



# HEATING, VENTILATION, AIR-CONDITIONING AND REFRIGERATION (HVACR)

SkillsUSA Championships Technical Standards

## PURPOSE

To evaluate competitors' preparation for employment and recognize outstanding students for excellence and professionalism in heating, ventilation, air conditioning and refrigeration.

First, download and review the General Regulations at: <http://updates.skillsusa.org>.

## ELIGIBILITY

Open to active SkillsUSA members enrolled in programs with heating, ventilation, air conditioning and refrigeration as the occupational objective.

## CLOTHING REQUIREMENTS

### **Class C: Competition Specific — Manufacturing/Construction Khaki Attire**

- Official SkillsUSA khaki short-sleeve work shirt
- Khaki pants
- Black, brown or tan leather work shoes

**Note:** Safety glasses must have side shields or goggles. (Prescription glasses may be used only if they are equipped with side shields. If not, they must be covered with goggles.)

These regulations refer to clothing items that are pictured and described at [www.skillsusastore.org](http://www.skillsusastore.org). If you have questions about clothing or other logo items, call 1-888-501-2183.

**Note:** Competitors must wear their official competition clothing to the competition orientation meeting.

## EQUIPMENT AND MATERIALS

1. Supplied by the technical committee:
  - a. All heating, refrigeration and air conditioning units necessary for the problem
  - b. Power supply for units
  - c. Test equipment
  - d. All tools and supplies to complete the competition
  - e. All necessary information and material for judges and technical committee
2. Supplied by the competitor:
  - a. Safety goggles
  - b. Hand-held, nonprogrammable calculator for the competitor meeting as well as for the competition. Cellphone calculators are not permitted.
  - c. All competitors must create a one-page resume. See “Resume Requirement” below for guidelines.

### RESUME REQUIREMENT

Competitors must create a one-page resume to submit online. SkillsUSA national competitors should submit their resume by June 1. The link for resume submission will be published on <http://updates.skillsusa.org> on May 1. Failure to submit a resume will result in a 10-point penalty.

**Your resume must be saved as a PDF file type using file name format of “Last Name\_First Name.”** For example, “Amanda Smith” would save her resume as **Smith\_Amanda**. If you need assistance with saving your file as a PDF, visit [the Adobe website](#) for more information.

**Note:** Check the Competition Guidelines and/or the updates page on the SkillsUSA website at <http://updates.skillsusa.org>.

### PROHIBITED DEVICES

Cell phones or other electronic devices not approved by a competition’s national technical committee are **NOT** allowed in the competition area. Please follow the guidelines in each technical standard for approved exceptions. Technical committee members may also approve exceptions onsite during the SkillsUSA Championships if deemed appropriate.

#### Penalties for Prohibited Devices

If a competitor’s electronic device makes noise or if the competitor is seen using it at any time during the competition, an official report will be documented for review by the SkillsUSA Championships director. If confirmed that the competitor used the device in a manner which compromised the integrity of the competition, the competitor’s scores may be canceled.

## SCOPE OF THE COMPETITION

This competition is defined by industry standards as set by the Air-Conditioning and Refrigeration Institute and the North American Technician Excellence (NATE) organization. The competition is divided into two parts: a written exam and a series of testing stations designed to assess knowledge in HVACR industry standards.

### KNOWLEDGE PERFORMANCE

The competition will include a written knowledge exam assessing knowledge of HVACR industry standards. The written test will be taken at orientation.

### SKILL PERFORMANCE

The competition includes a series of testing stations designed to assess skills identified by industry HVACR standards. Industry equipment used during the workstations portion of the competition may include, but is not limited to, ice machines, refrigerated display cases, small package HVAC units, furnaces and split-system air conditioning and/or heat pump units.

