# Instructional Framework

## Heating, Ventilation, and Air Conditioning

47.0201.00

This Instructional Framework identifies, explains, and expands the content of the standards/measurement criteria, and, as well, guides the development of multiple-choice items for the Technical Skills Assessment. This document corresponds with the Technical Standards endorsed on May 14, 2024.

| **Domain 1: HVAC Profession and Heating and Cooling Systems**<br>**Instructional Time: 25 - 35%** | |
|---|---|
| **STANDARD 1.0** INVESTIGATE THE HVAC PROFESSION | |
| 1.1 Describe the basic principles of heating, ventilation, air conditioning, and refrigeration (HVAC) | • Heating<br>• Ventilation<br>• Air conditioning<br>• Refrigeration<br>• Heat pumps |
| 1.2 Describe the role of the HVAC technician (e.g., install, maintain, and repair heating, cooling, and refrigeration systems) | • Install, maintain, and repair heating, cooling, and refrigeration systems<br>• Customer relations<br>• Maintaining paperwork<br>• Find, order, and price parts<br>• Produce quotes |
| 1.3 Describe the guiding principles of HVAC installation and service [e.g., common safety concerns and guidelines, Leadership in Energy and Environmental Design (LEED) principles, and codes and permits] | • Common safety concerns and guidelines<br>• Leadership in Energy and Environmental Design (LEED) principles<br>• Codes and permits |
| 1.4 Describe licensure and certification requirements of HVAC technicians | • Environmental Protection Agency (EPA) certifications<br>• Occupational Safety and Health Administration (OSHA) certifications<br>• Refrigerant safety certifications<br>• Equipment certifications |
| 1.5 Identify personal characteristics needed to be a successful HVAC technician | • Soft skills<br>• Honesty |

| | |
|---|---|
| | • Personal hygiene<br>• Cleanliness<br>• Efficient<br>• Self-starter<br>• Work independently |
| 1.6 Identify residential, commercial, and industrial career opportunities in HVAC | • Residential career opportunities<br>  ○ Maintenance technician<br>  ○ HVAC technician<br>• Commercial career opportunities<br>  ○ Maintenance technician<br>  ○ HVAC technician<br>  ○ HVAC sales<br>  ○ Installer<br>• Industrial career opportunities<br>  ○ HVAC engineer<br>  ○ HVAC manufacturer<br>  ○ HVAC contractor |
| **TANDARD 4.0** INSPECT AND SERVICE HEATING SYSTEMS | |
| 4.1 Explain the concepts of heating and combustion (e.g., the heat transfer process and gas fuels and their combustion characteristics) | • The heat transfer process<br>• Gas fuels and their combustion characteristics |
| 4.2 Describe types of gas furnaces and how they operate (e.g., upflow furnace, horizontal furnace, lowboy furnace, and counterflow furnace) | • Upflow furnace<br>• Horizontal furnace<br>• Lowboy furnace<br>• Counterflow furnace |
| 4.3 Describe the equipment and controls used in gas furnaces (e.g., heat exchangers, fans and motors, air filters, gas valves, manifold and orifices, gas burners, ignition devices, and safety controls) | • Heat exchangers<br>• Fans and motors<br>• Air filters<br>• Gas valves<br>• Manifold and orifices<br>• Gas burners<br>• Ignition devices<br>• Safety controls |
| 4.4 Describe the operation of hydronic heating systems versus electric heating systems | • Pumps<br>• Flow control devices<br>• Water source |

