

# Heating, Ventilation, Air Conditioning, & Refrigeration (HVAC-R) Standards and Skills

October 2023

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## Health & Safety Standards

### Standard 1: Safety and Health in the HVAC-R Work Environment

Students will prioritize safety by adhering to OSHA and EPA regulations, demonstrating proper use of personal protective equipment (PPE), and effectively identifying and mitigating workplace hazards.

* OSHA10 – Construction
* Credit toward EPA 608 Technician Certification
* Refrigeration Credit towards License

#### Skills:

1. Demonstrate safe use, storage and maintenance of hand tools, power tools, and ladders according to OSHA standards.
2. Examine concepts relating to ammonia refrigeration addressed in OSHA standards for general industry (29CFR 1910) and Hazard Recognition.
3. Complete EPA Section 608 and R-410a safety training.
4. Identify fall hazards, demonstrate scaffold safety practices, and use of fall arrest systems.
5. Describe OSHA 10 General Industry standards and explain their relevance to construction.
6. Comply with appropriate fire protection regulations, local permit regulations, and state/federal regulations.
7. Use tools and handle materials safely, in accordance with industry regulations and established shop procedures.
8. Describe and demonstrate the safe use of hand and power tools.
9. Describe and demonstrate methods of handling refrigerants safely.
10. Describe and demonstrate ladder safety procedures.
11. Identify and comply with regulations for working in confined spaces.
12. Identify and comply with fire prevention regulations, local permit requirements reference: OSHA, Hot Works, and MA Comprehensive Fire Code Safety 527CMR.1.00 which must be read in conjunction with 2021 NFPA Fire Code.
13. Demonstrate safety in refrigerant handling following Environment Protection Agency (EPA) regulations.
14. Demonstrate techniques in the use of manifold gauges.
15. Demonstrate techniques in the use of electrical meters.
16. Demonstrate techniques in swaging and flaring tubing.
17. Demonstrate techniques for setting-up and operating a variety of gas torches and regulators.

## Technical & Integrated Academic Standards

### Standard 2: Technical Drawings and Blueprint Reading

Students will be able to read and interpret technical drawings, blueprints, and specifications enabling them to plan and execute HVAC-R installations.

Credit toward NATE Ready to Work Certificate

**Skills:**

1. Read and interpret technical drawings.
2. Understand terms, abbreviations, symbols, and line types of technical drawings and blueprints.
3. Interpret and follow drawing dimensions.
4. Describe the methods of dimensioning construction drawings and convert blueprint measurements to architect’s scale.
5. Read and interpret floor plans, elevations, sections, details, ceiling plans, and finish schedules.
6. Examine state and local building codes, inspection processes, and zoning regulations.
7. Compare and contrast residential and commercial building codes.
8. Explain the basic layout of a set of prints as well as the importance of the accompanying job specifications document.
9. Discuss and implement estimating methods for pricing jobs using drawings/prints.
10. Identify, develop, and complete material quantity takeoff sheets.

### Standard 3: HVAC-R Fundamentals

Students will demonstrate application of HVAC-R standards and guidelines in accordance with The American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE).

Credit toward NATE Ready to Work Certificate

Refrigeration Credit towards License

#### Skills:

1. Identify and compare alternative and renewable technologies in the HVAC-R industry.
2. Examine the importance of the EPA’s Significant New Alternatives Policy (SNAP) Program to the HVAC-R industry.
3. Examine the regulatory codes and licensing requirements in the HVAC-R industry.
4. Explain the practice of applying the Affinity Laws of centrifugal pumps and fans.
5. Explain heat energy including how it is transferred: convection, conduction, and radiation.
6. Calculate the appropriate size and install a centrifugal pump in a residential hydronic heating system.
7. Identify career opportunities available in the HVAC-R industry.
8. Maintain service and repair documentation and operational activities records.
9. Determine operational compliance with regulations or standards.
10. Describe and apply HVAC-R principles and regulations in accordance with The American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE).
11. Explain the importance of HVAC-R in modern society.
12. Explain and apply the basic principles of heating, ventilating, and air conditioning & refrigeration systems.

### Standard 4: Pipe Joining Techniques

Students will demonstrate industry standard techniques to measure, cut, ream, thread, and join pipe utilizing common HVAC-R materials according to project specifications.

