

ED 388 875

CE 070 293

TITLE Heating, Ventilation, Air-Conditioning, and Refrigeration. Occupational Competency Analysis Profile.

INSTITUTION Ohio State Univ., Columbus. Vocational Instructional Materials Lab.

SPONS AGENCY Ohio State Dept. of Education, Columbus. Div. of Vocational and Adult Education.

PUB DATE 95

NOTE 80p.; For the 1992 edition, see ED 345 074. For other related profiles, see CE 070 281-294.

AVAILABLE FROM Vocational Instructional Materials Lab, Center on Education and Training for Employment, 1900 Kenny Road, Columbus, OH 43210-1090 (order no. OCAP-07R: \$10).

PUB TYPE Guides - Classroom Use - Teaching Guides (For Teacher) (052)

EDRS PRICE MF01/PC04 Plus Postage.

DESCRIPTORS Air Conditioning; Air Conditioning Equipment; Behavioral Objectives; Career Development; \*Competence; Competency Based Education; \*Employment Potential; Entry Workers; \*Heating; \*Job Skills; \*Occupational Information; Postsecondary Education; \*Refrigeration; Refrigeration Mechanics; Secondary Education; Ventilation

IDENTIFIERS DACUM Process; Ohio

## ABSTRACT

This Occupational Competency Analysis Profile (OCAP) contains a competency list verified by expert workers and developed through a modified DACUM (Developing a Curriculum) involving business, industry, labor, and community agency representatives from Ohio. This OCAP identifies the occupational, academic, and employability skills (competencies) needed to enter building climate control occupations. The competencies are clustered into 12 units that cover the following topics: fundamental concepts of human comfort; fundamental concepts of the refrigeration cycle; fundamental concepts of electricity; basic safety procedures; basic shop practices and tools; preventive maintenance; installing refrigeration and air-conditioning equipment; troubleshooting refrigeration and air-conditioning equipment; servicing and repairing refrigeration and air-conditioning equipment; installing heating systems; troubleshooting heating systems; and servicing and repairing heating systems. In addition, employability competencies are grouped into 12 units: career development; decision making and problem solving; work ethic; job-seeking skills; job retention and career advancement skills; technology in the workplace; lifelong learning; economic education; balancing work and family; citizenship in the workplace; leadership; and entrepreneurship. The units detail the knowledge, skills, and attitudes (competency builders) needed to perform each competency. Within the competency list are two levels of items, core items essential for entry-level employment, and items needed to advance in heating, ventilation, air-conditioning, and refrigeration occupations. The OCAP guide also contains an academic job profile based on the Work Keys system that identifies the level of applied academic skills that students must master to qualify for and be successful in their occupations; a total list of academic competencies in communication, mathematics, and science that all students should master; and a specific list of academic competencies needed for heating, ventilation, air-conditioning, and refrigeration occupations. (KC)

ED 388 875

# OAP

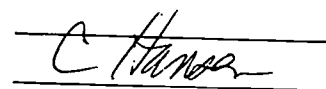
## OCCUPATIONAL COMPETENCY ANALYSIS PROFILE

### HEATING, VENTILATION, AIR-CONDITIONING, AND REFRIGERATION

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## Introduction

### What is an OCAP?

According to the *Action Plan for Accelerating the Modernization of Vocational Education: Ohio's Future at Work*—

A comprehensive and verified employer competency list will be developed and kept current for each program

—Imperative 3, Objective 2—

The Occupational Competency Analysis Profiles (OCAPs) are the Ohio Division of Vocational and Adult Education's response to that objective.

OCAPs are competency lists—verified by expert workers—that evolve from a modified DACUM job analysis process involving business, industry, labor, and community agency representatives from throughout Ohio. The OCAP process is directed by the Vocational Instructional Materials Laboratory located at The Ohio State University's Center on Education and Training for Employment.

### How is the OCAP used?

Each OCAP identifies the occupational, academic, and employability skills (or competencies) needed to enter a given occupation or occupational area. The OCAP not only lists the *competencies* but also clusters those competencies into broader *units* and details the knowledge, skills, and attitudes (*competency builders*) needed to perform each competency.

Within the competency list are two levels of items: core and advancing. *Core items*, which are essential for entry-level employment, are required to be taught and are the basis for questions on the Ohio Vocational Competency Assessment (OVCA). *Advancing items* (marked with an asterisk) are those needed to advance in a given occupation.

School districts may add as many units, competencies, and/or competency builders as desired to reflect local employment needs, trends, and specialties. Local advisory committees should be actively involved in the identification and verification of additional items. Vocational and applied academic instructors will be able to formulate their courses of study using the varied contents of the OCAP and will be able to monitor competency gains via the new criterion-referenced competency testing program, which is tied to the competencies identified on the OCAP.

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# Notes

**Occupational Competency  
Analysis Profile:**

**Heating, Ventilation,  
Air-Conditioning, and  
Refrigeration**

## Unit 1: Fundamental Concepts of Human Comfort

### Competency 1.1: Identify the effects of comfort factors

#### *Competency Builders:*

- 1.1.1 Explain the effects of temperature on human comfort
- 1.1.2 Explain the effects of humidity on human comfort
- 1.1.3 Explain the effects of air circulation on human comfort
- 1.1.4 Explain the effects of indoor air quality on human comfort
- 1.1.5 Explain the effects of air filtration on human comfort
- 1.1.6 Explain the effects of sound levels on human comfort

### Competency 1.2: Evaluate air samples using psychrometrics

#### *Competency Builders:*

- 1.2.1 Measure dry bulb temperature using a sling psychrometer
- 1.2.2 Measure wet bulb temperature using a sling psychrometer
- 1.2.3 Determine relative humidity (RH) using a psychrometric chart
- 1.2.4 Determine the total heat content of air in Btu/lb using a psychrometric chart
- 1.2.5 Determine the specific volume of air at different conditions using a psychrometric chart
- 1.2.6 Determine dew point temperature using a psychrometric chart\*
- 1.2.7 Determine the moisture content of air using a psychrometric chart\*

## Unit 2: Fundamental Concepts of the Refrigeration Cycle

### Competency 2.1: Interpret physical laws as applied to refrigeration

#### *Competency Builders:*

- 2.1.1 Identify the principles of refrigeration
- 2.1.2 Differentiate between sensible and latent heat
- 2.1.3 Define *energy*
- 2.1.4 Identify the types of energy
- 2.1.5 Explain the principles of energy conversion
- 2.1.6 Define *heat*
- 2.1.7 Explain the principles and methods of heat transfer

### Competency 2.2: Analyze mechanical refrigeration cycles and components

#### *Competency Builders:*

- 2.2.1 Explain heat absorption
- 2.2.2 Explain heat rejection
- 2.2.3 Compare the functions of the evaporator, condenser, compressor, piping, and metering device in a refrigeration circuit
- 2.2.4 Compare various refrigerants and their applications
- 2.2.5 Identify different types of refrigeration cycles

**Competency 2.3: Analyze the conditions of refrigerant in refrigeration cycle***Competency Builders:*

- 2.3.1 Measure/record temperature and pressure
- 2.3.2 Calculate/record refrigerant volume
- 2.3.3 Analyze temperature, pressure, and volume relationships
- 2.3.4 Measure/record the saturation temperature of refrigerant
- 2.3.5 Measure/record superheat
- 2.3.6 Measure/record subcooling

**Unit 3: Fundamental Concepts of Electricity****Competency 3.1: Analyze direct current (DC)***Competency Builders:*

- 3.1.1 Apply magnetic principles to electrical theory
- 3.1.2 Differentiate between conducting and insulating materials
- 3.1.3 Determine resistor values
- 3.1.4 Apply Ohm's law
- 3.1.5 Apply Kirchhoff's law
- 3.1.6 Construct series and parallel DC circuits for analysis
- 3.1.7 Measure current, voltage, and resistance in DC circuits
- 3.1.8 Explain simple DC generator action
- 3.1.9 Explain simple DC motor action
- 3.1.10 Identify solid-state switching devices

**Competency 3.2: Analyze alternating current (AC)***Competency Builders:*

- 3.2.1 Construct series and parallel AC circuits for analysis
- 3.2.2 Compare peak (PK), root mean square (RMS), and average values
- 3.2.3 Define *electrical power* and *power factor*
- 3.2.4 Explain the principles of transformers
- 3.2.5 Identify the characteristics of capacitors in series and parallel circuits
- 3.2.6 Measure current, voltage, and resistance in AC circuits
- 3.2.7 Calculate AC power using Ohm's law
- 3.2.8 Explain simple AC generator action
- 3.2.9 Explain simple AC motor action

**Competency 3.3: Use electrical test equipment***Competency Builders:*

- 3.3.1 Measure current using a using clamp-on ammeter
- 3.3.2 Measure voltage, current, and resistance using an analog volt-ohm-milliammeter (AVOM)
- 3.3.3 Measure voltage, current, and resistance using a digital volt-ohm-milliammeter (DVOM)
- 3.3.4 Check high-voltage insulation using a megohmmeter-insulation tester (megger)\*



**Competency 3.4: Apply knowledge of single-phase motors, capacitors, and transformers**

*Competency Builders:*

- 3.4.1 Analyze single-phase motors
- 3.4.2 Analyze capacitors and start-assist devices
- 3.4.3 Analyze single-phase transformers
- 3.4.4 Analyze single-phase motor starting types

**Competency 3.5: Apply knowledge of three-phase motors and transformers**

*Competency Builders:*

- 3.5.1 Identify ways to connect three-phase motors and confirm rotation
- 3.5.2 Identify three-phase transformer connections (wye, delta)
- 3.5.3 Identify three-phase motor starting and protection systems
- 3.5.4 Troubleshoot three-phase motors\*

## **Unit 4: Basic Safety Procedures**

**Competency 4.1: Use personal safety equipment in accordance with Occupational Safety and Health Administration (OSHA) standards**

*Competency Builders:*

- 4.1.1 Wear hard-toed shoes
- 4.1.2 Wear hard hat
- 4.1.3 Wear gloves
- 4.1.4 Secure long hair
- 4.1.5 Wear job-appropriate clothing
- 4.1.6 Wear job-appropriate eye protection
- 4.1.7 Wear job-appropriate hearing protection
- 4.1.8 Wear job-appropriate dust mask

**Competency 4.2: Use safety and fire equipment in accordance with OSHA standards**

*Competency Builders:*

- 4.2.1 Conduct routine inspections of safety apparatus and equipment
- 4.2.2 Follow established procedures for the use of safety apparatus and equipment, including fall protection
- 4.2.3 Conduct routine building/equipment safety inspections
- 4.2.4 Check power sources for potential hazards
- 4.2.5 Confirm proper grounding
- 4.2.6 Shut down power and equipment in dangerous situations using power disconnect switches and lock-out/tag-out procedures
- 4.2.7 Follow established procedures for the use of ladders and scaffolding
- 4.2.8 Select fire extinguisher appropriate for class of fire
- 4.2.9 Demonstrate basic first-aid techniques
- 4.2.10 Acquire CPR certification\*
- 4.2.11 Complete accident reports

**Competency 4.3: Handle hazardous materials**

*Competency Builders:*

- 4.3.1 Identify types of hazardous materials
- 4.3.2 Follow container label precautions
- 4.3.3 Interpret material safety data sheets (MSDSs)
- 4.3.4 Follow procedures specified on MSDSs
- 4.3.5 Store hazardous materials in accordance with Environmental Protection Agency (EPA) specifications
- 4.3.6 Dispose of hazardous materials in accordance with EPA specifications
- 4.3.7 Identify possible asbestos hazards

**Competency 4.4: Handle tools, materials, and equipment in accordance with manufacturers' specifications and OSHA standards for safety**

*Competency Builders:*

- 4.4.1 Identify potential hazards associated with hand and power tools
- 4.4.2 Demonstrate the safe use of hand tools
- 4.4.3 Demonstrate safe handling, lifting, and carrying methods
- 4.4.4 Demonstrate established procedures for operating power tools
- 4.4.5 Demonstrate established procedures for operating power equipment
- 4.4.6 Conduct routine inspections of tools and equipment
- 4.4.7 Maintain hand tools
- 4.4.8 Maintain power tools and equipment

**Unit 5: Basic Shop Practices and Tools**

**Competency 5.1: Perform soldering and brazing procedures**

*Competency Builders:*

- 5.1.1 Identify the compatibility of various alloys, fluxes, and materials
- 5.1.2 Clean tubing and fittings in preparation for soldering/brazing
- 5.1.3 Join materials with 95/5 solder
- 5.1.4 Join materials with low-temperature refrigerant-grade solder
- 5.1.5 Join materials with silver solder
- 5.1.6 Join materials with silver brazing alloy