| | |
|---|---|
| | • Water treatment |
| 4.5 Check and record temperature measurement calculations (e.g., rise, manifold gas pressure, and flame quality on an operating gas furnace) | • Rise<br>• Manifold gas pressure<br>• Flame quality on an operating gas furnace<br>• Combustion |
| 4.6 Use the manufacturer's installation instructions to determine if a furnace has the required clearances | • Calculate appropriate clearances<br>• Read installation instructions |
| **STANDARD 5.0** INSPECT AND SERVICE COOLING SYSTEMS | |
| 5.1 Explain the refrigeration cycle | • Evaporators<br>• Condensers<br>• Compressors<br>• Metering devices<br>• System components |
| 5.2 Identify common refrigerants and their characteristics (e.g., fluorocarbon refrigerants, ammonia as a refrigerant, refrigerant containers, and safe handling requirements) | • Fluorocarbon refrigerants<br>• Ammonia as a refrigerant<br>• Refrigerant containers<br>• Safe handling requirements<br>• Low GWP/AL2/flammable refrigerants |
| 5.3 Identify the major components of cooling systems (e.g., compressors, condensers, evaporators, refrigerant metering devices, refrigerant piping, and refrigerant circuit accessories) and explain how they function | • Compressors<br>• Condensers<br>• Evaporators<br>• Refrigerant metering devices<br>• Refrigerant piping<br>• Refrigerant circuit accessories<br>• Ptrap |
| 5.4 Identify the common primary and secondary controls in cooling systems (e.g., thermostats, pressure switches, time clocks, temperature switches, oil-pressure safety switches, and flow switches) and explain how they function | • Thermostats<br>• Pressure switches<br>• Time clocks<br>• Temperature switches<br>• Oil-pressure safety switches<br>• Flow switches<br>• Pressurestats |
| 5.5 Measure and record dry bulb and wet bulb temperatures of the | • Superheat |

| | |
|---|---|
| supply and return air streams in an operating cooling system | • Target superheat |
| 5.6 Connect a refrigerant gauge manifold and calculate subcooling and superheat on an operating system | • Gauges<br>• Pressure temperature (PT) charts<br>• Psychometrics<br>• Device to take pipe temperature |

| **Domain 2: Electrical Troubleshooting<br>Instructional Time: 25 - 35%** | |
|---|---|
| **STANDARD 3.0** INSPECT AND TROUBLESHOOT THE ELECTRICAL SYSTEM | |
| 3.1 Describe the fundamentals of power generation [e.g., power sources(i.e., solar power, solar heating, air source heat pumps, hydroelectric power, etc.) and direct and alternating current] | • Power sources<br>  ○ Solar power<br>  ○ Solar heating<br>  ○ Air source heat pumps<br>  ○ Hydroelectric power, etc.<br>• Direct and alternating current<br>• Ohm's Law<br>  ○ Resistance<br>  ○ Current<br>  ○ Voltage<br>• Magnet |
| 3.2 Identify types of electrical transformers and explain how they operate | • Delta<br>• Y<br>• Step up<br>• Step down |
| 3.3 Identify common electrical safety practices (e.g., lockout/tagout procedures, OSHA electrical safety requirements, and common PPE) | • Lockout/tagout procedures<br>• OSHA electrical safety requirements<br>• Common PPE<br>• Ladder safety<br>• Fall safety |
| 3.4 Define common electrical units (i.e., volt, ohm, watt, joule, etc.) and apply Ohm's law and the power formula (P=VI) to determine voltage, resistance, and current | • Ohm's Law<br>  ○ Common electrical units<br>  ■ Volt |

| | |
|---|---|
| | ■ Ohm<br>■ Watt<br>■ Joule<br>○ Resistance<br>○ Current<br>○ Voltage |
| 3.5 Differentiate between series circuits and parallel circuits and calculate circuit values for each type | ● Path and load<br>● Ohm's Law |
| 3.6 Identify electrical measuring instruments (e.g., voltage testers, inline current measurement, an megohmmeters) and describe their uses (e.g., measuring voltage, current, and resistance) | ● Electrical measuring instruments<br>○ Voltage testers<br>○ Inline current measurement<br>○ Megohmmeters<br>● Uses<br>○ Measuring voltage, current, and resistance |
| 3.7 Identify electrical components and describe their functions (e.g., loads, control devices, and electrical diagrams) | ● Loads<br>● Control devices<br>● Electrical diagrams |
| 3.8 Perform electrical component tasks (e.g., draw a connection diagram for a circuit, assemble a circuit based on the connection diagram, measure and record resistance of the transformer component tasks, record circuit current, measure voltage, and use a voltmeter to verify disabled power) | ● Draw a connection diagram for a circuit<br>● Assemble a circuit based on the connection diagram<br>● Measure and record the resistance of the transformer component tasks<br>● Record circuit current<br>● Measure voltage<br>● Use voltmeter to verify disabled power |