Credit toward NATE Ready to Work Certificate

Credit toward Hot Work Safety Certificate

#### Skills:

1. Demonstrate piping practices according to The American Society of Mechanical Engineers (ASME) code requirements 522 CMR 9.00 Refrigeration and Air Conditioning Systems.
2. Use mechanical flameless press technology.
3. Demonstrate brazing and soldering techniques.
4. Demonstrate brazing and soldering techniques using inert gas to prevent oxidation.
5. Identify, describe, and install various types and sizes of steel pipe and copper tubing.
6. Identify and install brass, steel, and copper fittings.
7. Measure, cut, ream, thread, and connect steel pipe.
8. Measure, cut, and bend copper tubing.
9. Connect copper tubing using fittings, flares, and swages.
10. Identify and install different types of pipe hangers and supports.
11. Describe and demonstrate safety requirements for pressure testing a refrigeration system.
12. Describe the use of PEX tubing in various applications.

### Standard 5: Electrical Systems and Controls

Students will comprehend electrical circuits, control systems, and wiring diagrams, allowing them to install, maintain, and troubleshoot HVAC-R electrical components.

Credit toward NATE Ready to Work Certificate

#### Skills:

1. Describe the purpose of the Massachusetts Electrical Code (MEC) as it pertains to HVAC-R.
2. Demonstrate wiring HVAC-R controls, motors, and circuits in accordance with Massachusetts Electrical Code, to be used in conjunction with the National Electrical Code (NEC), National Fire Protection Association (NFPA) 70.
3. Describe control characteristics and components, and program and configure HVAC control systems.
4. Identify and describe factory and field wiring, high and low voltage, details, and legends on wiring diagrams.
5. Demonstrate the application of several types of electric motors.
6. Demonstrate troubleshooting techniques with electrical motors.
7. Explain the importance of grounding and electrical safety codes.
8. Describe the characteristics of controls and install components into electrical circuits – low & high voltage.
9. Test and troubleshoot electrical circuits and devices using electrical meters.
10. Describe and apply properties of electrical conductors and insulators.
11. Describe and wire series, parallel and series/parallel circuits.
12. Explain concepts relating to direct current (DC) and alternating current (AC), Ohm’s law, Watts’s law and how they pertain to volts, amperes, ohms, impedances, and watts.
13. Explain concepts relating to resistive, capacitive, and inductive loads.
14. Determine voltage and current ratings of electrical devices.
15. Explain and apply principles of electrical circuit protection.
16. Describe, develop, and interpret schematics and other wiring diagrams.
17. Demonstrate the use of wire isolation and line transformers, relays, contactors, timers, sequencers, and switches.
18. Explain and demonstrate the use of overloads, capacitors, pressure switches, solenoids, and thermostats.
19. Describe current computer-aided control technology and components.

### Standard 6: Refrigeration Components and Systems

Students will be able to install, maintain and troubleshoot common refrigeration components, equipment, and systems.

Credit toward NATE Ready to Work Certificate

Credit toward EPA 608 Technician Certification

Refrigeration Credit towards License

#### Skills:

1. Inspect systems watching gauges, dials, or other indicators to determine if they are operating properly, adjust as needed to ensure optimal performance.
2. Explain the importance of condensate drain systems.
3. Identify refrigerant properties and perform superheat, delta T, and sub-cooling calculations.
4. Troubleshoot and install refrigeration components.
5. Describe and illustrate the mechanical refrigeration cycle.
6. Analyze and describe the operating conditions of mechanical compressors.
7. Describe system evacuation and dehydration/degassing.
8. Identify and use refrigeration leak detection methods and procedures according to industry standards.
9. Describe classifications, properties, and different applications of refrigerants and use Temperature/Pressure and enthalpy charts.
10. List and describe the characteristics of compressors.
11. List and describe the characteristics of condensers.
12. List and describe the characteristics of metering devices.
13. List and describe the characteristics of evaporators.
14. List and describe various types of liquid line components.
15. Describe various types of suction line components.
16. Describe the operation of refrigerant service valves.
17. Describe and use various types of refrigerant oils and lubricants.

### Standard 7: Heat Pumps and Air Conditioning Equipment

Students will demonstrate installation, service, and repair of air conditioning and heat pump equipment.

Credit toward NATE Ready to Work Certificate

Credit toward EPA 608 Technician Certification

#### Skills:

1. Identify and explain different heat pump classifications, including air-source, ground-source, and water-source.
2. Describe, install, and service condensate drain systems.
3. Demonstrate refrigerant charging techniques of air conditioning and heat pump systems using manufacturer’s recommended procedures.
4. Install and service heat pumps.
5. Install and service electric resistance heating systems.
6. Describe and install heat pump with electric heating elements.
7. List and describe the uses of heat pump operation in all modes.
8. List and describe the characteristics of and test heat pump reversing valves.
9. Define, calculate, and troubleshoot supplementary heat.
10. Describe the various applications and installations for ductless mini-split systems.
11. Describe applications of integrated controls used for supplemental heat and zoning technologies.