**Competency 5.2: Demonstrate use of common hand tools**

*Competency Builders:*

- 5.2.1 Demonstrate established procedures for using tools designed to loosen and tighten fasteners (e.g., open-end wrench, box wrench, adjustable wrench, torque wrench, screwdrivers)
- 5.2.2 Demonstrate established procedures for using gripping and holding tools (e.g., pliers, pipe wrenches)
- 5.2.3 Demonstrate established procedures for using cutting tools (e.g., cold chisel, hacksaw)
- 5.2.4 Demonstrate established procedures for using impact tools (e.g., ball peen, soft-faced, and claw hammers; punches)
- 5.2.5 Demonstrate established procedures for using shaping tools (e.g., files)

**Competency 5.3: Demonstrate use of refrigeration specialty tools**

*Competency Builders:*

- 5.3.1 Tighten/loosen refrigeration system valves and fittings using a service valve wrench
- 5.3.2 Cut/strip wire using a wiring tool
- 5.3.3 Crimp solderless connectors using a crimping tool
- 5.3.4 Inspect inaccessible areas or parts using an inspection mirror
- 5.3.5 Cut/ream soft copper and hard-drawn tubing using a tubing cutter
- 5.3.6 Remove burrs from cut tubing using a reamer
- 5.3.7 Shape end of tubing to match a mechanical fitting using a flaring tool
- 5.3.8 Enlarge a piece of tubing for a solder or braze connection using a swaging tool
- 5.3.9 Bend tubing using a mechanical bender
- 5.3.10 Seal off soft copper tubing using a pinch-off tool
- 5.3.11 Straighten the fins on an air-cooled condenser using a fin comb
- 5.3.12 Warm materials (e.g., refrigerant, ice) using a heat gun

**Competency 5.4: Demonstrate use of specialized service and installation equipment**

*Competency Builders:*

- 5.4.1 Charge refrigeration systems with refrigerant using a charging cylinder
- 5.4.2 Remove fluids (e.g., air, moisture) from a system using a vacuum pump
- 5.4.3 Detect differences in temperature level using a thermometer
- 5.4.4 Provide access to systems using a piercing valve (soldered)
- 5.4.5 Add oil to systems using an oil charging pump
- 5.4.6 Measure wet and dry bulb temperatures using a sling psychrometer
- 5.4.7 Measure air velocity in feet per minute using air velocity measuring instruments
- 5.4.8 Check CO content in flue gases using a combustion analyzer kit
- 5.4.9 Check low pressures using a manometer (U-tube or incline)
- 5.4.10 Measure vacuums in systems being evacuated using an electronic vacuum gauge
- 5.4.11 Measure belt tension using a belt tension gauge
- 5.4.12 Charge refrigeration systems by weight using an electronic charging scale
- 5.4.13 Remove refrigerant from systems using refrigerant recovery equipment
- 5.4.14 Analyze system conditions (e.g., operating pressures) using a gauge manifold
- 5.4.15 Add or remove refrigerant or oil using a gauge manifold
- 5.4.16 Measure the acid concentration in the compressor's oil using an acid test kit

**Unit 6: Preventive Maintenance (PM)**

**Competency 6.1: Perform PM on gas-fueled equipment**

*Competency Builders:*

- 6.1.1 Clean pilot
- 6.1.2 Test pilot safety
- 6.1.3 Check ignition
- 6.1.4 Check main gas valve
- 6.1.5 Clean main burner(s)
- 6.1.6 Check main burner(s)

*Continued*

**Competency 6.1: Perform PM on gas-fueled equipment—Continued**

- 6.1.7 Check draft
- 6.1.8 Check for fuel leaks
- 6.1.9 Inspect burner operation and flame characteristics

**Competency 6.2: Perform PM on electric heating equipment**

*Competency Builders:*

- 6.2.1 Measure amperage draw on elements
- 6.2.2 Check operation of sequencers and/or contactors
- 6.2.3 Check condition of electrical connections
- 6.2.4 Verify voltage
- 6.2.5 Inspect heating elements

**Competency 6.3: Perform PM on forced-air furnaces**

*Competency Builders:*

- 6.3.1 Clean reusable filters
- 6.3.2 Replace throwaway filters
- 6.3.3 Clean dirt from blowers
- 6.3.4 Oil motor bearings
- 6.3.5 Check condition of motor bearings (e.g., scoring)
- 6.3.6 Check blower bearings
- 6.3.7 Lubricate blower bearings
- 6.3.8 Check condition of fan belt
- 6.3.9 Adjust fan belt tension
- 6.3.10 Replace defective fan belt
- 6.3.11 Inspect pulleys (e.g., sheaves)
- 6.3.12 Adjust pulley alignment
- 6.3.13 Inspect chimney or vent system
- 6.3.14 Verify combustion air
- 6.3.15 Inspect heat exchanger
- 6.3.16 Test fan control
- 6.3.17 Test limit switches
- 6.3.18 Inspect wiring
- 6.3.19 Tighten wiring connections
- 6.3.20 Clean thermostat
- 6.3.21 Check thermostat
- 6.3.22 Verify anticipator setting
- 6.3.23 Verify operation of system by thermostat
- 6.3.24 Check temperature rise

**Competency 6.4: Perform PM on air handlers**

*Competency Builders:*

- 6.4.1 Clean reusable filters
- 6.4.2 Replace throwaway filters
- 6.4.3 Clean dirt from blowers

*Continued*

**Competency 6.4: Perform PM on air handlers—Continued**

- 6.4.4 Oil motor bearings
- 6.4.5 Check condition of motor bearings (e.g., scoring)
- 6.4.6 Check blower bearings
- 6.4.7 Lubricate blower bearings
- 6.4.8 Check condition of fan belt
- 6.4.9 Adjust fan belt tension
- 6.4.10 Replace defective fan belt
- 6.4.11 Inspect pulleys (e.g., sheaves)
- 6.4.12 Adjust pulley alignment
- 6.4.13 Clean dirt from heating coil
- 6.4.14 Test fan control
- 6.4.15 Test limit switches
- 6.4.16 Inspect wiring
- 6.4.17 Tighten wiring connections
- 6.4.18 Clean thermostat
- 6.4.19 Check thermostat
- 6.4.20 Verify anticipator setting

**Competency 6.5: Perform PM on electronic air cleaners**

*Competency Builders:*

- 6.5.1 Disconnect power supply
- 6.5.2 Verify discharge
- 6.5.3 Remove prefilter and cells
- 6.5.4 Clean prefilter and cells
- 6.5.5 Check ionizer wires
- 6.5.6 Test power pack
- 6.5.7 Reinstall dry components

**Competency 6.6: Perform PM on humidifiers**

*Competency Builders:*

- 6.6.1 Disconnect power supply
- 6.6.2 Verify that power is off
- 6.6.3 Shut off water supply
- 6.6.4 Clean water pan
- 6.6.5 Clean pads or drum
- 6.6.6 Replace defective pads or drum
- 6.6.7 Check motor
- 6.6.8 Check water valve and supply
- 6.6.9 Clean drain line
- 6.6.10 Check drain line for obstructions
- 6.6.11 Check humidistat operation

**Competency 6.7: Perform PM on indoor section of air conditioners or heat pumps**

*Competency Builders:*

- 6.7.1 Disconnect power supply
- 6.7.2 Verify that power is off
- 6.7.3 Inspect coil
- 6.7.4 Clean coil
- 6.7.5 Clean drain pan
- 6.7.6 Clean drain line and trap
- 6.7.7 Check for indications of leaks
- 6.7.8 Check for temperature differential (TD) across coil

**Competency 6.8: Perform PM on outdoor section of air conditioners or heat pumps**

*Competency Builders:*

- 6.8.1 Disconnect power supply
- 6.8.2 Verify that power is off
- 6.8.3 Inspect coil
- 6.8.4 Clean coil
- 6.8.5 Inspect fan blades
- 6.8.6 Lubricate fan motor
- 6.8.7 Inspect contactors and electrical components
- 6.8.8 Inspect wiring
- 6.8.9 Tighten wiring connections
- 6.8.10 Inspect refrigeration lines
- 6.8.11 Inspect for signs of leaks
- 6.8.12 Connect power
- 6.8.13 Check compressor noise level at start-up
- 6.8.14 Measure/record compressor amperage
- 6.8.15 Check fan operation and rotation
- 6.8.16 Check operation of reversing valve
- 6.8.17 Check operation of defrost controls

## **Unit 7: Installing Refrigeration and Air-Conditioning Equipment**

**Competency 7.1: Install window air conditioners**

*Competency Builders:*

- 7.1.1 Verify that equipment received matches specifications
- 7.1.2 Interpret equipment installation instructions
- 7.1.3 Verify availability of power supply compatible with voltage and current requirements of unit
- 7.1.4 Install unit in accordance with installation instructions
- 7.1.5 Verify unit operation
- 7.1.6 Instruct customer concerning unit operation

**Competency 7.2: Install central air conditioners and heat pumps**

*Competency Builders:*

- 7.2.1 Verify that equipment received matches specifications
- 7.2.2 Interpret equipment installation instructions
- 7.2.3 Verify availability of power supply compatible with voltage and current requirements of unit
- 7.2.4 Install base for outdoor unit
- 7.2.5 Install outdoor unit
- 7.2.6 Install indoor coil
- 7.2.7 Connect vapor and liquid lines between indoor coil and outdoor unit
- 7.2.8 Evacuate vapor and liquid lines
- 7.2.9 Install power supply
- 7.2.10 Install low-voltage system
- 7.2.11 Perform start-up procedures
- 7.2.12 Verify system operation
- 7.2.13 Instruct customer concerning system operation

**Competency 7.3: Install self-contained commercial refrigeration units**

*Competency Builders:*

- 7.3.1 Verify that equipment received matches specifications
- 7.3.2 Interpret equipment installation instructions
- 7.3.3 Verify availability of power supply compatible with voltage and current requirements of unit
- 7.3.4 Connect power supply
- 7.3.5 Perform start-up procedures
- 7.3.6 Verify unit operation
- 7.3.7 Instruct customer concerning unit operation

**Competency 7.4: Install remote condensing units with single cabinet**

*Competency Builders:*

- 7.4.1 Verify that equipment received matches specifications
- 7.4.2 Interpret equipment installation instructions
- 7.4.3 Verify availability of power supply compatible with voltage and current requirements of unit
- 7.4.4 Install condensing unit
- 7.4.5 Install vapor and liquid lines
- 7.4.6 Pressure-test system
- 7.4.7 Evacuate system
- 7.4.8 Charge system
- 7.4.9 Perform start-up procedures
- 7.4.10 Verify unit operation
- 7.4.11 Instruct customer concerning unit operation

**Competency 7.5: Install remote commercial condensing units with multiple cabinets\****Competency Builders:*

- 7.5.1 Verify that equipment received matches specifications\*
- 7.5.2 Interpret equipment installation instructions\*
- 7.5.3 Verify availability of power supply compatible with voltage and current requirements of unit\*
- 7.5.4 Install condensing unit\*
- 7.5.5 Install vapor and liquid lines\*
- 7.5.6 Pressure-test system\*
- 7.5.7 Evacuate system\*
- 7.5.8 Charge system\*
- 7.5.9 Perform start-up procedures\*
- 7.5.10 Verify unit operation\*
- 7.5.11 Instruct customer concerning unit operation\*

**Unit 8: Troubleshooting Refrigeration and Air-Conditioning Equipment****Competency 8.1: Perform basic HVAC/R troubleshooting***Competency Builders:*

- 8.1.1 Confirm complaint
- 8.1.2 Identify whether the problem is mechanical or electrical
- 8.1.3 Identify probable cause(s) of problem
- 8.1.4 Isolate source(s) of problem
- 8.1.5 Verify source(s) of problem through testing
- 8.1.6 Determine repair strategy

**Competency 8.2: Analyze compressor and power supply components***Competency Builders:*

- 8.2.1 Check power supply and voltage specifications
- 8.2.2 Isolate compressor
- 8.2.3 Check compressor windings
- 8.2.4 Verify internal electrical integrity of compressor using a start cord
- 8.2.5 Isolate circuitry
- 8.2.6 Ohm-check components

**Competency 8.3: Analyze capacitor***Competency Builders:*

- 8.3.1 Disconnect power supply
- 8.3.2 Verify that power is off
- 8.3.3 Discharge capacitor
- 8.3.4 Remove capacitor
- 8.3.5 Inspect capacitor
- 8.3.6 Test capacitor



**Competency 8.4: Analyze system pressures in units with service valves**

*Competency Builders:*

- 8.4.1 Check gauge calibration
- 8.4.2 Remove service caps
- 8.4.3 Connect manifold and gauges to service valves
- 8.4.4 Purge hoses
- 8.4.5 Check pressures
- 8.4.6 Remove gauge manifold
- 8.4.7 Replace service caps
- 8.4.8 Perform leak test