### STANDARDS AND COMPETENCIES

#### HVAC 1.0 — Demonstrate safety skills in typical HVACR work situations

- 1.1. Demonstrate safe practices when working in electrical control panels and electric supply devices
  - 1.1.1. Demonstrate how to turn off power
  - 1.1.2. Describe the purpose of lockout/tag-out devices
  - 1.1.3. Demonstrate use of lockout/tag-out devices
  - 1.1.4. Use electrically insulated tools suitable for the voltage involved
- 1.2. Use appropriate safety apparel for the task being performed
  - 1.2.1. Wear appropriate safety glasses, gloves, work shoes, etc., for a given situation
- 1.3. Demonstrate safety when using brazing torches
  - 1.3.1. Demonstrate correct procedure for connecting torch equipment including regulators, tanks, hose, torch and tips
  - 1.3.2. Light torch using proper procedure and safe practice
  - 1.3.3. Demonstrate safe practice when using open flame heating equipment
  - 1.3.4. Extinguish torch flame using proper procedure and safe practice
  - 1.3.5. Check for unsafe conditions such as cracked hoses, safety ring caps, damaged gauges, dented tanks and leaks
  - 1.3.6. Explain the “never use oil” rule with regard to brazing torches
- 1.4. Demonstrate the safe use of electric test meter
  - 1.4.1. Set meter for the test being performed
  - 1.4.2. Hold meter leads with one hand when practical or use clip-on test lead
- 1.5. Demonstrate the safe handling of pressurized gases
  - 1.5.1. Ensure valves are properly closed prior to removing attached hoses/caps
  - 1.5.2. Show caution when removing attached components under pressure
  - 1.5.3. Ensure that pressure vessels are not overfilled

## **HVAC 2.0 — Exhibit employment skills (Personal ethics and conduct and interpersonal relations)**

- 2.1. Complete job application and resume
  - 2.1.1. Complete all questions on application
  - 2.1.2. Compose concise professional resume
- 2.2. Demonstrate interview skills
  - 2.2.1. Smile, make eye contact with interviewer and speak up
- 2.3. Prepare correspondence related to employment process
  - 2.3.1. Use proper grammar
  - 2.3.2. Ensure spelling is correct
- 2.4. Exhibit personal skills such as attendance, time management, individual responsibility and teamwork
  - 2.4.1. Provide references for confirming these skills
- 2.5. Maintain professional conduct and appearance
  - 2.5.1. Demonstrate polite, attentive attitude
  - 2.5.2. Wear neat, clean clothing and be well groomed

## **HVAC 3.0 — Demonstrate basic refrigeration skills**

- 3.1. Explain the refrigeration cycle
  - 3.1.1. Describe the refrigeration cycle and refrigerant circuits
  - 3.1.2. Demonstrate knowledge of refrigerant flow, state of refrigerant in various parts of the circuit, superheat, sub cooling and the refrigerant pressure/temperature relationship
- 3.2. Evacuate a refrigeration system
  - 3.2.1. Describe the procedure
  - 3.2.2. Demonstrate the procedure
- 3.3. Pump down a refrigeration system
  - 3.3.1. Describe the procedure
  - 3.3.2. Demonstrate the procedure
- 3.4. Recover refrigerant from system and store in external container using self-contained recovery equipment
  - 3.4.1. Describe the procedure
  - 3.4.2. Demonstrate the procedure
  - 3.4.3. Calculate the maximum capacity of a refrigerant cylinder
  - 3.4.4. Demonstrate the correct refrigerant cylinder handling procedures
- 3.5. Check and troubleshoot a refrigerant metering device
  - 3.5.1. Explain thermostatic expansion valve operation
  - 3.5.2. Explain fixed orifice operation
  - 3.5.3. Explain superheat measurement
  - 3.5.4. Take a superheat measurement
- 3.6. Check a refrigeration system for leaks
  - 3.6.1. Explain leak checking during evacuation
  - 3.6.2. Demonstrate leak checking during evacuation
  - 3.6.3. Explain leak checking of a charged system
  - 3.6.4. Demonstrate leak checking of a charged system
- 3.7. Charge a refrigeration system
  - 3.7.1. Read and interpret the equipment manufacturer's charging procedure

- 3.7.2. Follow manufacturer's charging procedure
- 3.8. Identify refrigerant type
  - 3.8.1. Use a pressure/temperature chart to identify refrigerant type

#### **HVAC 4.0 — Demonstrate electric knowledge and skills necessary for HVACR situations**

- 4.1. Explain basic principles of electricity
  - 4.1.1. Describe how electricity is generated and distributed to residences and businesses
  - 4.1.2. Explain the interaction of voltage, resistance and current flow
  - 4.1.3. Describe how transformers change voltage
  - 4.1.4. Explain the importance of grounding electrical circuits
- 4.2. Explain the principle of electric circuits
  - 4.2.1. Describe the components of an electric circuit including switches, loads and connectors
  - 4.2.2. Define the function of various elements of an electric circuit: resistors, capacitors, contactors, motors, relays, fuses, circuit breakers, time delays, timers, etc.
- 4.3. Read and interpret wiring diagrams
  - 4.3.1. Interpret basic types of diagrams: pictorial, schematic and ladder
  - 4.3.2. Explain the use for each type
  - 4.3.3. Describe electrical symbols
  - 4.3.4. Identify individual circuits within the entire diagram
- 4.4. Diagnose electrical problems
  - 4.4.1. Demonstrate the proper use of a multi-meter test instrument
  - 4.4.2. Demonstrate the proper places within the circuit to measure electricity
  - 4.4.3. Interpret and explain meter readings in relationship to a reported problem