| **Domain 3: Piping and Tubing**<br>**Instructional Time: 20 - 25%** | |
|---|---|
| **STANDARD 7.0** CUT AND JOIN COPPER AND PLASTIC PIPING | |
| 7.1 Identify different types, markings, and sizes of copper tubing and their fittings (e.g., flare fittings, compression fittings, sweat fittings, press-to-connect fittings, and push-to-connect fittings) | ● Flare fittings<br>● Compression fittings<br>● Sweat fittings<br>● Press-to-connect fittings |

| | |
|---|---|
| | • Push-to-connect fittings |
| 7.2 Explain how to join copper tubing (i.e., measure, cut, bend, and swag tubing; join using flare and compression joints; join using press-to-connect and push-to-connect fittings; how-to pressure test; common hangers and supports used in installations, etc.) | • Measure, cut, bend, and swag tubing<br>• Join using flare and compression joints<br>• Join using press-to-connect and push-to-connect fittings<br>• How-to pressure test<br>• Common hangers and supports used in installations |
| 7.3 Identify different types of plastic piping (e.g., AABS Pipe, PE and PEX Tubing, P Tubing, and CPVC Pipe) and explain how they are joined (e.g., solvent-cementing products, solvent-cementing plastic pipe, and plastic pipe support spacing) | • AABS pipe<br>• PE and PEX tubing<br>• P tubing<br>• CPVC pipe |
| 7.4 Cut and bend copper tubing | • Tubing cutter<br>• Tubing bender<br>  ○ Lever or spring-type |
| 7.5 Join copper tubing using a flared connection | • Flare fittings<br>• Flare tool |
| 7.6 Join copper tubing using a compression fitting and ferrule | • Compression fittings<br>• Ferrules |
| 7.7 Assemble press-to-connect joints in copper tubing according to manufacturer's instructions | • Shark bite |
| 7.8 Cut and join PVC pipe and fittings | • Primer<br>• Glue |
| **STANDARD 8.0** DEMONSTRATE SOLDERING AND BRAZING TECHNIQUES | |
| 8.1 Explain when soldering and brazing techniques are used | • Solder<br>• Brazing rod<br>• Flux<br>• Temperatures<br>• Gasses |
| 8.2 Identify PPE and safety guidelines, tools, and materials used for soldering and brazing | • Safety glasses<br>• Gloves<br>• Appropriate clothing |

| | |
|---|---|
| 8.3 Demonstrate the process of soldering copper tubing | • Cutting pipe<br>• Framing the pipe<br>• Swaging the pipe<br>• Heating the pipe<br>• Adding the filler metal to the pipe<br>• Flux |
| 8.4Demonstrate the process of brazing copper tubing to either steel or brass components (e.g., joints and dissimilar metals) | • Joints<br>• Dissimilar metals<br>• Flux<br>• Silver content |
| 8.5 Describe the brazing process (e.g., set up the equipment, light the acetylene torch, set up the air-acetylene equipment, and purge refrigerant lines) | • Set up the equipment<br>• Lighting the torches<br>  ○ Light the acetylene torch<br>• Set up the air-acetylene equipment<br>• Purge refrigerant lines<br>• Oxy-acetylene |