**Competency 8.5: Analyze system pressures in units without service valves**

*Competency Builders:*

- 8.5.1 Install sweat-type service valve in accordance with manufacturer's specifications
- 8.5.2 Install gauge manifold
- 8.5.3 Purge line
- 8.5.4 Check pressures
- 8.5.5 Remove gauge manifold
- 8.5.6 Replace valve cap
- 8.5.7 Perform leak test

**Competency 8.6: Examine oil level and sight glass moisture indicator**

*Competency Builders:*

- 8.6.1 Check unit operation
- 8.6.2 Check oil level
- 8.6.3 Check moisture indicator
- 8.6.4 Check oil condition in open systems

**Competency 8.7: Locate leaks in charged refrigeration systems**

*Competency Builders:*

- 8.7.1 Check for signs of oil
- 8.7.2 Check for leaks using an electronic leak detector
- 8.7.3 Check for leaks using soap bubbles
- 8.7.4 Check for leaks using a halide leak detector
- 8.7.5 Explain the nitrogen boost technique
- 8.7.6 Explain the fluorescence leak-detection technique\*

**Competency 8.8: Locate leaks in refrigeration systems without refrigerant charge**

*Competency Builders:*

- 8.8.1 Explain the nitrogen isolation technique
- 8.8.2 Connect manifold and gauges
- 8.8.3 Add a trace of R22 refrigerant
- 8.8.4 Add nitrogen up to low-side test pressure
- 8.8.5 Check system using leak detector appropriate to given situation

**Competency 8.9: Analyze circuitry of refrigeration electrical defrost element**

*Competency Builders:*

- 8.9.1 Disconnect power supply
- 8.9.2 Verify that power is off
- 8.9.3 Isolate defrost circuitry
- 8.9.4 Inspect defrost element
- 8.9.5 Ohm-check element

**Competency 8.10: Check refrigeration control thermostat**

*Competency Builders:*

- 8.10.1 Determine actual cut-in and cut-out temperatures
- 8.10.2 Compare actual readings to manufacturer's specifications
- 8.10.3 Adjust thermostat in accordance with manufacturer's specifications
- 8.10.4 Verify thermostat operation

**Competency 8.11: Analyze circulation fan motor**

*Competency Builders:*

- 8.11.1 Verify availability of power supply compatible with voltage and current requirements of unit
- 8.11.2 Disconnect power supply
- 8.11.3 Verify that power is off
- 8.11.4 Check mechanical elements
- 8.11.5 Ohm-check motor winding
- 8.11.6 Check run capacitor
- 8.11.7 Reconnect power
- 8.11.8 Verify rotation
- 8.11.9 Check amperage draw relative to nameplate specifications

**Competency 8.12: Check blower assembly and filter**

*Competency Builders:*

- 8.12.1 Disconnect power supply
- 8.12.2 Verify that power is off
- 8.12.3 Clean filters
- 8.12.4 Replace filters according to airflow direction
- 8.12.5 Verify blower operation
- 8.12.6 Inspect blower assembly
- 8.12.7 Clean blower assembly
- 8.12.8 Lubricate blower assembly
- 8.12.9 Adjust blower assembly

**Competency 8.13: Check condensate pump and drain**

*Competency Builders:*

- 8.13.1 Disconnect power supply
- 8.13.2 Verify that power is off
- 8.13.3 Clean pump assembly
- 8.13.4 Check drain trap and check valve
- 8.13.5 Check pump operation

**Competency 8.14: Check humidistat using a sling psychrometer**

*Competency Builders:*

- 8.14.1 Prepare psychrometer for use
- 8.14.2 Measure wet and dry bulb temperature using a sling psychrometer
- 8.14.3 Determine relative humidity (RH) using a psychrometric chart
- 8.14.4 Verify humidistat calibration

**Competency 8.15: Check system for burnout\***

*Competency Builders:*

- 8.15.1 Recover refrigerant\*
- 8.15.2 Remove compressor\*
- 8.15.3 Conduct test for burnout\*
- 8.15.4 Install cleanup kit\*
- 8.15.5 Remove cleanup kit\*
- 8.15.6 Replace compressor\*
- 8.15.7 Perform final cleanup\*

**Competency 8.16: Check heat pump reversing valve**

*Competency Builders:*

- 8.16.1 Energize system
- 8.16.2 Identify present operating mode (i.e., heating or cooling)
- 8.16.3 Switch modes
- 8.16.4 Verify reversing valve operation

**Competency 8.17: Check heat pump defrost solenoid valve**

*Competency Builders:*

- 8.17.1 Check unit for ice buildup
- 8.17.2 Check mechanical operation of unit
- 8.17.3 Verify solenoid continuity
- 8.17.4 Verify defrost timer operation
- 8.17.5 Verify defrost operation

**Competency 8.18: Check ice maker**

*Competency Builders:*

- 8.18.1 Verify operation of system in accordance with specifications of original equipment manufacturer (OEM)
- 8.18.2 Check water valve
- 8.18.3 Check electrical system
- 8.18.4 Check mechanical system
- 8.18.5 Verify system operation

**Competency 8.19: Check oil pressure control\***

*Competency Builders:*

- 8.19.1 Locate control\*
- 8.19.2 Check compressor oil level\*
- 8.19.3 Check pressures\*
- 8.19.4 Check assembly for level\*

**Competency 8.20: Check refrigerant pressure safety controls\***

*Competency Builders:*

- 8.20.1 Locate control\*
- 8.20.2 Inspect control\*
- 8.20.3 Check pressures\*
- 8.20.4 Adjust control operation to manufacturer's specifications\*
- 8.20.5 Verify control performance\*

**Competency 8.21: Check thermostatic expansion valve**

*Competency Builders:*

- 8.21.1 Locate valve
- 8.21.2 Inspect valve
- 8.21.3 Verify location and mounting of sensing bulb
- 8.21.4 Determine superheat at bulb
- 8.21.5 Adjust valve
- 8.21.6 Verify valve performance

**Competency 8.22: Check automatic expansion valve\***

*Competency Builders:*

- 8.22.1 Locate valve\*
- 8.22.2 Inspect valve\*
- 8.22.3 Check system pressures\*
- 8.22.4 Verify valve operation\*
- 8.22.5 Adjust valve\*
- 8.22.6 Verify valve performance\*

## **Unit 9: Servicing and Repairing Refrigeration and Air-Conditioning Equipment**

### **Competency 9.1: Obtain required certifications for the handling of refrigerants**

#### *Competency Builders:*

- 9.1.1 Identify requirements for EPA technician certification
- 9.1.2 Identify requirements for EPA refrigeration recovery/recycling equipment certification
- 9.1.3 Complete EPA documentation
- 9.1.4 Obtain EPA technician certification

### **Competency 9.2: Recover refrigerant from a sealed system**

#### *Competency Builders:*

- 9.2.1 Follow safety procedures established for refrigerant handling
- 9.2.2 Follow safety procedures established for filling recovery cylinders
- 9.2.3 Connect recovery equipment to system
- 9.2.4 Recover refrigerant using recovery equipment
- 9.2.5 Label recovery cylinders

### **Competency 9.3: Evacuate refrigeration system**

#### *Competency Builders:*

- 9.3.1 Connect manifold and gauges
- 9.3.2 Recover refrigerant
- 9.3.3 Evacuate system to desired micron reading
- 9.3.4 Perform standing vacuum leak test

### **Competency 9.4: Recharge system by weighing-in refrigerant**

#### *Competency Builders:*

- 9.4.1 Connect manifold and gauges
- 9.4.2 Evacuate system in accordance with manufacturer's specifications
- 9.4.3 Confirm recommended refrigerant amount and type
- 9.4.4 Connect refrigerant tank to gauge manifold
- 9.4.5 Purge charging hose
- 9.4.6 Weigh-in system charge to nameplate specifications
- 9.4.7 Test for leaks
- 9.4.8 Verify system operation

**Competency 9.5: Recharge refrigeration system using charging cylinder***Competency Builders:*

- 9.5.1 Connect manifold and gauges
- 9.5.2 Determine recommended refrigerant amount and type
- 9.5.3 Evacuate system in accordance with manufacturer's specifications
- 9.5.4 Evacuate charging cylinder
- 9.5.5 Connect charging cylinder to supply tank
- 9.5.6 Purge charging hose
- 9.5.7 Fill charging cylinder
- 9.5.8 Charge to manufacturer's specifications
- 9.5.9 Test for leaks
- 9.5.10 Verify system operation

**Competency 9.6: Pump system down into refrigerant receiver***Competency Builders:*

- 9.6.1 Prepare system
- 9.6.2 Connect manifold and gauges
- 9.6.3 Purge hoses
- 9.6.4 Close king valve on receiver outlet
- 9.6.5 Monitor high-side pressure during pump down
- 9.6.6 Monitor low-side gauge
- 9.6.7 Stop compressor at one pound per square inch gauge (psig)

**Competency 9.7: Repair leaks in system lines***Competency Builders:*

- 9.7.1 Survey area of repair identified during troubleshooting
- 9.7.2 Recover refrigerant
- 9.7.3 Patch leak using technique appropriate for materials involved
- 9.7.4 Install new or replacement dryer
- 9.7.5 Evacuate system
- 9.7.6 Recharge system
- 9.7.7 Perform leak test
- 9.7.8 Verify system operation

**Competency 9.8: Replace drier***Competency Builders:*

- 9.8.1 Select drier to match type being replaced
- 9.8.2 Prepare system for repair (recover or pump down)
- 9.8.3 Remove old drier
- 9.8.4 Install replacement drier
- 9.8.5 Evacuate system
- 9.8.6 Recharge system
- 9.8.7 Verify system operation

**Competency 9.9: Replace capillary tube or fixed orifice metering device**

*Competency Builders:*

- 9.9.1 Select capillary tube or fixed orifice metering device to match type being replaced
- 9.9.2 Prepare system for repair (recover or pump down)
- 9.9.3 Remove old capillary tube or fixed orifice metering device
- 9.9.4 Install replacement capillary tube or fixed orifice metering device
- 9.9.5 Close up system
- 9.9.6 Verify system operation

**Competency 9.10: Replace high-pressure control (HPC) or low-pressure control (LPC)**

*Competency Builders:*

- 9.10.1 Select control to match type being replaced
- 9.10.2 Isolate control
- 9.10.3 Remove old control
- 9.10.4 Install replacement control
- 9.10.5 Adjust replacement control
- 9.10.6 Verify system operation

**Competency 9.11: Replace compressor\***

*Competency Builders:*

- 9.11.1 Disconnect power supply\*
- 9.11.2 Verify that power is off\*
- 9.11.3 Recover refrigerant\*
- 9.11.4 Select compressor to match type being replaced\*
- 9.11.5 Remove old compressor\*
- 9.11.6 Install replacement compressor\*
- 9.11.7 Select drier to match type being replaced\*
- 9.11.8 Remove old drier\*
- 9.11.9 Install replacement drier\*
- 9.11.10 Evacuate system\*
- 9.11.11 Recharge system\*
- 9.11.12 Verify system operation\*

**Competency 9.12: Replace thermostat**

*Competency Builders:*

- 9.12.1 Disconnect power supply
- 9.12.2 Verify that power is off
- 9.12.3 Select thermostat to match type being replaced
- 9.12.4 Remove old thermostat
- 9.12.5 Install replacement thermostat
- 9.12.6 Verify system operation

**Competency 9.13: Replace fan motor***Competency Builders:*

- 9.13.1 Disconnect power supply
- 9.13.2 Verify that power is off
- 9.13.3 Select motor to match type being replaced
- 9.13.4 Remove old motor
- 9.13.5 Install replacement motor
- 9.13.6 Verify rotation and pitch

**Competency 9.14: Replace overload protector for the compressor motor***Competency Builders:*

- 9.14.1 Disconnect power supply
- 9.14.2 Verify that power is off
- 9.14.3 Select overload protector to match type being replaced
- 9.14.4 Remove old overload protector
- 9.14.5 Install replacement overload protector
- 9.14.6 Verify system operation

**Competency 9.15: Replace start capacitor***Competency Builders:*

- 9.15.1 Disconnect power supply
- 9.15.2 Verify that power is off
- 9.15.3 Discharge capacitor
- 9.15.4 Select capacitor to match type being replaced
- 9.15.5 Remove old capacitor
- 9.15.6 Install replacement capacitor
- 9.15.7 Install bleed resistor
- 9.15.8 Verify system operation

**Competency 9.16: Replace defrost heater***Competency Builders:*

- 9.16.1 Disconnect power supply
- 9.16.2 Verify that power is off
- 9.16.3 Select heater to match type being replaced
- 9.16.4 Remove old heater
- 9.16.5 Install replacement heater
- 9.16.6 Verify system operation