#### **HVAC 5.0 — Install, diagnose and service HVACR controls and control components**

- 5.1. Install and replace a temperature control, a pressure control and a solid-state control
- 5.2. Calibrate and adjust a temperature control
- 5.3. Adjust a pressure control
- 5.4. Install, replace and adjust a defrost control
- 5.5. Install and service electrical components
- 5.6. Install, disconnect switch and circuit wiring
- 5.7. Install wiring from disconnect switch to equipment
- 5.8. Install and replace an electric motor
- 5.9. Install and replace electric contactor, current/potential relay, transformer, electric motor, capacitor, solenoid valve coil and circuit board
  - 5.9.1. Explain the purpose of the control component
  - 5.9.2. Describe the procedure to check out the control or control component
  - 5.9.3. Describe the procedure to install or service the control or control component

#### **HVAC 6.0 — Install and service mechanical components**

- 6.1. Install and replace a compressor
  - 6.1.1. Isolate compressor from refrigeration system
  - 6.1.2. Remove refrigerant pressure
  - 6.1.3. Remove compressor from refrigeration system

- 6.1.4. Use correct brazing procedure to prevent copper oxidation
- 6.2. Install and replace evaporators and condensers
  - 6.2.1. Explain purpose of each
  - 6.2.2. Describe operation of each
  - 6.2.3. Measure superheat and sub cooling
  - 6.2.4. Clean condenser and evaporator
- 6.3. Install and replace a filter/drier/cleanup kit, refrigerant metering device, solenoid valve body, sight-glass/moisture indicator and head pressure control
  - 6.3.1. Explain the purpose of the component
  - 6.3.2. Describe the procedure to install or service the component
  - 6.3.3. Isolate component from refrigerant circuit prior to removal/service
  - 6.3.4. Use procedures to prevent moisture contamination
- 6.4. Install and replace refrigerant piping
  - 6.4.1. Cut, swage, flare, bend and braze steel, brass aluminum or copper tubing and fittings
  - 6.4.2. Identify correct applications of different types of brazing filler metals and fluxes
  - 6.4.3. Demonstrate correct preparation of materials
  - 6.4.4. Demonstrate correct brazing procedures including the use of nitrogen to prevent copper oxidation
  - 6.4.5. Complete project that matches a given plan
- 6.5. Install and replace a manifold gauge set
  - 6.5.1. Explain operation of manifold gauge
  - 6.5.2. Identify use of each of the various pressure measurements — absolute, gauge, inches mercury, microns
  - 6.5.3. Calibrate manifold gauge

**HVAC 7.0 — Diagnose and repair common problems in refrigeration systems according to applicable requirements identified by the Refrigeration Service Engineers Society**

- 7.1. Diagnose electrical problems in self-contained refrigerated merchandisers
  - 7.1.1. Use a schematic diagram to trace circuits in equipment
  - 7.1.2. Diagnose problems in single-phase motor circuit
  - 7.1.3. Diagnose merchandiser lighting problems
- 7.2. Diagnose refrigeration problems in self-contained refrigerated merchandisers
  - 7.2.1. Determine reason for frosted evaporator
  - 7.2.2. Explain defrost cycles
- 7.3. Diagnose air flow problems
  - 7.3.1. Check and clean air passages
  - 7.3.2. Check and clean evaporator
  - 7.3.3. Check/replace evaporator fan
  - 7.3.4. Diagnose air pattern disturbances
- 7.4. Diagnose flooded evaporator drain pan
  - 7.4.1. Check condensate drain line for blockage
  - 7.4.2. Explain principles of condensate traps including their application to evaporators mounted in the inlet or outlet of the system blower
- 7.5. Install and replace a plastic pipe
  - 7.5.1. Prepare materials
  - 7.5.2. Demonstrate correct gluing procedure

