



# HEATING, VENTILATION, AND AIR CONDITIONING 47.0201.00 TECHNICAL STANDARDS

Arizona CTE's Heating, Ventilation, and Air Conditioning Program Technical Standards are adopted from the National Center for Construction Education Research (NCCER), the leading provider of construction education for industry and career and technical education programs. The Arizona Career and Technical Education Quality Commission, the validating authority for the Arizona Skills Standards Assessment System, approved this adoption on May 14, 2024.

Note: Arizona's Professional Skills are taught as an integral part of the Heating, Ventilation, and Air Conditioning program.

**The Technical Skills Assessment for Heating, Ventilation, Air Conditioning, and Refrigeration is available SY 2025-2026.**

Note: In this document i.e. explains or clarifies the content and e.g. provides examples of the content that must be taught.

## STANDARD 1.0 INVESTIGATE THE HVAC PROFESSION

- 1.1 Describe the basic principles of heating, ventilation, air conditioning, and refrigeration (HVAC)
- 1.2 Describe the role of the HVAC technician (e.g., install, maintain, and repair heating, cooling, and refrigeration systems)
- 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]
- 1.4 Describe licensure and certification requirements of HVAC technicians
- 1.5 Identify personal characteristics needed to be a successful HVAC technician
- 1.6 Identify residential, commercial, and industrial career opportunities in HVAC

## 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)
- 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)
- 2.3 Define basic algebraic terms
- 2.4 Solve basic algebra equations using the sequence of operations
- 2.5 Perform calculations involving geometric figures (e.g., circle, angles, polygons, and triangles)

## 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]
- 3.2 Identify types of electrical transformers and explain how they operate
- 3.3 Identify common electrical safety practices (e.g., lockout/tagout procedures, OSHA electrical safety requirements, and common PPE)
- 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
- 3.5 Differentiate between series circuits and parallel circuits and calculate circuit values for each type
- 3.6 Identify electrical measuring instruments (e.g., voltage testers, inline current measurement, and megohmmeters) and describe their uses (e.g., measuring voltage, current, and resistance)
- 3.7 Identify electrical components and describe their functions (e.g., loads, control devices, and 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)

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## **STANDARD 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)
- 4.2 Describe types of gas furnaces and how they operate (e.g., upflow furnace, horizontal furnace, lowboy furnace, and 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)
- 4.4 Describe the operation of hydronic heating systems versus electric heating systems
- 4.5 Check and record temperature measurement calculations (e.g., rise, manifold gas pressure, and flame quality on an operating gas furnace)
- 4.6 Use the manufacturer's installation instructions to determine if a furnace has the required clearances

## **STANDARD 5.0 INSPECT AND SERVICE COOLING SYSTEMS**

- 5.1 Explain the refrigeration cycle
- 5.2 Identify common refrigerants and their characteristics (e.g., fluorocarbon refrigerants, ammonia as a refrigerant, refrigerant containers, and safe handling requirements)
- 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
- 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
- 5.5 Measure and record dry bulb and wet bulb temperatures of the supply and return air streams in an operating cooling system
- 5.6 Connect a refrigerant gauge manifold and calculate subcooling and superheat on an operating system

## **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)
- 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)
- 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)
- 6.4 Use a manometer to measure static pressure in a duct
- 6.5 Use a velometer to measure the velocity of airflow at supply diffusers or registers
- 6.6 Use a velometer to calculate the volume of airflow in a duct

## **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)
- 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.)
- 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)
- 7.4 Cut and bend copper tubing
- 7.5 Join copper tubing using a flared connection
- 7.6 Join copper tubing using a compression fitting and ferrule
- 7.7 Assemble press-to-connect joints in copper tubing according to manufacturer's instructions
- 7.8 Cut and join PVC pipe and fittings

## **STANDARD 8.0 DEMONSTRATE SOLDERING AND BRAZING TECHNIQUES**

- 8.1 Explain when soldering and brazing techniques are used
- 8.2 Identify PPE and safety guidelines, tools, and materials used for soldering and brazing
- 8.3 Demonstrate the process of soldering copper tubing
- 8.4 Demonstrate the process of brazing copper tubing to either steel or brass components (e.g., joints and dissimilar metals)
- 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)

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## **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)
- 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)
- 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)
- 9.4 Cut, ream, and thread steel pipe
- 9.5 Join threaded pipe or pipe nipples using various fittings