### Standard 8: Oil Heating Equipment and Natural and Liquified Gas Equipment

Students will be able to install, test, maintain, and repair oil heating and gas equipment.

Credit toward NATE Ready to Work Certificate

#### Skills:

1. Identify the major components of an oil system and describe the function of each component.
2. Install and troubleshoot oil heating equipment in accordance with NFPA 31 of the Massachusetts Oil Code.
3. Describe and follow oil heat safety.
4. Describe and perform an oil burner efficiency test and adjust according to manufacturer’s specifications.
5. Define and demonstrate the operations of starting an oil burner according to manufacturer’s specifications and current industry standards.
6. Demonstrate maintenance, and repair of oil supply systems.
7. Field-test furnace/boiler operation with industry approved instruments.
8. Install and service oil-fired boilers & furnaces.
9. Perform a delta T reading for purposes of troubleshooting and installation according to industry standards.
10. Test and replace boiler/furnace operating and safety controls.
11. Describe steam heating systems, components, and safety controls.
12. Describe characteristics of, and maintain and service hydronic components (e. g., centrifugal pumps and circulators).
13. Describe and demonstrate methods of preparing fuel for combustion.
14. Describe the characteristics of primary and safety controls.
15. Describe and install various venting systems for oil appliances.
16. Describe the use of biofuel.
17. Install and troubleshoot gas heating equipment.
18. Describe and follow gas heat safety.
19. Discuss and measure liquefied petroleum (L.P.) and natural gas supply and manifold pressures.
20. List characteristics of, test, and operate standing pilot ignition systems.
21. List characteristics of, test, and operate hot surface, intermittent ignition device, spark ignition devices and electronic components.
22. List characteristics of and test combustion fan motor operation.
23. List and describe properties of, test, and adjust combustion on a gas appliance.
24. List and describe characteristics of, test, replace, and adjust gas valves (positive & negatives).
25. Describe potential problems with, test, adjust, and replace operating and safety controls.
26. Describe characteristics and troubleshoot 80% and 90% plus efficiency gas furnaces.
27. Describe the installation of LP/Natural gas conversion kits.
28. Install and service gas boilers and furnaces to manufacturer’s specifications.
29. Describe characteristics of venting systems for gas appliances.

### Standard 9: Indoor Air Quality and Ventilation

Students will be able to assess indoor air quality and air/heat distribution and adjust ventilation and air-duct systems as required.

Credit toward NATE Ready to Work Certificate

Credit toward EPA 608 Technician Certification

#### Skills:

* + - 1. Discuss the importance of indoor air quality (IAQ), including identification of common pollutants and allergens and IAQ regulations and guidelines.
      2. Describe and use the different standards/codes for measuring indoor air quality (IAQ).
      3. Calculate heat loss and gain for a structure.
      4. Explain the principles of air distribution systems (e.g., stratification of air, drafts, etc.) following industry standards.
      5. Demonstrate the application of dampers, diffusers, grills, and zoning technologies.
      6. Describe and demonstrate ventilation applications and forced-air duct systems.
      7. Perform duct calculations for air distribution.
      8. Design and draw basic forced-air duct system.
      9. Explain and use concepts of the physical properties of air.
      10. Describe the procedures used to troubleshoot and adjust humidification accessories.
      11. Describe the installation and application of Heat Recovery Ventilation (HRV) and Energy Recovery Ventilation (ERV) Systems.
      12. Describe and demonstrate duct construction, including assembling, duct sealing, and insulating according to industry standards.
      13. Design and install a ventilation system.

### Standard 10: HVAC-R Roof Top Units

Students will be able to identify the components and classifications of HVAC-R rooftop units (RTU’s).

Credit toward NATE Ready to Work Certificate

#### Skills:

1. Identify benefits and drawbacks of the different types of RTUs and their system optimization strategies.
2. Describe the integration of various building energy management systems (BEMS) with RTUs.
3. Define the classifications of rooftop units (RTUs) and illustrate how they work.
4. Describe and identify the characteristics of RTU’s self-contained/package air conditioners heating units.
5. Describe and identify the components of a RTU’s Split-System.
6. Identify and define operation of RTU’s variable-air-volume (VAV) systems.
7. Define the functions of the components of an air distribution system including major equipment types and auxiliary components.
8. Operate cranes, hoists, or other moving or lifting equipment.