**Competency 9.17: Replace defrost terminator**

*Competency Builders:*

- 9.17.1 Disconnect power supply
- 9.17.2 Verify that power is off
- 9.17.3 Select terminator to match type being replaced
- 9.17.4 Remove old terminator
- 9.17.5 Install replacement terminator
- 9.17.6 Verify system operation

**Competency 9.18: Replace defrost timer**

*Competency Builders:*

- 9.18.1 Disconnect power supply
- 9.18.2 Verify that power is off
- 9.18.3 Select timer to match type being replaced
- 9.18.4 Remove old timer
- 9.18.5 Install replacement timer
- 9.18.6 Verify system operation

**Competency 9.19: Replace relay**

*Competency Builders:*

- 9.19.1 Disconnect power supply
- 9.19.2 Verify that power is off
- 9.19.3 Select relay to match type being replaced
- 9.19.4 Remove old relay
- 9.19.5 Install replacement relay
- 9.19.6 Verify system operation

**Competency 9.20: Check system airflow\***

*Competency Builders:*

- 9.20.1 Record air temperature at both supply and return ducts\*
- 9.20.2 Calculate temperature differential (TD)\*
- 9.20.3 Adjust blower speed to achieve manufacturer-recommended differential\*
- 9.20.4 Verify system operation\*

**Competency 9.21: Replace oil-pressure safety control\***

*Competency Builders:*

- 9.21.1 Select control to match type being replaced\*
- 9.21.2 Isolate control\*
- 9.21.3 Remove old control\*
- 9.21.4 Install replacement control\*
- 9.21.5 Perform leak test\*
- 9.21.6 Verify system operation\*

**Competency 9.22: Replace reversing valve\***

*Competency Builders:*

- 9.22.1 Disconnect power supply\*
- 9.22.2 Verify that power is off\*
- 9.22.3 Recover refrigerant from system\*
- 9.22.4 Select valve to match type being replaced\*
- 9.22.5 Remove old valve\*
- 9.22.6 Install replacement valve\*
- 9.22.7 Perform leak test\*
- 9.22.8 Evacuate system\*
- 9.22.9 Charge system\*
- 9.22.10 Verify system operation\*

**Competency 9.23: Replace thermostatic expansion valve (TEV or TXV)**

*Competency Builders:*

- 9.23.1 Disconnect power supply
- 9.23.2 Verify that power is off
- 9.23.3 Recover refrigerant from system
- 9.23.4 Select valve to match type being replaced
- 9.23.5 Remove old valve
- 9.23.6 Install replacement valve
- 9.23.7 Perform leak test
- 9.23.8 Evacuate system
- 9.23.9 Charge system
- 9.23.10 Test replacement valve performance
- 9.23.11 Adjust valve
- 9.23.12 Verify system operation

**Competency 9.24: Replace automatic expansion valve (AEV)\***

*Competency Builders:*

- 9.24.1 Disconnect power supply\*
- 9.24.2 Verify that power is off\*
- 9.24.3 Recover refrigerant from system\*
- 9.24.4 Select valve to match type being replaced\*
- 9.24.5 Remove old valve\*
- 9.24.6 Install replacement valve\*
- 9.24.7 Perform leak test\*
- 9.24.8 Evacuate system\*
- 9.24.9 Charge system\*
- 9.24.10 Test replacement valve performance\*
- 9.24.11 Adjust valve\*
- 9.24.12 Verify system operation\*

**Competency 9.25: Add oil to refrigeration system**

*Competency Builders:*

- 9.25.1 Select oil appropriate for refrigerant in system
- 9.25.2 Add oil using technique appropriate for system
- 9.25.3 Verify system operation

**Unit 10: Installing Heating Systems\***

**Competency 10.1: Install forced-air heating system\***

*Competency Builders:*

- 10.1.1 Evaluate customer needs\*
- 10.1.2 Survey structure to determine physical requirements\*
- 10.1.3 Calculate design heat loss\*
- 10.1.4 Select equipment in accordance with established needs and requirements\*
- 10.1.5 Design duct system\*
- 10.1.6 Remove old duct work\*
- 10.1.7 Fabricate new duct work\*
- 10.1.8 Install new distribution system\*
- 10.1.9 Verify system operation\*
- 10.1.10 Clean area\*
- 10.1.11 Instruct customer concerning system operation\*

**Competency 10.2: Install gas heating unit\***

*Competency Builders:*

- 10.2.1 Verify that equipment received matches specifications\*
- 10.2.2 Remove old unit\*
- 10.2.3 Position/level new unit\*
- 10.2.4 Install duct work and flue\*
- 10.2.5 Connect fuel supply\*
- 10.2.6 Connect electrical lines\*
- 10.2.7 Perform start-up in accordance with manufacturer's specifications\*
- 10.2.8 Test safety controls\*
- 10.2.9 Balance air side of system using dampers\*
- 10.2.10 Verify system operation\*
- 10.2.11 Clean area\*
- 10.2.12 Instruct customer concerning system operation\*

**Competency 10.3: Install electric heating unit\***

*Competency Builders:*

- 10.3.1 Verify that equipment received matches specifications\*
- 10.3.2 Remove old unit\*
- 10.3.3 Position/level new unit\*
- 10.3.4 Install duct work\*
- 10.3.5 Connect electrical lines\*
- 10.3.6 Perform start-up in accordance with manufacturer's specifications\*
- 10.3.7 Test safety controls\*
- 10.3.8 Balance air side of system using dampers\*
- 10.3.9 Verify system operation\*
- 10.3.10 Clean area\*
- 10.3.11 Instruct customer concerning system operation\*

**Competency 10.4: Install oil heating unit\***

*Competency Builders:*

- 10.4.1 Verify that equipment received matches specifications\*
- 10.4.2 Remove old unit\*
- 10.4.3 Position/level new unit\*
- 10.4.4 Install duct work and flue\*
- 10.4.5 Connect fuel supply\*
- 10.4.6 Connect electrical lines\*
- 10.4.7 Perform start-up in accordance with manufacturer's specifications\*
- 10.4.8 Test safety controls\*
- 10.4.9 Balance air side of system using dampers\*
- 10.4.10 Verify system operation\*
- 10.4.11 Clean area\*
- 10.4.12 Instruct customer concerning system operation\*

**Competency 10.5: Install water-to-air heat pump\***

*Competency Builders:*

- 10.5.1 Verify that equipment received matches specifications\*
- 10.5.2 Verify availability of power supply compatible with voltage and current requirements of unit\*
- 10.5.3 Position/level unit\*
- 10.5.4 Install duct work\*
- 10.5.5 Install water piping\*
- 10.5.6 Test safety controls\*
- 10.5.7 Balance air side of system using dampers\*
- 10.5.8 Verify system operation\*
- 10.5.9 Instruct customer concerning system operation\*

**Competency 10.6: Install active solar heating system\***

*Competency Builders:*

- 10.6.1 Verify that collector panels received match building requirements\*
- 10.6.2 Position collector panels\*
- 10.6.3 Install collector panels\*
- 10.6.4 Install storage tank\*
- 10.6.5 Install indoor coil\*
- 10.6.6 Install interconnecting tubing\*
- 10.6.7 Install control system\*
- 10.6.8 Test safety controls\*
- 10.6.9 Balance air side of system using dampers\*
- 10.6.10 Verify system operation\*
- 10.6.11 Instruct customer concerning system operation\*

**Unit 11: Troubleshooting Heating Systems**

**Competency 11.1: Check gas pilot and thermocouple assembly**

*Competency Builders:*

- 11.1.1 Follow established gas safety procedures
- 11.1.2 Check thermocouple output
- 11.1.3 Check safety pilot operation
- 11.1.4 Verify pilot operation

**Competency 11.2: Check wall thermostat**

*Competency Builders:*

- 11.2.1 Level thermostat
- 11.2.2 Clean thermostat
- 11.2.3 Verify that heat anticipator setting matches circuit
- 11.2.4 Verify thermostat set point
- 11.2.5 Verify system operation

**Competency 11.3: Check gas valve assembly**

*Competency Builders:*

- 11.3.1 Follow established gas safety procedures
- 11.3.2 Verify voltage
- 11.3.3 Test valve performance
- 11.3.4 Verify system operation

**Competency 11.4: Check gas manifold pressure***Competency Builders:*

- 11.4.1 Follow established gas safety procedures
- 11.4.2 Shut off gas supply to main gas valve
- 11.4.3 Locate manifold
- 11.4.4 Remove plug
- 11.4.5 Connect manometer
- 11.4.6 Turn on gas
- 11.4.7 Start system
- 11.4.8 Verify that regulator matches manufacturer's or utility's specifications
- 11.4.9 Conduct operational check
- 11.4.10 Shut off gas supply
- 11.4.11 Remove manometer
- 11.4.12 Replace plug
- 11.4.13 Perform leak test
- 11.4.14 Verify system operation

**Competency 11.5: Check solid-state ignition systems on gas units***Competency Builders:*

- 11.5.1 Follow established gas safety procedures
- 11.5.2 Locate ignition module
- 11.5.3 Check electrode or hot surface ignitor for physical damage
- 11.5.4 Disassemble ignitor
- 11.5.5 Clean ignition assembly
- 11.5.6 Reinstall ignition assembly
- 11.5.7 Start up system with power on and thermostat turned up
- 11.5.8 Verify gas and ignition
- 11.5.9 Shut down system

**Competency 11.6: Check fan control***Competency Builders:*

- 11.6.1 Locate fan control
- 11.6.2 Start up system with power on and thermostat turned up
- 11.6.3 Verify fan "on" setting
- 11.6.4 Turn thermostat down
- 11.6.5 Verify fan "off" setting

**Competency 11.7: Check limit control***Competency Builders:*

- 11.7.1 Locate limit control
- 11.7.2 Start up system with power on and thermostat turned up
- 11.7.3 Test limit control for "off" operation
- 11.7.4 Turn thermostat down
- 11.7.5 Test limit control for "on" operation

**Competency 11.8: Check heat exchanger**

*Competency Builders:*

- 11.8.1 Inspect heat exchanger
- 11.8.2 Check for erratic flame pattern on pilot and main burner before and after blower is turned on
- 11.8.3 Conduct inert gas test
- 11.8.4 Verify system operation

**Competency 11.9: Check oil ignition system**

*Competency Builders:*

- 11.9.1 Verify voltage supply to unit
- 11.9.2 Verify ignition transformer voltage
- 11.9.3 Start up system with power on and thermostat turned up
- 11.9.4 Check for ignition
- 11.9.5 Shut down system
- 11.9.6 Verify that ignition is off

**Competency 11.10: Check oil pump**

*Competency Builders:*

- 11.10.1 Check inlet strainer
- 11.10.2 Start up system with power on and thermostat turned up
- 11.10.3 Check pump pressure
- 11.10.4 Perform leak test
- 11.10.5 Shut down system

**Competency 11.11: Check oil supply**

*Competency Builders:*

- 11.11.1 Check oil level in storage tank
- 11.11.2 Check storage tank for water
- 11.11.3 Inspect oil filter
- 11.11.4 Check distribution lines and valves
- 11.11.5 Check pitch on storage tank

**Competency 11.12: Troubleshoot mid- and high-efficiency power vented systems**

*Competency Builders:*

- 11.12.1 Check power supply to motor
- 11.12.2 Start up system with power on and thermostat turned up
- 11.12.3 Prove airflow
- 11.12.4 Check pressure switch operation
- 11.12.5 Inspect pressure switch tubing for restrictions or condensate
- 11.12.6 Inspect condensate drain system

## Unit 12: Servicing and Repairing Heating Systems

### Competency 12.1: Adjust residential-type oil burner\*

#### *Competency Builders:*

- 12.1.1 Conduct preliminary inspection of unit\*
- 12.1.2 Adjust pump pressure\*
- 12.1.3 Adjust barometric damper\*
- 12.1.4 Perform smoke test\*
- 12.1.5 Perform flue gas analysis\*
- 12.1.6 Measure flue gas temperature\*
- 12.1.7 Adjust burners to specified efficiency\*
- 12.1.8 Verify system operation\*

### Competency 12.2: Assist in replacing heat exchanger

#### *Competency Builders:*

- 12.2.1 Disconnect power supply
- 12.2.2 Verify that power is off
- 12.2.3 Verify that equipment received matches specifications
- 12.2.4 Remove old heat exchanger
- 12.2.5 Install replacement heat exchanger
- 12.2.6 Verify system operation

### Competency 12.3: Replace limit control

#### *Competency Builders:*

- 12.3.1 Disconnect power supply
- 12.3.2 Verify that power is off
- 12.3.3 Select control to match type being replaced
- 12.3.4 Remove old control
- 12.3.5 Install replacement control
- 12.3.6 Verify system operation

