Skill Questions

- When should a valve be replaced?
- What are the different types of gas valves?

Task Number 75

Convert natural gas components to propane components, using a conversion kit.

Definition

Conversion should include

- checking gas pressure switch
- replacing orifice and springs
- adjusting the gas valve regulator.

Process/Skill Questions

- What is the pressure difference between the two gases?
- Why would a conversion kit be used?
- How does elevation affect the selected orifice size?

Servicing and Maintaining Alternative Fuel Heating Systems

Task Number 76

Summarize the concepts of electric heat, heat pump, and hydronics heating systems.

Definition

Summary should include

- the applications of each system
- situations in which one system might be preferred over another.

Process/Skill Questions

- In what parts of the country are more electric heat systems used?
- Why is location a factor in heat choices?
- What are the advantages and disadvantages of each system?

Task Number 77

Calculate cubic feet per minute (CFM), using the temperature-rise method.

Definition

Calculation should include using the following equation:

CFM = (volts x amps x 3.41) /1.08 x delta T (temperature rise)

Process/Skill Questions

- What does this calculation determine?
- What is delta T?
- How might you improve the low or high calculation?

Task Number 78

Identify the components of each alternative system.

Definition

Identification should include the major components for the following systems:

- Electric—the element, sequencer, limit switch/control

- Heat pump—reversing valve, defrost control
- Hydronics—water or circulating pump, isolation valve, expansion tank, zone valve, pressure-reducing valve

Process/Skill Questions

- How is electric heat measured?
- What is the function of a reversing valve?
- What are the sequences of the defrost cycle?

Task Number 79

Purge air from a hydronics system (e.g., radiators).

Definition

Purging should include

- using water keys
- locating purge points
- purging the expansion tank.

Process/Skill Questions

- How does air get into the system?
- How does air affect the system?
- What is the purpose of the expansion tank?

Servicing and Maintaining Cooling Systems

Task Number 80

Interpret customer cooling complaints.

Definition

Interpretation should be formed by listening to the customer, deciding whether the problem is electrical or mechanical, and pinpointing the problem by process of elimination.

Process/Skill Questions

- What is most important procedure when fielding customer complaints?
- What is the general diagnosis procedure?

Task Number 81

Read various tools and instruments needed for checking, testing, operating, and troubleshooting air-conditioning systems.

Definition

Reading should include interpreting information from the following:

- Schematic or wiring diagram
- Ammeter
- Capacitor tester
- Manometer
- Multimeter
- Ohmmeter
- Voltmeter
- Refrigerant leak detector
- Manifold gauge
- Refrigerant scale
- Micron gauge

Process/Skill Questions

- What do accurate readings have to do with worker safety?
- What are the proper usage and storage requirements of HVACR tools and instruments?
- Why are these issues important when taking proper readings?

Task Number 82

Measure the temperature difference across a coil.

Definition

Measurement should be made by using a thermometer on both sides of a condenser.

Process/Skill Questions

- What is the appropriate range of temperature difference across the coil?
- What instrument is used to measure temperature?

Task Number 83

Describe the process for installing a condensing unit.

Definition

Description should include

- setting and leveling the unit
- connecting the control-wiring and line voltage
- connecting the liquid and suction lines using proper procedures.

Process/Skill Questions

- Why should the condensing unit be level?
- Why should the condensing unit have a pad?
- What are the spatial specifications required for condensing units?
- What are different considerations between setting a condensing unit and a heat pump?

Task Number 84

Describe the process for installing an air-handler unit.

Definition

Description should include wiring the control voltage and the line voltage connections and selecting the proper blower speeds.

Process/Skill Questions

- How is the best location for installation determined?
- What is the power supply for an air-handler unit?

Task Number 85

Describe methods of charging the air-conditioning system, using various methods.

Definition

Description should include how to charge the air-conditioning system according to manufacturer specifications.

Process/Skill Questions

- What is the proper charging procedure?
- Where is information about charging pressures located?

Task Number 86

Check the external components of the system.

Definition

Checking should include

- using mechanical and electrical instruments
- forming a diagnosis based on troubleshooting methods
- checking for proper air flow around and above the unit.