## Employability Standards

### Standard 11: Employability Skills

Students will understand and demonstrate the roles of professional communication, critical thinking, problem solving, professionalism, teamwork, and collaboration within the context of HVAC-R careers.

#### Skills:

1. Demonstrate the impact of communication skills on the success of an HVAC-R technician.
2. Describe appropriate methods of communication for internal and external stakeholders.
3. Evaluate the impact of poor communication by a HVAC-R technician on the safety of a job site.
4. Troubleshoot a project plan to find mistargeted or extraneous work that does not contribute to the ultimate objectives of the project.
5. Build a team-based project plan that results in a successful HVAC-R system installation and that includes recruiting teammates and assigning roles for a project.
6. Examine the role of an HVAC-R  Technician in society, particularly in terms of its significance for employability and career opportunities.

## Entrepreneurship Standards

### Standard 12: Entrepreneurship

Students will be able to describe opportunities for entrepreneurship and be able to evaluate the value proposition of business ownership in the HVAC-R field.

#### Skills:

1. Students will understand and be able to describe the role of an HVAC-R technician in the overall operations of an HVAC-R company.
2. Describe the concept of professional networking and demonstrate personal introductions and an “elevator speech” appropriate for other HVAC-R, contractors, developers, and other potential business partners.
3. Evaluate the licensing, regulatory and tax implications of self-employment and business ownership as a HVAC-R technician compared to W-2 employment.

## Digital Literacy Standards

### Standard 13: Digital Literacy

Students will be able to demonstrate the use of common software and information technology in a modern HVAC-R environment.

#### Skills:

1. Describe the use of online resources in licensing and professional development as an HVAC-R technician.
2. Demonstrate the use of common ticketing, scheduling, resource management and/or customer relationship management systems for HVAC-R services.
3. Understand where to find online resources that support effective HVAC-R work and how to be a safe and ethical consumer and creator of digital content.
4. Apply strategies for using digital tools and technology to drive business and commerce.

## Sample Performance Tasks

### Standard 1: Safety and Health in the HVAC-R Work Environment

Students will prioritize safety by adhering to OSHA and EPA regulations, demonstrating proper use of personal protective equipment (PPE), and effectively identifying and mitigating workplace hazards. OSHA10 – Construction

Credit toward EPA 608 Technician Certification

#### Sample Performance Tasks:

* Student will participate in daily /weekly “Toolbox Safety Talks”.
* Student will set-up and demonstrate the use of acetylene/oxygen/nitrogen gas equipment.

### Standard 2: Technical Drawings and Blueprint Reading

Students will be able to read and interpret technical drawings, blueprints, and specifications enabling them to plan and execute HVAC-R installations.

Credit toward NATE Ready to Work Certificate

#### Sample Performance Tasks:

* Student will perform shop work /job site projects/ from appropriate sets of prints/drawings.
* Student will develop a material quantity takeoff for given project/job.
* Student will develop a cost estimate from material quantity takeoff for given project/job.

### Standard 3: HVAC-R Fundamentals

Students will demonstrate application of HVAC-R standards and guidelines in accordance with The American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE).

Credit toward NATE Ready to Work Certificate

#### Sample Performance Tasks:

* Student will create a written composition based on the historical development and the importance of HVAC-R in modern society.
* Student will properly size and install a centrifugal pump in a residential hydronic heating system.

### Standard 4: Pipe Joining Techniques

Students will demonstrate industry standard techniques to measure, cut, ream, thread, and join pipe utilizing common HVAC-R materials according to project specifications.  
Credit toward NATE Ready to Work Certificate

Credit toward Hot Work Safety Certificate

#### Sample Performance Tasks:

* Student will perform, measuring, cutting, bending, flaring, swaging, soldering/brazing copper tubing following the specifications on a given project.

### Standard 5: Electrical Systems and Controls

Students will comprehend electrical circuits, control systems, and wiring diagrams, allowing them to install, maintain, and troubleshoot HVAC-R electrical components.

Credit toward NATE Ready to Work Certificate

#### Sample Performance Tasks:

* Student will demonstrate their knowledge of electrical theory, by troubleshooting components using a schematic and analyzing equipment.

### Standard 6: Refrigeration Components and Systems

Students will be able to install, maintain and troubleshoot common refrigeration components, equipment, and systems.