### Competency 12.4: Replace fan control

#### *Competency Builders:*

- 12.4.1 Disconnect power supply
- 12.4.2 Verify that power is off
- 12.4.3 Select control to match type being replaced
- 12.4.4 Remove old control
- 12.4.5 Install replacement control
- 12.4.6 Verify system operation



**Competency 12.5: Replace combination fan/limit control**

*Competency Builders:*

- 12.5.1 Disconnect power supply
- 12.5.2 Verify that power is off
- 12.5.3 Select control to match type being replaced
- 12.5.4 Remove old control
- 12.5.5 Install replacement control
- 12.5.6 Verify system operation

**Competency 12.6: Replace gas valve assembly**

*Competency Builders:*

- 12.6.1 Disconnect power supply
- 12.6.2 Verify that power is off
- 12.6.3 Turn off gas supply at source
- 12.6.4 Select valve to match type being replaced
- 12.6.5 Remove old valve
- 12.6.6 Install replacement valve
- 12.6.7 Test performance of replacement valve
- 12.6.8 Perform leak test
- 12.6.9 Check thermostat anticipator
- 12.6.10 Adjust thermostat anticipator
- 12.6.11 Verify system operation

**Competency 12.7: Replace wall thermostat**

*Competency Builders:*

- 12.7.1 Disconnect power supply
- 12.7.2 Verify that power is off
- 12.7.3 Select thermostat to match type being replaced
- 12.7.4 Remove old thermostat
- 12.7.5 Install replacement thermostat
- 12.7.6 Test performance of replacement thermostat
- 12.7.7 Set anticipator
- 12.7.8 Verify system operation

**Competency 12.8: Replace pilot safety**

*Competency Builders:*

- 12.8.1 Disconnect power supply
- 12.8.2 Verify that power is off
- 12.8.3 Select component to match type being replaced
- 12.8.4 Remove old component
- 12.8.5 Install replacement component
- 12.8.6 Verify system operation

**Competency 12.9: Replace solid-state ignition systems in gas units***Competency Builders:*

- 12.9.1 Disconnect power supply
- 12.9.2 Verify that power is off
- 12.9.3 Select ignition assembly and solid-state control to match type being replaced
- 12.9.4 Remove old ignition assembly and solid-state control
- 12.9.5 Install replacement ignition assembly and solid-state control
- 12.9.6 Verify system operation

**Competency 12.10: Replace direct-drive blower motor***Competency Builders:*

- 12.10.1 Disconnect power supply
- 12.10.2 Verify that power is off
- 12.10.3 Select motor to match type being replaced
- 12.10.4 Remove old motor
- 12.10.5 Clean blower cage and housing
- 12.10.6 Install replacement motor
- 12.10.7 Check motor operation (e.g., current draw)
- 12.10.8 Check blower rotation and fan blade direction

**Competency 12.11: Replace blower shaft and shaft bearings***Competency Builders:*

- 12.11.1 Disconnect power supply
- 12.11.2 Verify that power is off
- 12.11.3 Select parts to match type being replaced
- 12.11.4 Remove blower assembly
- 12.11.5 Clean blower assembly
- 12.11.6 Install replacement parts
- 12.11.7 Reassemble blower
- 12.11.8 Reinstall blower assembly
- 12.11.9 Verify system operation

**Competency 12.12: Replace belt-driven blower motor***Competency Builders:*

- 12.12.1 Disconnect power supply
- 12.12.2 Verify that power is off
- 12.12.3 Select motor to match type being replaced
- 12.12.4 Remove blower motor
- 12.12.5 Ensure belt tension and pulley alignment
- 12.12.6 Install replacement motor
- 12.12.7 Check motor operation (e.g., current draw)
- 12.12.8 Check blower rotation

**Competency 12.13: Replace electrodes**

*Competency Builders:*

- 12.13.1 Locate electrodes
- 12.13.2 Select electrodes to match type being replaced
- 12.13.3 Remove old electrodes
- 12.13.4 Install replacement electrodes
- 12.13.5 Verify system operation

**Competency 12.14: Replace oil nozzle**

*Competency Builders:*

- 12.14.1 Remove old nozzle
- 12.14.2 Select nozzle to match type being replaced
- 12.14.3 Install replacement nozzle
- 12.14.4 Verify system operation

**Competency 12.15: Replace cad cell**

*Competency Builders:*

- 12.15.1 Disconnect power supply
- 12.15.2 Verify that power is off
- 12.15.3 Select cad cell to match type being replaced
- 12.15.4 Remove old cad cell
- 12.15.5 Install replacement cad cell
- 12.15.6 Verify system operation

**Competency 12.16: Replace oil pump**

*Competency Builders:*

- 12.16.1 Select pump to match type being replaced
- 12.16.2 Remove old pump
- 12.16.3 Install replacement pump
- 12.16.4 Bleed air from lines
- 12.16.5 Measure pump pressure
- 12.16.6 Verify system operation

**Occupational Competency  
Analysis Profile:**

**Employability**

## Unit 1: Career Development

### Competency 1.1: Investigate career options

#### *Competency Builders:*

- 1.1.1 Determine interests and aptitudes
- 1.1.2 Identify career options
- 1.1.3 Research interests, knowledge, abilities, and skills needed in an occupation
- 1.1.4 Select careers that best match interests and aptitudes
- 1.1.5 Identify advantages and disadvantages of career options, including self-employment and nontraditional careers

### Competency 1.2: Utilize career information

#### *Competency Builders:*

- 1.2.1 Identify a range of career information resources
- 1.2.2 Use a range of resources to obtain career information (e.g., handbooks, career materials, labor market information, and computerized career-information delivery systems)
- 1.2.3 Demonstrate knowledge of various classification systems that categorize occupations and industries (e.g., *Dictionary of Occupational Titles*)
- 1.2.4 Describe the educational requirements of various occupations
- 1.2.5 Identify individuals in selected occupations as possible information resources, role models, or mentors
- 1.2.6 Describe the impact of factors such as population, climate, employment trends, and geographic location on occupational opportunities
- 1.2.7 Assess differences in the wages, benefits, annual incomes, cost of living, and job opportunities associated with selected career options
- 1.2.8 Determine labor market projections for selected career options

### Competency 1.3: Participate in a career exploration activity

#### *Competency Builders:*

- 1.3.1 Identify career exploration activities (e.g., job shadowing, mentoring, volunteer experiences, part-time employment, and cooperative education)
- 1.3.2 Compare traits, skills, and characteristics required for specific career choices with individual's traits, skills, and characteristics
- 1.3.3 Recognize potential conflicts between personal characteristics and career choice areas
- 1.3.4 Describe the impact of exploration activities on current career choices

### Competency 1.4: Assess the relationship between educational achievement and career planning

#### *Competency Builders:*

- 1.4.1 Describe how skills developed in academic and vocational programs relate to career goals
- 1.4.2 Describe how education relates to the selection of a college major, further training, and/or entry into the job market
- 1.4.3 Identify skills that can apply to a variety of occupational requirements
- 1.4.4 Explain the importance of possessing learning skills in the workplace

**Competency 1.5: Develop an individual career plan***Competency Builders:*

- 1.5.1 Identify career goal(s)
- 1.5.2 Identify worker conditions, education, training, and employment opportunities related to selected career goal(s)
- 1.5.3 Describe school and community resources available to help achieve career goal(s)
- 1.5.4 Identify career ladders possible within selected career goal(s)\*
- 1.5.5 Identify additional experiences needed to move up identified career ladders\*
- 1.5.6 Recognize that changes may require retraining and upgrading of employees' skills

**Competency 1.6: Annually review/revise the individual career plan***Competency Builders:*

- 1.6.1 Identify experiences that have reinforced selection of the specific career goal(s) listed on the individual career plan
- 1.6.2 Identify experiences that have changed the specific career goal(s) listed on the individual career plan
- 1.6.3 Modify the career goals(s) and educational plans on the individual career plan
- 1.6.4 Ensure that parents or guardians provide input into the individual career plan process.
- 1.6.5 Identify the correlation between the individual career plan and the actual courses to be taken in high school
- 1.6.6 Identify the correlation between the individual career plan and postsecondary training, adult education, or employment

**Unit 2: Decision Making and Problem Solving****Competency 2.1: Apply decision-making techniques in the workplace***Competency Builders:*

- 2.1.1 Identify the decision to be made
- 2.1.2 Compare alternatives
- 2.1.3 Determine the consequences of each alternative
- 2.1.4 Make decisions based on values and goals
- 2.1.5 Evaluate the decision made

**Competency 2.2: Apply problem-solving techniques in the workplace***Competency Builders:*

- 2.2.1 Diagnose the problem, its urgency, and its causes
- 2.2.2 Identify alternatives and their consequences in relation to the problem
- 2.2.3 Recognize multicultural and nonsexist dimensions of problem solving
- 2.2.4 Explore possible solutions to the problem using a variety of resources
- 2.2.5 Compare/contrast the advantages and disadvantages of each solution
- 2.2.6 Determine appropriate action
- 2.2.7 Implement action
- 2.2.8 Evaluate results of action implemented

## Unit 3: Work Ethic

### Competency 3.1: Evaluate the relationship of self-esteem to work ethic

#### *Competency Builders:*

- 3.1.1 Identify special characteristics and abilities in self and others
- 3.1.2 Identify internal and external factors that affect self-esteem
- 3.1.3 Identify how individual characteristics relate to achieving personal, social, educational, and career goals
- 3.1.4 Identify the relationship between personal behavior and self-concept

### Competency 3.2: Analyze the relationship of personal values and goals to work ethic both in and out of the workplace

#### *Competency Builders:*

- 3.2.1 Distinguish between values and goals
- 3.2.2 Determine the importance of values and goals
- 3.2.3 Evaluate how one's values affect one's goals
- 3.2.4 Identify own short- and long-term goals
- 3.2.5 Prioritize own short- and long-term goals
- 3.2.6 Identify how one's values are reflected in one's work ethic
- 3.2.7 Identify how interactions in the workplace affect one's work ethic
- 3.2.8 Identify how life changes affect one's work ethic

### Competency 3.3: Demonstrate work ethic

#### *Competency Builders:*

- 3.3.1 Examine factors that influence work ethic
- 3.3.2 Display initiative
- 3.3.3 Demonstrate dependable attendance and punctuality
- 3.3.4 Demonstrate organizational skills
- 3.3.5 Adhere to schedules and deadlines
- 3.3.6 Demonstrate a willingness to learn
- 3.3.7 Demonstrate a willingness to accept feedback and evaluation
- 3.3.8 Demonstrate interpersonal skills required for working with and for others
- 3.3.9 Describe appropriate employer-employee interactions for various situations
- 3.3.10 Express feelings and ideas in an appropriate manner for the workplace

### Competency 3.4: Demonstrate safety skills

#### *Competency Builders:*

- 3.4.1 Practice safe work habits
- 3.4.2 Identify safety hazards
- 3.4.3 Employ preventative safety measures
- 3.4.4 Demonstrate appropriate care and use of equipment and facilities to ensure safety
- 3.4.5 Comply with safety and emergency procedures

## Unit 4: Job-Seeking Skills

### Competency 4.1: Prepare for employment

#### *Competency Builders:*

- 4.1.1 Identify traditional and nontraditional employment sources
- 4.1.2 Utilize employment sources
- 4.1.3 Research job opportunities, including nontraditional careers
- 4.1.4 Interpret equal employment opportunity laws
- 4.1.5 Explain the critical importance of personal appearance, hygiene, and demeanor throughout the employment process
- 4.1.6 Prepare for generic employment tests and those specific to an occupation/organization

### Competency 4.2: Develop a résumé

#### *Competency Builders:*

- 4.2.1 Identify personal strengths and weaknesses
- 4.2.2 List skills and/or abilities, career objective(s), accomplishments/achievements, educational background, work experience, volunteer/community contributions, and organizational memberships
- 4.2.3 Select an acceptable résumé format
- 4.2.4 Use correct grammar and spelling and concise wording
- 4.2.5 Secure references
- 4.2.6 Complete the résumé

### Competency 4.3: Complete the job application process

#### *Competency Builders:*

- 4.3.1 Explain the importance of an application form
- 4.3.2 Obtain job application forms
- 4.3.3 Demonstrate appropriate behaviors (e.g., personal appearance, hygiene, and demeanor) for obtaining job application forms in person
- 4.3.4 Describe methods for handling illegal questions on job application forms
- 4.3.5 Demonstrate legible written communication skills using correct grammar and spelling and concise wording
- 4.3.6 Return application to appropriate person
- 4.3.7 Request interview
- 4.3.8 Follow up on application status

### Competency 4.4: Demonstrate interviewing skills

#### *Competency Builders:*

- 4.4.1 Investigate interview procedures
- 4.4.2 Demonstrate appropriate behaviors (e.g., appearance, hygiene, and demeanor) for the interview
- 4.4.3 Demonstrate question-and-answer techniques
- 4.4.4 Demonstrate methods for handling difficult and/or illegal interview questions
- 4.4.5 Use correct grammar and concise wording



**Competency 4.5: Secure employment**

*Competency Builders:*

- 4.5.1 Identify present and future employment opportunities within an occupation/organization
- 4.5.2 Research the organization/company
- 4.5.3 Use follow-up techniques to enhance employment potential
- 4.5.4 Evaluate job offer(s)
- 4.5.5 Respond to job offer(s)

**Unit 5: Job Retention and Career Advancement Skills**

**Competency 5.1: Analyze the organizational structure of the workplace**

*Competency Builders:*

- 5.1.1 Identify employer expectations regarding job performance, work habits, attitudes, personal appearance, and hygiene
- 5.1.2 Comply with company policies and procedures
- 5.1.3 Examine the role/relationship between employee and employer
- 5.1.4 Recognize opportunities for advancement and reasons for termination
- 5.1.5 Recognize the organization's ethics.