Process/Skill Questions

- What are external components of the system?
- When should external components be serviced?

Sizing and Installing Duct Systems

Task Number 87

Modify existing plenum for evaporator installation.

Definition

Modification of existing plenum for an evaporator installation should include calculating the size and location of an opening, if needed.

Process/Skill Questions

- Where is the plenum located?
- How is the plenum sealed?

Task Number 88

Describe the installation of the branch duct takeoff from the main, using round metal duct and fittings.

Definition

Description should include sizing according to cubic feet per minute (CFM) capacity of the round duct and using proper tools to demonstrate the procedure for installing a branch duct.

Process/Skill Questions

- Which has less air resistance, square or round takeoff? Why?
- What is the maximum length for flexible round takeoff?

Task Number 89

Describe the installation of a rectangular metal duct and fittings.

Definition

Description should include sizing, laying out, and installing a rectangular metal duct and fittings, using proper tools and following safety procedures.

Process/Skill Questions

- Should a branch be connected at the end of a trunk? Why, or why not?
- Should duct tape or metal aluminum tape be used as a sealer? Why, or why not?

Task Number 90

Describe the installation of a round duct and fittings.

Definition

Description should include the steps of sizing and installing a round metal duct and fittings, using proper tools and following safety procedures.

Process/Skill Questions

- Can a round duct be installed in rectangular fittings? Why, or why not?
- How is round duct size determined?

Task Number 91

Describe the installation of the main duct (rectangular rigid fiberglass) and fittings.

Definition

Description should include the steps of layout and installation of rigid fiberglass duct, using proper tools and following safety procedures.

Process/Skill Questions

- What are the health risks of working with fiberglass in duct systems, and what safety precautions should one take?
- What tools are used to install fiberglass?

Task Number 92

Determine the optimal air flow based on the size of the unit/equipment and the duct.

Definition

Determination should include

- using a sizing chart
- calculating for size of equipment and load
- calculating for type of duct and design.

Process/Skill Questions

- What is CFM?
- How is a ductulator used? What are the benefits?
- How many CFMs exist within one ton of air conditioning?

Complying with EPA Laws and Regulations

Task Number 93

Identify regulations affecting ozone depletion and global warming.

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 94

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 95

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 the recovery cylinders?
- How does Boyle's law apply to noncondensable gasses?

Task Number 96

Install both high- 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 97

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

Definition

Recovery should include

- comparing the two methods
- selecting the best method for 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 98

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 99

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 according to 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 repairs need to be made?
- What percentage of refrigerant can leak from commercial industrial process refrigeration before repairs need to be made?
- What should be done with equipment that cannot be repaired?

Task Number 100

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 101

Identify the components of high-pressure and low-pressure appliances and 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 102

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 103

Identify EPA recordkeeping requirements for refrigerant handling and disposal.

Definition

Identification should include requirements for owners and operators.

Process/Skill Questions

- How long do records need to be retained?
- What is the required information to record?

Task Number 104

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 open-book or 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?

Exploring Emerging HVACR Technologies and Industry Considerations

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Task Number 105

Describe design choices for a proposed HVACR project that reflect an efficient use of energy.

Definition

Description should include

- energy performance policies
- building components (e.g., lighting, equipment, insulation, building envelope, windows)
- energy sources, including alternative and renewable
- energy usage, including energy performance measurement and monitoring.

Note: For a list of additional instructional resources, please go to http://www.cteresource.org/featured/green_technology.html.

Process/Skill Questions

- What do seasonal energy efficiency ratio (SEER) ratings indicate?
- Which heat sources can affect energy use the most in HVAC systems?
- What is the relationship between heat load and heat loss?
- What is the role of the HVACR technician in maintaining the efficiency of the project? Sustainability?

Task Number 106

Describe design choices for a proposed HVACR system that reflect an efficient use of water.

Definition

Description should include

- the ways that water is used within the system design
- the options for using and reusing water to increase efficiency.

Process/Skill Questions

- Why should water conditions be tested?
- What minerals can be found in water sources? How do these affect system operations?
- Which water systems reuse or recycle water?
- How is water used within HVACR systems?
- What is typically the source for HVACR water use, and how is it disposed of?