Credit toward NATE Ready to Work Certificate

Credit toward EPA 608 Technician Certification

#### Sample Performance Tasks:

* Student will create a basic refrigeration system by installing & connecting multiple refrigerant components into an operating system.
* Student will perform system evacuation and dehydration/degassing.
* Student will demonstrate their knowledge of heat transfer principles by indicating temperature and pressure readings from given project.

### Standard 7: Heat Pumps and Air Conditioning Equipment

Students will demonstrate installation, service and repair of air conditioning and heat pump equipment.

Credit toward NATE Ready to Work Certificate

#### Sample Performance Tasks:

* Using the manufacturer’s installation manuals and specifications the student will install air-conditioning, heat pump and mini-split systems.

### Standard 8: Oil Heating Equipment and Natural and Liquified Gas Equipment

Students will be able to install, test, maintain and repair oil heating and gas equipment. Credit toward NATE Ready to Work Certificate

#### Sample Performance Tasks:

* Student will install and service an oil burner/boiler – service should include performing a combustion efficiency test.
* Student will define the major components of an oil system and describe the function of each component.
* Student will install and service a gas fired furnace/boiler –service should include checking safety devices and maintaining appropriate temperatures from Delta-T readings.
* Students will properly size and install a centrifugal pump in a residential hydronic heating system.

### Standard 9: Indoor Air Quality and Ventilation

Students will be able to assess indoor air quality and air/heat distribution and adjust ventilation and air-duct systems as required.

Credit toward NATE Ready to Work Certificate

Credit toward EPA 608 Technician Certification

#### Sample Performance Tasks:

* Student will perform a Manual J calculation from given print/drawing.
* Student will perform a Manual D calculation from given print/drawing.

### Standard 10: HVAC Roof Top Units

Students will be able to identify the components and classifications of HVAC rooftop units (RTU’s).

Credit toward NATE Ready to Work Certificate

#### Sample Performance Tasks:

* Build a team-based project plan that results in a successful HVAC-R system installation and that includes recruiting teammates and assigning roles for a project.

## Certification References

* OSHA 10 – Construction [OSHA 10 Hour Construction Course Online - OSHA.com](https://www.osha.com/courses/10-hour-construction.html?utm_source=bing&utm_medium=cpc&utm_campaign=361657709&utm_content=1173179812116977&utm_term=osha%2010%20construction&msclkid=e0e95a7b3fac1262742c3f650af208e4)
* **Section 608 Technician Certification by the Environmental Protection Agency (EPA)** [Section 608 Technician Certification | US EPA](https://www.epa.gov/section608/section-608-technician-certification-0)
  + As part of the Federal Clean Air Act, the **EPA 608 Certification** is required for any technician who maintains, services, repairs, or disposes of appliances that contain regulated refrigerants. The good news about the EPA 608 certification is that it is a one-time test, with no expiration and no requirement for renewal.
    - * Hot Work Safety Training & Certification, by The National Fire Protection Association (NFPA) [NFPA - Hot Work Safety Program](https://www.nfpa.org/Training-and-Events/By-topic/Hot-Work)
      * Mandatory program in Boston and Massachusetts: The City of Boston requires a Hot Work Safety Certificate for all persons engaged in hot work operations on the work site. This is mandatory in the state of Massachusetts as of July 1, 2018.
      * North American Technician Excellence (NATE), Ready to Work Certificate. (Replaces ICE Certificate)
  + Founded in 1997, North American Technician Excellence (**NATE**) is the nation’s largest non-profit certification organization for heating, ventilation, air conditioning and refrigeration technicians. The company's vision is to be the leader in developing and recognizing professional HVAC-R technicians.
  + **The**[**Ready to Work certificate exam**](https://natex.org/technician/take-an-exam/nate-certificates-and-certification-exams)**is designed for technicians who are just entering the HVAC-R field, with little to no formal education or training.**
  + Several national organizations, including the Environmental Protection Agency (EPA) and the American Society of Heating, Refrigeration and Air-Conditioning Engineers recognize and partner with NATE, along with other contractors, distributors, educators, technicians, utilities, and manufacturers. [North American Technician Excellence | Department of Energy](https://www.energy.gov/eere/buildings/north-american-technician-excellence#:~:text=Founded%20in%201997%2C%20North%20American%20Technician%20Excellence%20%28NATE%29,leader%20in%20developing%20and%20recognizing%20professional%20HVACR%20technicians.) [Homeowner Page - NATE (natex.org)](https://natex.org/contractor/home-owner-page)