**Competency 5.2: Maintain positive relations with others**

*Competency Builders:*

- 5.2.1 Exhibit appropriate work habits and attitudes
- 5.2.2 Identify behaviors for establishing successful working relationships
- 5.2.3 Cooperate through teamwork and group participation
- 5.2.4 Demonstrate a willingness to compromise
- 5.2.5 Identify methods for dealing with harassment, bias, and discrimination based on race, color, national origin, gender, religion, disability, or age
- 5.2.6 Cooperate with authority
- 5.2.7 Accept supervision

**Competency 5.3: Demonstrate accepted social and work behaviors**

*Competency Builders*

- 5.3.1 Demonstrate a positive attitude
- 5.3.2 Demonstrate accepted conversation skills
- 5.3.3 Use good manners
- 5.3.4 Accept responsibility for assigned tasks
- 5.3.5 Demonstrate personal hygiene
- 5.3.6 Demonstrate knowledge of a position
- 5.3.7 Perform quality work

**Competency 5.4: Analyze opportunities for personal and career growth\****Competency Builders:*

- 5.4.1 Determine opportunities within chosen occupation/organization\*
- 5.4.2 Determine other career opportunities outside chosen occupation/ organization\*
- 5.4.3 Evaluate the factors involved in considering a new position within or outside an occupation/ organization\*
- 5.4.4 Exhibit characteristics needed for advancement\*

**Unit 6: Technology in the Workplace****Competency 6.1: Demonstrate knowledge of technology issues***Competency Builders:*

- 6.1.1 Demonstrate knowledge of the characteristics of technology
- 6.1.2 Demonstrate knowledge of how technology systems are applied
- 6.1.3 Assess the impact of technology on the individual, society, and environment
- 6.1.4 Demonstrate knowledge of the evolution of technology
- 6.1.5 Identify how people, information, tools and machines, energy, capital, physical space, and time influence the selection and use of technology
- 6.1.6 Identify legal and ethical issues related to technology (e.g., confidentiality, information sharing, copyright protection)

**Competency 6.2: Demonstrate skills related to technology issues***Competency Builders:*

- 6.2.1 Exhibit willingness to adapt to technological change
- 6.2.2 Utilize technological systems
- 6.2.3 Utilize a variety of resources and processes to solve technological problems
- 6.2.4 Employ higher-order thinking skills for solving technological problems
- 6.2.5 Work as a team member in solving technological problems
- 6.2.6 Use technology in a safe and responsible manner
- 6.2.7 Apply science, mathematics, communication, and social studies concepts to solve technological problems
- 6.2.8 Demonstrate ingenuity and creativity in the use of technology\*
- 6.2.9 Utilize a formal method (systems approach) in solving technological problems\*

## Unit 7: Lifelong Learning

### Competency 7.1: Apply lifelong learning practices to individual situations

#### *Competency Builders:*

- 7.1.1 Define lifelong learning
- 7.1.2 Identify factors that cause the need for lifelong learning
- 7.1.3 Identify changes that may require the retraining and upgrading of employee's skills
- 7.1.4 Identify avenues for lifelong learning
- 7.1.5 Participate in lifelong learning activities

### Competency 7.2: Adapt to change

#### *Competency Builders:*

- 7.2.1 Analyze the causes and effects of change
- 7.2.2 Identify the effect of change on goals
- 7.2.3 Identify the importance of flexibility when reevaluating goals
- 7.2.4 Evaluate the need for lifelong learning experiences in adapting to change

## Unit 8: Economic Education

### Competency 8.1: Analyze how an economy functions as a whole

#### *Competency Builders:*

- 8.1.1 Describe how individuals and societies make choices to satisfy needs and wants with limited resources
- 8.1.2 Identify how production factors (land, labor, capital, and entrepreneurship) are used to produce goods and services
- 8.1.3 Illustrate how individuals and households exchange their resources for the income they use to buy goods and services
- 8.1.4 Explain how individuals and business firms use resources to produce goods and services to generate income
- 8.1.5 Identify characteristics of command, market, and traditional economies\*
- 8.1.6 Describe how all levels of government assess taxes in order to provide services

### Competency 8.2: Analyze how an economic system is a framework within which decisions are made by individuals and groups

#### *Competency Builders:*

- 8.2.1 List several individuals and groups that make economic decisions at the local, state, and national levels
- 8.2.2 Identify the important roles that local, state, and national governments play in a market economy

*Continued*

**Competency 8.2:**      *Analyze how an economic system is a framework within which decisions are made by individuals and groups—Continued*

- 8.2.3      List examples of how government decisions affect individuals
- 8.2.4      Identify how geographic locations affect the political and economic systems of the world
- 8.2.5      Evaluate how markets allocate goods and services
- 8.2.6      Explain how resources, goods, and services are exchanged in markets
- 8.2.7      Explain competition and its effect on the market

**Competency 8.3:**      **Analyze the importance of making informed personal financial decisions**

*Competency Builders:*

- 8.3.1      Describe the need for personal management records
- 8.3.2      Create a personal budget
- 8.3.3      Create a budget for a family of four for one month
- 8.3.4      Explain how credit affects personal/family finances
- 8.3.5      Identify steps to avoid credit problems
- 8.3.6      Make informed consumer choices in response to personal needs and wants
- 8.3.7      Identify factors that influence consumer decisions (e.g., advertisements, peer groups, price, and location)
- 8.3.8      Explain the costs and benefits for individuals of various types of taxation at the local, state, and federal levels

## **Unit 9:    Balancing Work and Family**

**Competency 9.1:**      **Analyze the effects of family on work**

*Competency Builders:*

- 9.1.1      Recognize how family values, goals, and priorities are reflected in the workplace
- 9.1.2      Identify present and future family structures and responsibilities
- 9.1.3      Describe personal and family roles
- 9.1.4      Analyze concerns of working parent(s)
- 9.1.5      Examine how family responsibilities can conflict with work
- 9.1.6      Identify ways to resolve family-related conflicts
- 9.1.7      Explain how to use support systems/community resources to help resolve family-related conflicts

**Competency 9.2:**      **Analyze the effects of work on family**

*Competency Builders:*

- 9.2.1      Identify responsibilities associated with paid and nonpaid work
- 9.2.2      Compare the advantages and disadvantages of multiple incomes
- 9.2.3      Explain how work can conflict with family responsibilities
- 9.2.4      Explain how work-related stress can affect families
- 9.2.5      Identify family support systems and resources

## Unit 10: Citizenship in the Workplace

### **Competency 10.1: Exercise the rights and responsibilities of citizenship in the workplace**

#### *Competency Builders:*

- 10.1.1 Identify the basic rights and responsibilities of citizenship in the workplace
- 10.1.2 Identify situations in which compromise is necessary
- 10.1.3 Examine how individuals from various backgrounds contribute to the workplace
- 10.1.4 Demonstrate initiative to facilitate cooperation
- 10.1.5 Give/receive constructive criticism to enhance cooperation

### **Competency 10.2: Prepare to work in a multicultural society**

#### *Competency Builders:*

- 10.2.1 Identify ways to live in a multicultural society with mutual respect and appreciation for others
- 10.2.2 Examine how culture and experience create differences in people
- 10.2.3 Demonstrate respect for the contributions made by all people
- 10.2.4 Investigate personal cultural background as a means of developing self-respect
- 10.2.5 Make personal choices that reduce discrimination, isolation, and prejudice
- 10.2.6 Work effectively with people irrespective of their race, gender, religion, ethnicity, disability, age, or cultural background

## Unit 11: Leadership

### **Competency 11.1: Evaluate leadership styles appropriate for the workplace**

#### *Competency Builders:*

- 11.1.1 Identify characteristics of effective leaders
- 11.1.2 Compare leadership styles
- 11.1.3 Demonstrate effective delegation skills
- 11.1.4 Investigate empowerment concepts
- 11.1.5 Identify opportunities to lead in the workplace

### **Competency 11.2: Demonstrate effective teamwork skills**

#### *Competency Builders:*

- 11.2.1 Identify the characteristics of a valuable team member
- 11.2.2 Identify methods of involving each team member
- 11.2.3 Contribute to team efficiency and success
- 11.2.4 Determine ways to motivate team members

**Competency 11.3: Utilize effective communication skills***Competency Builders:*

- 11.3.1 Identify the importance of listening.
- 11.3.2 Demonstrate effective listening skills
- 11.3.3 Demonstrate assertive communication techniques
- 11.3.4 Recognize the importance of verbal and nonverbal cues and messages
- 11.3.5 Prepare written material
- 11.3.6 Analyze written material
- 11.3.7 Give/receive feedback
- 11.3.8 Communicate thoughts
- 11.3.9 Use appropriate language
- 11.3.10 Follow oral and written instructions
- 11.3.11 Demonstrate effective telephone techniques
- 11.3.12 Identify technology in communications

**Unit 12: Entrepreneurship****Competency 12.1: Evaluate the role of small business***Competency Builders:*

- 12.1.1 Identify the impact of small business on the local economy
- 12.1.2 Examine the relationship of small business to a national (USA) and global economy
- 12.1.3 Identify factors that contribute to the success of small business
- 12.1.4 Identify factors that contribute to the failure of small business
- 12.1.5 Identify the components of a business plan

**Competency 12.2: Examine entrepreneurship as a personal career option***Competency Builders:*

- 12.2.1 Evaluate personal interests and skills
- 12.2.2 Compare personal interests and skills with those necessary for entrepreneurship
- 12.2.3 Determine motives for becoming an entrepreneur
- 12.2.4 Identify the advantages and disadvantages of owning a small business
- 12.2.5 Compare business ownership to working for others

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# Notes

## **Academic Job Profile**



## The Purpose of Job Profiling

Developed by American College Testing (ACT), the purpose of the Job Profiling process is to identify the **level** of applied academic skills that, according to business and industry, students must master to qualify for and be successful in their occupation of choice. The results of Job Profile "leveling" can help teachers to better target instruction toward their students' needs.

As part of the Ohio Vocational Competency Assessment (OVCA) program, the Vocational Instructional Materials Laboratory (VIML) at The Ohio State University has conducted Job Profiling workshops in which representatives of business, industry, labor, and community organizations identified the academic skill levels needed by entry-level workers in the occupational areas covered by the OCAPs. The Job Profiling, which was carried out in spring 1994 and spring 1995, was sponsored by the Ohio Department of Education, Division of Vocational and Adult Education.

### OVCA—What Is It?

The Ohio Vocational Competency Assessment (or OVCA) package consists of two assessment components: OCAP and Work Keys. Together they measure entry-level occupational, academic, and employability skills. All OVCA items are criterion-referenced, use a multiple-choice format, and are administered using a traditional paper-and-pencil method. The OVCA is designed to do the following:

- Provide one dimension of a multi-assessment strategy for career passport credentialing
- Evaluate learner readiness for jobs requiring specific occupational, academic, and employability skills
- Assist educators in curriculum development
- Provide state-aggregated learning gain scores to comply with the regulations in the Carl D. Perkins Vocational and Applied Technology Act of 1990

**OCAP.** The OCAP component of OVCA assesses students in occupational skills—employment requirements—in a particular occupational area. Assessment is based on the core competencies identified through the OCAP process, and each multiple-choice assessment item is correlated to those essential competencies.

**Work Keys.** The Work Keys component, developed by ACT, measures students' applied academic skills. All OVCA packages contain two Work Keys assessments:

- *Applied Mathematics* measures students' ability to analyze, set up, and solve math problems typically found in the workplace.
- *Locating Information* measures students' ability to use graphic documents to insert, extract, and apply information.