Task Number 107

Describe design choices that can affect indoor air quality for proposed HVACR projects.

Definition

Description should include

- minimum ventilation requirements
- occupation density of the building
- air filtration, including smoking control
- interior materials (e.g., paint and stain finishes, adhesives, flooring products).

Note: For a list of additional instructional resources, please go to http://www.cteresource.org/featured/green_technology.html.

Process/Skill Questions

- How does poor indoor air quality affect people?
- What type of air filter can remove odors?
- When should an air filter be replaced?
- What are variables that can affect air quality?
- How is air typically circulated within a building?

Task Number 108

Describe the history and definition of direct digital control (DDC) systems.

Definition

Description should include a definition of DDC systems, how they are different from energy management systems (EMS), and a description of how digital controls save energy.

Process/Skill Questions

- Why is a DDC used?
- Where is a DDC used?
- What are the applications for DDCs?
- What did the DDC replace?

Task Number 109

Install a programmable controller.

Definition

Installation of a programmable controller should comply with manufacturer instructions and specifications.

Process/Skill Questions

- What are the advantages of a programmable controller?
- What is the function of a programmable controller?

Task Number 110

Describe emerging technology and energy-management options in the industry.

Definition

Description should include

- cellphones
- smart homes, complete home automation
- green technology
- new refrigerants.

Process/Skill Questions

- What are the differences between a thermostat and a user interface?
- What are the benefits of energy management?
- What are green technologies associated with air conditioning?

Exploring R-410A

Task Number 111

Distinguish between an R-22 and an R-410A system and the requirements of each.

Definition

Distinction should include

- pressure
- temperature
- color of labeling
- gauges.

Process/Skill Questions

- Why was R-410A developed?
- What are the safety aspects of R-410A?
- What tools are associated with R-410A?
- How does R-410A affect the environment?

Task Number 112

Describe the safety issues related to working with R-410A systems and components.

Definition

Description should include

- issues and techniques associated with safely working with high-pressure systems
- servicing equipment with high-pressure ratings
- components (e.g., gauges and their scales)
- chemicals.

Process/Skill Questions

- What are the pressure ratings of manifold hoses and recovery tanks?
- What color is used to indicate R-410A systems and components?
- What type of refrigerant is R-410A?

Task Number 113

Identify the benefits of R-410A systems.

Definition

Identification should include

- environmental advantages (e.g., does not deplete the ozone layer)
- energy conservation benefits
- cost benefits.

Process/Skill Questions

- What is the minimum SEER rating for R-410A?
- What are the cost differences between R-410A and R-22?
- What type of compressor oil is used in R-410A systems?

SOL Correlation by Task

Comply with federal, state, and local safety requirements.	English: 11.5, 12.5 History and Social Science: GOVT.7, GOVT.8, GOVT.9, GOVT.15 Science: BIO.1, CH.1
Identify personal protective equipment (PPE) requirements.	English: 11.5, 12.5

Maintain a safe working environment.	English: 11.5, 12.5
Identify emergency first-aid procedures.	English: 11.5, 12.5
Explain safe working practices around electrical hazards.	English: 11.5, 12.5 History and Social Science: GOVT.7, GOVT.8, GOVT.9, GOVT.15
Identify the types of fires and the methods used to extinguish them.	English: 11.5, 12.5 Science: CH.1
Inspect course-specific hand and power tools to visually identify defects.	English: 11.5, 12.5
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: 11.5, 11.6, 11.7, 12.5, 12.6, 12.7 History and Social Science: GOVT.7, GOVT.8, GOVT.9, GOVT.15
Demonstrate lockout and tagout procedures.	
Pass a safety test for lab/site safety and for specific tool use.	English: 11.5, 12.5
Install a magnetic coil in the motor starter.	English: 11.5, 12.5
Identify different types of motors.	
Remove or replace the fan motor, blower wheel, and motor.	
Set the V-belt tension or replace.	
Check motor current (i.e., amps).	
Lubricate bearings.	
Describe different ignition methods in a fossil fuel heating system.	English: 11.5, 12.5
Interpret customer heating complaints.	English: 11.1, 12.1
Determine furnace efficiency through combustion analysis.	
Clean furnace and components.	
Test oil and gas safety controls.	
Adjust the burner primary air on an oil furnace.	
Adjust the oil pump pressure.	
Identify the basic sequence of operation of a gas furnace.	English: 11.5, 12.5
Replace an oil burner (chassis and air tube).	English: 11.5, 12.5
Replace the oil burner motor.	English: 11.5, 12.5
Replace the burner nozzle.	
Replace the fuel oil pump.	English: 11.5, 12.5