## **HVAC 8.0 — Diagnose and solve common problems related to air conditioners and heat pumps**

- 8.1. Troubleshoot a refrigerant circuit
  - 8.1.1. Explain the refrigerant circuit and its operation
  - 8.1.2. Demonstrate a systematic approach to diagnosing the cause of an incorrect operation
- 8.2. Troubleshoot an electrical circuit
  - 8.2.1. Explain the electrical circuit and its operation
  - 8.2.2. Demonstrate a systematic approach to diagnosing the cause of an incorrect operation
- 8.3. Test a control thermostat, fuse, capacitor, compressor motor, electric motor and refrigerant metering device
  - 8.3.1. Describe the purpose of each component
  - 8.3.2. Explain the operation of each component
  - 8.3.3. State the proper test methods for each component
  - 8.3.4. Test each component
- 8.4. Inspect a condensate pump and drain, blower assembly and filter
  - 8.4.1. Explain the function of component
  - 8.4.2. Demonstrate inspection procedure
- 8.5. Check refrigerant charge
  - 8.5.1. Read and interpret the equipment manufacturer's procedure for checking charge
  - 8.5.2. Check charge to stated procedure
- 8.6. Check superheat
  - 8.6.1. Explain the function of refrigeration superheat
  - 8.6.2. Demonstrate the procedure to check superheat
- 8.7. Check sub cooling
  - 8.7.1. Explain the function of refrigeration sub cooling
  - 8.7.2. Demonstrate proper procedure to check sub cooling
- 8.8. Check wet-bulb depression
  - 8.8.1. Explain wet-bulb depression
  - 8.8.2. Define the difference from dry-bulb temperature
  - 8.8.3. Demonstrate procedure to check wet-bulb depression

## **HVAC 9.0 — Install and service general heating systems**

- 9.1. Install furnace or blower coil with electric auxiliary heat
  - 9.1.1. Read and interpret the manufacturer's installation instructions
  - 9.1.2. Explain the applicable codes
  - 9.1.3. Demonstrate procedures
- 9.2. Explain operation of the system
  - 9.2.1. Describe the sequence of operation
  - 9.2.2. Explain the safety controls
- 9.3. Service electronic controls, timing devices, sensing devices and solid-state control boards
  - 9.3.1. Describe the function of the component
  - 9.3.2. Demonstrate test procedure
  - 9.3.3. Demonstrate adjustment procedure
- 9.4. Troubleshoot and service various electrical capacitors, relays, contractors, motors, controls, heaters and transformers
  - 9.4.1. Describe the function of the component

- 9.4.2. Demonstrate test procedure for each
- 9.5. Check and adjust gas furnace
  - 9.5.1. Demonstrate gas leak checking procedure
  - 9.5.2. Check line pressure, manifold pressure and firing rate
  - 9.5.3. Explain the principles of gas venting
  - 9.5.4. Explain the effects of altitude on furnace operation and steps needed during setup to compensate
- 9.6. Check and adjust electric heat section in coil blower
  - 9.6.1. Explain operation of electric heat elements
  - 9.6.2. Explain operation of electric heat sequencers
  - 9.6.3. Explain operation of limits, fusible links and other safety devices
  - 9.6.4. Check voltage and amperage draw of electric elements
- 9.7. Service blower in a forced-air system
  - 9.7.1. Explain operation of blower including correct rotation, blower housing and cutoff plate
  - 9.7.2. Describe relationship between system static pressure, air flow and temperature rise
- 9.8. Clean and inspect a heating system
- 9.9. Measure air flow of air handling apparatus
  - 9.9.1. Explain the various measurement methods

#### **HVAC 10.0 — Install and service an air conditioner or heat pump system with auxiliary electric**

- 10.1. Install an air conditioner or heat pump system
  - 10.1.1. Read and interpret the manufacturer's installation instructions
  - 10.1.2. Describe the applicable codes
  - 10.1.3. Demonstrate knowledge of the necessary steps for correct installation
- 10.2. Explain the operation of the system
  - 10.2.1. Explain the sequence of operation
  - 10.2.2. State the purpose of safety controls and their operation
- 10.3. Service electronic controls, timing devices, sensing devices and solid-state control boards
  - 10.3.1. Describe the function of the component
  - 10.3.2. Demonstrate test procedure
  - 10.3.3. Demonstrate adjustment procedure
- 10.4. Troubleshoot and service various electrical capacitors, relays, contractors, motors, controls, heaters and transformers
  - 10.4.1. Describe the function of the component
  - 10.4.2. Demonstrate test procedure
  - 10.4.3. Demonstrate adjustment procedure
- 10.5. Troubleshoot and service various refrigeration components including reversing valves, check/expansion valves and shutoff valves
  - 10.5.1. Describe the function of the component
  - 10.5.2. Demonstrate test procedure
  - 10.5.3. Demonstrate adjustment procedure



## **HVACR 11.0 — Use basic construction designs in HVACR situations**

11.1. Read and interpret basic construction designs for piping/plumbing layouts, room specifications, roofs, ceilings, walls, floors, girders, trusses and duct layout

### **COMMITTEE IDENTIFIED ACADEMIC SKILLS**

The technical committee has identified that the following academic skills are embedded in this competition.