| **Domain 4: Trade Math used in Diagnostics**<br>**Instructional Time: 5 - 10%** | |
|---|---|
| **STANDARD 2.0** USE MATH SKILLS IN HVAC APPLICATIONS | |
| 2.1 Identify math applications in HVAC (e.g., cutting and fitting pipe, sizing and installing ductwork, and calculating electrical values) | • Cutting and fitting pipe<br>• Sizing and installing ductwork<br>• Calculating electrical values<br>• Heating and cooling loads |
| 2.2 Convert units of measurement from the U.S. standard system to the metric system and vice-versa (e.g., dimensions and distances, weight, volume, pressure, and temperature) | • Standard to metric and vice-versa<br>• Dimensions and distances<br>• Weight<br>• Volume<br>• Pressure<br>• Temperature |
| 2.3 Define basic algebraic terms | • Formulas<br>• Measurements |

| | |
|---|---|
| 2.4 Solve basic algebra equations using the sequence of operations | • Equations<br>• Sequence of operations |
| 2.5 Perform calculations involving geometric figures (e.g., circles, angles, polygons, and triangles) | • Circle<br>• Angles<br>• Polygons<br>• Triangles<br>• Area<br>• Square footage<br>• Cubic inches |
| **STANDARD 6.0** RECOGNIZE DEFICIENCIES IN AIR DISTRIBUTION SYSTEMS | |
| 6.1 Describe how pressure, velocity, and volume are related to air movement and identify common air measurement instruments (e.g., manometer and velometer) | • Manometer<br>• Velometer<br>• Psychrometer |
| 6.2 Describe mechanical equipment and materials used to create air distribution systems (e.g., blowers, fans, fan laws, duct materials and fittings, and diffusers, registers, grilles, and dampers) | • Blowers<br>• Fans<br>• Fan laws<br>• Duct materials and fittings<br>• Diffusers<br>• Registers<br>• Grilles<br>• Dampers<br>• Filtration |
| 6.3 Identify different approaches to air distribution system design and energy conservation (e.g., air distribution system layouts, heating and cooling room airflow, and energy efficiency in air distribution systems) | • Air distribution system layouts<br>• Heating and cooling room airflow<br>• Energy efficiency in air distribution systems<br>• Filtration |
| 6.4 Use a manometer to measure static pressure in a duct | • Pressure<br>• Resistance |
| 6.5 Use a velometer to measure the velocity of airflow at supply diffusers or registers | • Free space |
| 6.6 Use a velometer to calculate the volume of airflow in a duct | • Volume calculation<br>• Mass airflow |

| **Domain 5: Steel Piping**<br>**Instructional Time: 5 - 10%** | |
|---|---|
| **STANDARD 9.0** DEMONSTRATE BASIC CARBON STEEL PIPING TECHNIQUES | |
| 9.1 Identify and describe various types of steel pipe and fittings (e.g., characteristics and uses of steel pipe; how to measure pipe threads; how different pipe fittings are used; and how to measure pipe and determine cut lengths) | • Characteristics and uses of steel pipe<br>• How to measure pipe threads<br>• How different pipe fittings are used<br>• How to measure pipe and determine cut lengths |
| 9.2 Describe tools and methods used to cut and thread steel pipe (e.g., pipe cutting and reaming tools and pipe threading equipment and how to thread pipe) | • Pipe cutting and reaming tools<br>• Pipe threading equipment<br>• How to thread pipe |
| 9.3 Describe how to mechanically join and install steel pipe (e.g., identify tools and techniques to connect threaded pipe, describe pipe grooving methods and techniques, explain how to assemble flanged steel pipe; and explain how to install and support steel pipe) | • Identify tools and techniques to connect threaded pipe<br>• Describe pipe grooving methods and techniques<br>• Explain how to assemble flanged steel pipe<br>• Explain how to install and support steel pipe |
| 9.4 Cut, ream, and thread steel pipe | • Pipe cutting and reaming tools<br>• Pipe threading equipment<br>• How to thread pipe |
| 9.5 Join threaded pipe or pipe nipples using various fittings | • Identify tools and techniques to connect threaded pipe<br>• Describe pipe grooving methods and techniques<br>• Explain how to assemble flanged steel pipe<br>• Explain how to install and support steel pipe |