Replace the oil filter cartridge.	English: 11.5, 12.5
Adjust gas pressure.	
Test for gas leaks.	
Replace the gas orifice and gas burner.	
Replace the gas valve.	
Convert natural gas components to propane components, using a conversion kit.	
Summarize the concepts of electric heat, heat pump, and hydronics heating systems.	English: 11.5, 12.5 Science: PH.7
Calculate cubic feet per minute (CFM), using the temperature-rise method.	Mathematics: AII.3
Identify the components of each alternative system.	
Purge air from a hydronics system (e.g., radiators).	
Interpret customer cooling complaints.	English: 11.1, 12.1
Read various tools and instruments needed for checking, testing, operating, and troubleshooting air-conditioning systems.	
Measure the temperature difference across a coil.	
Describe the process for installing a condensing unit.	English: 11.5, 12.5
Describe the process for installing an air-handler unit.	
Describe methods of charging the air-conditioning system, using various methods.	English: 11.5, 12.5
Check the external components of the system.	English: 11.5, 12.5
Modify existing plenum for evaporator installation.	
Describe the installation of the branch duct takeoff from the main, using round metal duct and fittings.	
Describe the installation of a rectangular metal duct and fittings.	
Describe the installation of a round duct and fittings.	
Describe the installation of the main duct (rectangular rigid fiberglass) and fittings.	
Determine the optimal air flow based on the size of the unit/equipment and the duct.	
Identify regulations affecting ozone depletion and global warming.	English: 11.5, 12.5 History and Social Science: GOVT.7, GOVT.8, GOVT.9, GOVT.14, GOVT.15
Identify the evacuation requirements for small appliances.	English: 11.5, 12.5
Detect noncondensables, using the pressure and temperature relationship (i.e., the P/T chart).	
Install both high- 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.	English: 11.5, 12.5
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.	English: 11.5, 12.5
Identify high-pressure and low-pressure recovery techniques and requirements.	English: 11.5, 11.8, 12.5, 12.8 History and Social Science: GOVT.7, GOVT.8, GOVT.14, GOVT.15
Identify the components of high-pressure and low-pressure appliances and state of refrigerant.	
Identify pressure-temperature relationships of high-pressure and low-pressure refrigerants.	English: 11.5, 12.5 Science: CH.5, PH.7
Identify EPA recordkeeping requirements for refrigerant handling and disposal.	English: 11.5, 12.5 History and Social Science: GOVT.7, GOVT.8, GOVT.14, GOVT.15
Obtain the EPA Section 608 certification.	English: 11.5, 12.5 History and Social Science: GOVT.7, GOVT.8, GOVT.14, GOVT.15
Describe design choices for a proposed HVACR project that reflect an efficient use of energy.	English: 11.5, 12.5 History and Social Science: GOVT.7, GOVT.8, GOVT.9, GOVT.15, GOVT.16
Describe design choices for a proposed HVACR system that reflect an efficient use of water.	English: 11.5, 12.5 History and Social Science: GOVT.7, GOVT.8, GOVT.9, GOVT.15, GOVT.16
Describe design choices that can affect indoor air quality for proposed HVACR projects.	English: 11.5, 12.5 History and Social Science: GOVT.9, GOVT.15, GOVT.16
Describe the history and definition of direct digital control (DDC) systems.	English: 11.5, 12.5
Install a programmable controller.	
Describe emerging technology and energy-management options in the industry.	English: 11.5, 12.5

Distinguish between an R-22 and an R-410A system and the requirements of each.	
Describe the safety issues related to working with R-410A systems and components.	English: 11.5, 12.5
Identify the benefits of R-410A systems.	English: 11.5, 12.5

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 I (8503/36 weeks, 140 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**