In addition, certain taxonomies will use the following Work Keys assessments:

- *Reading for Information* will be used by Business, Marketing, Home Economics, Health Education, and Cosmetology taxonomies.
- *Applied Technology* will be used by Trade and Industrial and Agricultural Education taxonomies.

Other optional Work Keys assessments, not included in the basic OVCA package, are *Teamwork*, *Listening*, and *Writing*.

Each Work Keys assessment is further broken down into four to five levels of achievement, with higher numbers indicating higher achievement in the assessed skill (descriptions of the levels for each Work Keys assessment are provided on pp. 49-55). For each academic skill, the Job Profiling process identifies the level required for successful entry into an occupational area.

## Job Profiling—How It Works

VIML's Job Profiling process was initiated by mailing surveys to current workers in OCAP occupations all across Ohio. The survey's purpose: to have actual workers in specific occupations rate job tasks according to each task's frequency and criticality—that is, the amount of time spent performing each task relative to other tasks and the importance of each task to overall job performance.

To complete the survey, participants examined OCAP competencies for their occupation. Based on the survey's results, VIML staff produced a list of the most critical competencies in each occupation.

The next stage of Job Profiling was to convene committees of subject-matter experts to perform "leveling," which involved the following tasks:

- Examining the frequency and criticality competency lists for an occupation
- Reviewing the levels associated with each of the seven Work Keys academic skills: *Locating Information*, *Reading for Information*, *Applied Mathematics*, *Applied Technology*, *Listening*, *Writing*, and *Teamwork*
- Identifying the level of skill students must master relative to each Work Keys academic skill in order to successfully perform the occupational competencies

Finally, in 1995, the initial leveling of Work Keys academic skills for the occupational area covered by this OCAP was revalidated by the new panel of expert workers convened to update the OCAP (see inside back cover).

## Example of Job Profiling

For every occupational area, there are shaded graphs to represent each of the seven Work Keys academic skills. Each graph shows the range of levels for that particular skill; the shading represents the academic skill level required by an entry-level worker in that occupation, as determined by the Job Profiling committee. For example:

### Applied Mathematics



In the example shown, Applied Mathematics has a skill range of 3–7. The required skill level, determined by Job Profiling and shown by the highlighting, is 6.

## Academic Job Profile: Heating, Ventilation, Air-Conditioning, and Refrigeration

**Applied  
Mathematics**

**6**

**Locating  
Information**

**5**

**Reading for  
Information**

**5**

**Applied  
Technology**

**5**

**Teamwork**

**3**

**Listening**

**4**

**Writing**

**3**

NOTE: Definitions of each level in each of the seven academic skill areas are provided on the pages that follow.

## Levels of Work Keys Defined

The skills needed to achieve each level for each of the seven Work Keys\* academic skills are as follows.

### Applied Mathematics

*Applied Mathematics* measures skill in applying mathematical reasoning to work-related problems. There are five levels of complexity, 3 through 7, with Level 3 being the least complex and Level 7 the most complex. The levels build on each other, each incorporating the skills at the preceding levels.

#### Level 3

- Perform basic mathematical operations (addition, subtraction, multiplication, and division) and conversions from one form to another, using whole numbers, fractions, decimals, or percentages.
- Translate simple verbal problems into mathematical equations.
- Directly apply logical information provided to solve problems, including those with measurements and dollars and cents.

#### Level 4

- Perform one or two mathematical operations (such as addition, subtraction, or multiplication) on several positive or negative numbers. (Division of negative numbers is not covered until Level 5.)
- Add commonly known fractions, decimals, or percentages (e.g.,  $\frac{1}{2}$ , .75, 25%) or add three fractions that share a common denominator.
- Calculate averages, simple ratios, proportions, and rates, using whole numbers and decimals.
- Reorder verbal information before performing calculations.
- Read simple charts or graphs to obtain information needed to solve a problem.

#### Level 5

- Look up and calculate single-step conversions within English or non-English measurement systems (e.g., converting ounces to pounds or centimeters to meters) or between measurement systems (e.g., converting centimeters to inches).
- Make calculations using mixed units (e.g., hours and minutes).
- Determine what information, calculations, and unit conversions are needed to find a solution.

#### Level 6

- Calculate using negative numbers, fractions, ratios, percentages, mixed numbers, and formulas.
- Identify and correct errors in calculations.
- Translate complex verbal problems into mathematical expressions, using considerable setup and multiple-step calculations or conversions.

#### Level 7

- Solve problems requiring multiple steps of logic and calculation.
- Solve problems involving more than one unknown, nonlinear functions (e.g., rate of change), and applications of basic statistical concepts (e.g., error of measurement).
- Locate errors in multiple-step calculations.
- Solve problems with unusual content or format, or with incomplete or implicit information.

\*Work Keys Score Interpretation Guide. © 1994 by American College Testing (ACT). Used with permission.

## Locating Information

*Locating Information* measures skill in using information taken from workplace graphics such as diagrams, blueprints, floor plans, tables, forms, graphs, charts, and instrument gauges. There are four levels of complexity, 3 through 6, with Level 3 being the least complex and Level 6 the most complex. The levels build on each other, each incorporating the skills at the preceding levels.

### Level 3

- Find one or two pieces of information in elementary workplace graphics, such as simple order forms, bar graphs, tables, flowcharts, and floor plans.
- Fill in one or two pieces of information that are missing from elementary workplace graphics.

### Level 4

- Find several pieces of information in straightforward workplace graphics, such as basic order forms, line graphs, tables, instrument gauges, maps, flowcharts, and diagrams.
- Summarize and/or compare information and trends in a single straightforward graphic.
- Summarize and/or compare information and trends among more than one straightforward workplace graphic, such as a bar chart and a data table showing related information.

### Level 5

- Summarize and/or compare information and trends in single complicated workplace graphics, such as detailed forms, tables, graphs, maps, instrument gauges, and diagrams.
- Summarize and/or compare information and trends among more than one complicated workplace graphic, such as a bar chart and a data table showing related information.

### Level 6

- Make decisions, draw conclusions, and/or apply information to new situations using several related and complex workplace graphics that contain a great amount of information or have challenging presentations (e.g., very detailed graphs, charts, tables, forms, maps, blueprints, diagrams).

## Reading for Information

*Reading for Information* measures skill in reading and understanding work-related reading materials. There are five levels of complexity, 3 through 7, with Level 3 being the least complex and Level 7 the most complex. Although Level 3 is the least complex, it still represents a level of reading skill well above "no skill at all." The levels build on each other, each incorporating the skills at the preceding levels.

### Level 3

- Identify uncomplicated key concepts and simple details.
- Recognize the proper placement of a step in a sequence of events, or the proper time to perform a task.
- Identify the meaning of words that are defined within a passage.
- Identify the meaning of simple words that are not defined within a passage.
- Recognize the application of instructions from a passage to situations that are described in the passage.

### Level 4

- Identify details that are more subtle than those in Level 3.
- Recognize the application of more complex instructions, some of which involve several steps, to described situations.
- Recognize cause-effect relationships.

### Level 5

- Identify the paraphrased definition of jargon or technical terms that are defined in a passage and recognize the application of jargon or technical terms to stated situations.
- Recognize the definition of acronyms that are defined in a passage.
- Identify the appropriate definition of words with multiple meanings.
- Recognize the application of instructions from a passage to new situations that are similar to the situations described in the reading materials.
- Recognize the applications of more complex instructions to described situations, including conditionals and procedures with multiple steps.

### Level 6

- Recognize the application of jargon or technical terms to new situations.
- Recognize the application of complex instructions to new situations.
- Recognize the less-common meaning of a word with multiple meanings from context.
- Generalize from a passage to situations not described in the passage.
- Identify implied details.
- Explain the rationale behind a procedure, policy, or communication.
- Generalize from a passage to a somewhat similar situation.

### Level 7

- Recognize the definitions of difficult, uncommon jargon or technical terms from context.
- Generalize from a passage to situations neither described in nor completely similar to those in a passage.

## Applied Technology

*Applied Technology* measures skill in solving problems of a technological nature, involving the basic principles of mechanics, electricity, fluid dynamics, and thermodynamics as they apply to machines and equipment found in the workplace. There are four levels of complexity, 3 through 6, with Level 3 being the least complex and Level 6 the most complex. Although Level 3 is the least complex, it still represents a level of applied technology skill well above "no skill at all." The levels build on each other, each incorporating the skills at the preceding levels.

### Level 3

- Apply the elementary physical principles underlying the operation of uncomplicated systems or tools.
- Recognize and identify relevant aspects of simple problems that involve one uncomplicated system or tool.
- Select appropriate methods or materials needed to solve problems.

### Level 4

- Recognize, identify, and order relevant aspects of one moderately complex system or more than one uncomplicated system.
- Evaluate alternative solutions to determine the most appropriate one for the situation presented.

### Level 5

- Solve problems based on one complex system, or one or more uncomplicated tools or systems.
- Understand and apply moderately difficult principles of mechanics, electricity, thermodynamics, and fluid dynamics, in addition to understanding complex machines and systems.
- Recognize, identify, and order relevant aspects of a problem before reaching an appropriate solution.

### Level 6

- Solve problems that do not contain all the information needed to solve them, and/or in which the information provided may be out of logical order.
- Solve problems that contain extraneous information.
- Solve problems involving one or more tools or systems having a wide range of complexity.
- Apply difficult physical principles.
- Understand and correctly interpret the interaction of several complex systems.

## Listening

*Listening* measures skill in listening to and understanding work-related messages; receiving information from customers, coworkers, or suppliers; and then writing down the information to communicate it to someone else. Students demonstrate their ability to distinguish and communicate critical information and noncritical information.

**Critical information** consists of those details that the recipient of the message must have in order to understand the message and act upon it (e.g., names, phone numbers, addresses, times). **Non-critical information** can improve a message by providing details that further explain the message or its tone, but the absence of this noncritical information does not interfere with the recipient's ability to understand and accurately act upon the message. Each *Listening* level describes the **content and quality** of messages students write to describe an audio message.

### Level 0

- No meaningful information, or totally inaccurate information.

### Level 1

- Minimal pertinent information; enough context to provide clues as to gist of situation or source of further information.

### Level 2

- Some pertinent information; may have incorrect critical information, but sketch of the situation is correct.

### Level 3

- All the critical information that is present is correct; may be missing a few pieces of critical information.

### Level 4

- All critical information is given and is correct; may be missing subtle details or tone; may have incorrect noncritical information that does not interfere with central meaning.

### Level 5

- All critical information is present and correct; response conveys insight into situation through tone and/or subtle details.



## Writing

*Writing* measures skill at writing work-related messages; receiving information from customers, co-workers, or suppliers; and then writing down the information to communicate it to someone else. Each *Writing* level rates the **writing mechanics** (such as sentence structure and grammar) and **writing style** of messages students write to describe an audio message.

### Level 0

- An attempt is made at the message, but the message is completely garbled with no recognizable sentence structure.

### Level 1

- Message conveyed inadequately; overall lack of proper sentence structure.

### Level 2

- Message conveyed inadequately; weak sentence structure; large number of mechanical errors.

### Level 3

- Message conveyed clearly; most sentences complete; some mechanical errors.

### Level 4

- Message conveyed clearly; all sentences are complete; may have a few minor mechanical errors; may have a choppy style.

### Level 5

- Message conveyed clearly; good sentence structure; no mechanical errors; highly appropriate for business setting and situation; smooth, logical style.

## Teamwork

*Teamwork* measures skill in choosing behaviors and/or actions that simultaneously support team interrelationships and lead toward the accomplishment of work tasks. There are four levels of complexity, 3 through 6, with Level 3 being the least complex and Level 6 the most complex. Although Level 3 is the least complex, it still represents a level of teamwork skill well above "no skill at all." The levels build on each other, each incorporating the skills at the preceding levels.

### Level 3

- Identify team goals and ways to work with other team members to accomplish those goals.
- Choose actions that support the ideas of other team members to accomplish team goals.
- Recognize that a team is having problems finishing a task and identify the cause of those problems.

### Level 4

- Identify the organization of tasks and the time schedule that would help accomplish team goals efficiently and effectively.
- Select approaches that accept direction from other team members in order to accomplish tasks and to build and keep up good team relations.
- Identify behaviors that show appreciation for the personal and professional qualities of other team members and respect for their diversity.

### Level 5

- Identify courses of action that give direction to other team members effectively.
- Choose approaches that encourage and support the efforts of other team members to further team relationships and/or task accomplishment.
- Consider the possible effects of alternative behaviors on both team relationships and team accomplishments and select the one that would best help the team meet its goals.