#### **Math Skills**

- Use fractions to solve practical problems
- Use proportions and ratios to solve practical problems
- Simplify numerical expressions
- Solve practical problems involving percentages
- Solve single variable algebraic expressions
- Measure angles
- Find surface area and perimeter of two-dimensional objects
- Find volume and surface area of three-dimensional objects
- Apply transformations (rotate or turn, reflect or flip, translate or slide, and dilate or scale) to geometric figures
- Apply Pythagorean Theorem
- Solve problems using proportions, formulas and functions

#### **Science Skills**

- Plan and conduct a scientific investigation
- Use knowledge of the particle theory of matter
- Describe and recognize solids, liquids and gases
- Use knowledge of physical properties (shape, density, solubility, odor, melting point, boiling point, color)
- Use knowledge of chemical properties (acidity, basicity, combustibility and reactivity)
- Understand the modern model of atomic structure
- Describe phases of matter
- Describe and identify physical changes to matter
- Predict chemical changes to matter (types of reactions, reactants, and products; and balanced equations)
- Use knowledge of potential and kinetic energy
- Use knowledge of mechanical, chemical and electrical energy
- Use knowledge of heat, light and sound energy
- Use knowledge of temperature scales, heat and heat transfer
- Use knowledge of sound and technological applications of sound waves
- Use knowledge of the nature and technological applications of light
- Use knowledge of speed, velocity and acceleration
- Use knowledge of Newton's laws of motion
- Use knowledge of work, force, mechanical advantage, efficiency and power
- Use knowledge of principles of electricity and magnetism

- Use knowledge of static electricity, current electricity and circuits
- Use knowledge of magnetic fields and electromagnets
- Use knowledge of motors and generators

### **Language Arts Skills**

- Provide information in conversations and in group discussions
- Provide information in oral presentations
- Demonstrate use of such verbal communication skills as word choice, pitch, feeling, tone and voice
- Demonstrate use of such nonverbal communication skills as eye contact, posture, and gestures using interviewing techniques to gain information
- Demonstrate comprehension of a variety of informational texts
- Understand source, viewpoint and purpose of texts
- Demonstrate knowledge of appropriate reference materials
- Use print, electronic databases, and online resources to access information in books and articles
- Demonstrate informational writing
- Edit writing for correct grammar, capitalization, punctuation, spelling, sentence structure and paragraphing

## **CONNECTIONS TO NATIONAL STANDARDS**

State-level academic curriculum specialists identified the following connections to national academic standards.

### **Math Standards**

- Numbers and operations
- Algebra
- Geometry
- Measurement
- Data analysis and probability
- Problem solving
- Reasoning and proof
- Communication
- Connections
- Representation

*Source: NCTM Principles and Standards for School Mathematics. For more information, visit: [www.nctm.org](http://www.nctm.org).*

### **Science Standards**

- Understands the structure and properties of matter
- Understands the sources and properties of energy
- Understands forces and motion
- Understands the nature of scientific inquiry

*Source: McREL compendium of national science standards. To view and search the compendium, visit: [www2.mcrel.org/compendium/browse.asp](http://www2.mcrel.org/compendium/browse.asp).*

### **Language Arts Standards**

- Students read a wide range of print and non-print texts to build an understanding of texts, of themselves, and of the cultures of the United States and the world; to acquire new information; to respond to the needs and demands of society and the workplace; and for personal fulfillment. Among these texts are fiction and nonfiction, classic and contemporary works.
- Students apply a wide range of strategies to comprehend, interpret, evaluate and appreciate texts. They draw on their prior experience, their interactions with other readers and writers, their knowledge of word meaning and of other texts, their word identification strategies, and their understanding of textual features (e.g., sound-letter correspondence, sentence structure, context, graphics).
- Students adjust their use of spoken, written and visual language (e.g., conventions, style, vocabulary) to communicate effectively with a variety of audiences and for different purposes.
- Students employ a wide range of strategies as they write and use different writing process elements appropriately to communicate with different audiences for a variety of purposes.
- Students apply knowledge of language structure, language conventions (e.g., spelling and punctuation), media techniques, figurative language, and genre to create, critique and discuss print and nonprint texts.
- Students use spoken, written and visual language to accomplish their own purposes. (e.g., for learning, enjoyment, persuasion, and the exchange of information.)

*Source: IRA/NCTE Standards for the English Language Arts. To view the standards, visit: [www.ncte.org/standards](http://www.ncte.org/standards).*