### Level 6

- Identify the focus of team activity and select a new focus if that would help the team meet its goals more effectively.
- Select approaches that show the willingness to give and take direction as needed to further team goals (e.g., recognize the organization of team members' tasks that would best serve the larger goals of the team).
- Choose approaches that encourage a team to act as a unit and reach agreement when discussing specific issues.
- Identify actions that would help manage differences of opinion among team members, moving the team toward its goals while valuing and supporting individual diversity.

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# Notes

## **Academic Competencies**

## Total List of Academic Competencies

Three products of the Ohio Department of Education, Division of Curriculum, Instruction, and Professional Development, describe the academic skills that should be possessed by each student at the end of each grade level:

- *Model Competency-Based Language Arts Program*
- *Model Competency-Based Mathematics Program*
- *Model Competency-Based Science Program*

The following lists were derived from the academic competencies delineated for Grades 9-12 in these documents. Although the competencies are listed separately by grade level in the original documents, the levels were combined—and in some cases refined—for OCAP purposes, any overlap was eliminated, and a numbering system was imposed for ease of reference.

During the course of the OCAP workshops, each of the representatives from business, industry, labor, and community-based organizations was given a copy of these lists of academic competencies and instructed to circle the competencies that an entry-level employee should possess. The results from each panel were tallied to identify those required academic competencies most crucial to entry level in each specific occupational area. The results for this OCAP are presented on pp. 73-76

### Unit: Communications Skills

#### *Subunit: Reading—Structure*

Competencies:

- RS1 Exhibit knowledge of language structure
- RS2 Recognize that there may be more than one interpretation of reading selections
- RS3 Recognize various literary devices (e.g., metaphor, simile, personification, hyperbole, pun, alliteration)
- RS4 Recognize and discuss literary elements (e.g., plot, dialogue, theme, setting, characterization)
- RS5 Develop and use an increasingly sophisticated vocabulary gained through context
- RS6 Apply knowledge of language structure to reading
- RS7 Explain why there may be more than one interpretation of reading selections
- RS8 Recognize effect of literary devices on meaning
- RS9 Analyze author's use of literary elements
- RS10 Recognize relationship of structure to meaning
- RS11 Describe various interpretations and levels of meaning in reading selections (e.g., symbolism, nuance)
- RS12 Characterize author's use of literary devices
- RS13 Characterize use of literary techniques (e.g., irony, satire, allegory, onomatopoeia)
- RS14 Critique a variety of literature with regard to plot, dialogue, theme, setting, and characterization
- RS15 Apply an expanding vocabulary gained through reading
- RS16 Explain various interpretations and levels of meaning in reading selections (e.g., symbolism, nuance)
- RS17 Analyze use of literary devices (e.g., extended metaphor, simile, personification, hyperbole, pun, alliteration)
- RS18 Understand use of literary techniques (e.g., irony, satire, allegory, onomatopoeia)
- RS19 Analyze and synthesize pieces of literature with regard to plot, dialogue, theme, setting, and characterization

***Subunit: Reading—Meaning Construction***

## Competencies:

- RM1 Demonstrate ability to recognize appropriate pre-reading strategies
- RM2 Describe effectiveness of a reading selection
- RM3 Read to clarify personal thinking and knowledge
- RM4 Support interpretation of text by locating and citing specific information
- RM5 Develop personal response to a variety of literary works
- RM6 Recognize diverse literary interpretations
- RM7 Engage in self-selected reading activities
- RM8 Confirm and extend meaning in reading by researching new concepts and facts
- RM9 Self-monitor and apply corrective strategies when communication has been interrupted or lost
- RM10 Use features of literary genres to extend meaning
- RM11 Assess effectiveness of a selection read
- RM12 Use reading as a possible problem-solving strategy to clarify personal thinking and knowledge
- RM13 Use knowledge of semantic elements (e.g., figurative language, denotation, connotation, dialect) to clarify meaning when reading
- RM14 Predict, recognize, interpret, and analyze themes based on familiarity with author's work
- RM15 Compare and contrast literary genres
- RM16 Assess validity and quality of selection read (e.g., predict, summarize, analyze, infer)
- RM17 Clarify meaning when reading, using knowledge of literary devices, stylistic diction, and other semantic elements
- RM18 Compare personal reaction to critical assessment of a literary selection
- RM19 Assess validity of diverse literary interpretations
- RM20 Use reference books to find, evaluate, and synthesize information
- RM21 Identify tone of a literary work (e.g., ironic, serious, conversational, humorous)
- RM22 Critique validity of diverse literary interpretations
- RM23 Integrate personal reaction to and critical assessment of a literary selection

***Subunit: Reading—Application***

## Competencies:

- RA1 Select and read material for personal enjoyment and information
- RA2 Read a variety of complete, unabridged works (e.g., self-selected or assigned stories, essays, nonfiction, plays, novels, poetry)
- RA3 Employ various reading strategies (e.g., scanning, skimming, reviewing, questioning, testing, retaining) according to purpose
- RA4 Participate in selection of books, materials, and topics for literature study groups
- RA5 Develop and apply knowledge of the interrelationship of concepts (e.g., construction of webs, graphs, timelines)
- RA6 Read selections from a variety of styles and formats, recognizing that style and format influence meaning
- RA7 Extend value of reading, writing, speaking, viewing, and listening by pursuing, through reading, new concepts and interests developed as a result of these activities
- RA8 Read extensively from the works of a particular author, and explain elements of author's style

***Subunit: Reading—Multidisciplinary***

## Competencies:

- RM1 Connect themes and ideas across disciplines through literature
- RM2 Read to facilitate learning across curriculum
- RM3 Read to develop awareness of human rights and freedom
- RM4 Participate actively in a community of learners

- RM5 Recognize and explain interaction between literature and various cultural domains (e.g., social, technological, political, economic)
- RM6 Explore and analyze a variety of cultural elements, attitudes, beliefs, and value structures by reading and experiencing our diverse literary tradition, including works by men and women of many racial, ethnic, and cultural groups
- RM7 Value thinking and language of others
- RM8 Relate literature to historical period about which or in which it was written
- RM9 Read to facilitate content learning

### ***Subunit: Writing—Structure***

#### Competencies:

- WS1 Develop and expand a repertoire of organizational strategies (e.g., narration, comparison/contrast, and description) through practice and discussion
- WS2 Clarify word choice according to audience, topic, and purpose
- WS3 Locate and correct errors in usage, spelling, and mechanics (e.g., subject-verb agreement, parallel construction, pronoun reference, punctuation, capitalization, sentence structure) using a variety of resources
- WS4 Recognize information gained from primary and secondary sources
- WS5 Develop writing that contains ordered, related, well-developed paragraphs with sentences of varied lengths and patterns
- WS6 Use information from a variety of sources to develop an integrated piece of writing
- WS7 Evaluate and revise writing to focus on such things as audience, tone, and purpose
- WS8 Recognize differences between documentation and reference list styles
- WS9 Develop extended pieces of writing that contain ordered, related, well-developed paragraphs with sentences of varied lengths and patterns
- WS10 Select from a repertoire of organization strategies a pattern appropriate to a topic (e.g., narration, example, detail, comparison/contrast, classification)
- WS11 Synthesize information from a variety of sources to construct meaning
- WS12 Refine word choice and tone according to audience, situation, and purpose
- WS13 Appropriately cite information gained from primary and secondary sources
- WS14 Use style manuals or software to prepare documentation and reference lists
- WS15 Develop effectively organized pieces of expository writing containing strong voice, clear thesis, and well-developed ideas
- WS16 Identify organization patterns appropriate to writing topic
- WS17 Respond to others' suggested revisions to a writing piece

### ***Subunit: Writing—Meaning Construction***

#### Competencies:

- WM1 Demonstrate knowledge of the recursive nature of the writing process by applying it appropriately to various topics, situations, and audiences (e.g., making connections between prior knowledge and new information, consulting other sources)
- WM2 Develop criteria for writing evaluation using scoring guides (e.g., rubric/holistic scale, primary trait scoring) and peer/teacher assistance to clarify meaning
- WM3 Respond to others' suggested revisions to a piece of writing (e.g., self-question, re-read, revise)
- WM4 Use word processing, graphics, and publishing as aids for constructing meaning in writing
- WM5 Engage in self-initiated writing activities
- WM6 Incorporate personal criteria with generally accepted standards for writing evaluation
- WM7 Evaluate, analyze, and synthesize information for writing
- WM8 Evaluate own writing using personal and established scoring criteria
- WM9 Assess personal/peer revisions to a writing piece
- WM10 Recognize and refine personal writing styles

***Subunit: Writing—Application***

## Competencies:

- WA1 Apply appropriate writing techniques (e.g., prewriting, drafting, revising, editing, presenting) suitable for varied writing tasks
- WA2 Use sentence-combining techniques to improve syntactic fluency and maturity
- WA3 Write in response to prompted and self-selected topics in practical, persuasive, descriptive, narrative, and expository domains
- WA4 Develop personal voice in writing
- WA5 Consider audience and purpose for writing
- WA6 Develop criteria for selection and potential development of topic
- WA7 Write in a journal or learning log to clarify personal thinking and knowledge
- WA8 Apply an expanding vocabulary gained through writing
- WA9 Make judicious use of reference sources (e.g., dictionary, thesaurus, online database, encyclopedia)
- WA10 Demonstrate an appreciation for aesthetically pleasing language through word choice and style
- WA11 Apply revising and editing strategies needed for writing task
- WA12 Vary sentence lengths and patterns
- WA13 Refine personal voice in writing
- WA14 Vary styles and formats for intended purpose and audience
- WA15 Apply criteria for selection and development of topic
- WA16 Participate in peer review of writing in progress
- WA17 Use transitions between sentences, ideas, and paragraphs in writing
- WA18 Revise and edit papers extensively in preparation for presentation/publication
- WA19 Develop a variety of genres (e.g. fantasy, science fiction, short stories, poetry)
- WA20 Focus writing and tone on such elements as audience, situation, and purpose
- WA21 Develop topic fully and appropriately
- WA22 Use writing process to clarify personal thinking and knowledge
- WA23 Apply appropriate recursive writing process as suggested by writing task and writer's process
- WA24 Develop an extended piece of writing (e.g., story, narrative poem, autobiography, novel, research paper)
- WA25 Revise writing and tone to assure focus on such elements as audience, situation, and purpose
- WA26 Use writing process to write reflectively

***Subunit: Writing—Multidisciplinary***

## Competencies:

- WM1 Use writing process for learning across curriculum
- WM2 Use writing process to demonstrate knowledge of need for human rights and freedom
- WM3 Value and apply collaborative skills in the writing process
- WM4 Write in response to reading, speaking, viewing, and listening
- WM5 Use multidisciplinary resources in writing projects
- WM6 Use writing process to facilitate learning across curriculum
- WM7 Recognize value of and engage in collaboration in the writing process
- WM8 Use communication processes to develop a published writing piece in collaboration with others
- WM9 Record experiences and observations related to content learning
- WM10 Apply collaborative skills in the writing process
- WM11 Write collaboratively with peers
- WM12 Use cross-disciplinary resources in writing projects

***Subunit: Listening/Visual Literacy—Structure***

## Competencies:

- L.S1 Listen to and view a wide variety of genres (e.g. mystery, drama, poetry)
- L.S2 Become aware of an author's style through listening to and viewing a variety of works



- LS3 Recognize correct and appropriate grammar, diction, and syntax
- LS4 Expand vocabulary through listening to and viewing varied media (e.g., recordings, films, music, news broadcasts)
- LS5 Recognize beauty of language
- LS6 Enhance recognition of an author's style through listening to and viewing a variety of works
- LS7 Recognize use and misuse of language in media
- LS8 Refine knowledge of style through listening to and viewing multiple works by the same author
- LS9 Expand and refine grammar, diction, and syntax through listening
- LS10 Compare authors' styles through viewing and listening to their works
- LS11 Expand knowledge of complex grammar, diction, and syntax issues

### ***Subunit: Listening/Visual Literacy—Meaning Construction***

#### Competencies:

- LM1 Develop critical thinking skills necessary to evaluate media and assess oral presentations
- LM2 Compare new oral texts to past experiences and knowledge in order to enhance comprehension
- LM3 Recognize how rhythmic patterns, silence, and cadences enhance quality of speech and literature
- LM4 Focus listening and viewing on themes and/or plots
- LM5 Gather information from listening and viewing experiences to enhance research
- LM6 Use critical thinking skills to evaluate media and oral presentations
- LM7 Use prior knowledge and experiences to facilitate comprehension of new oral texts
- LM8 Identify rhythmic and time patterns in speech and literature
- LM9 Identify and analyze themes and/or plots when listening and viewing
- LM10 Use information gathered from listening and viewing experiences to expand research
- LM11 Enhance use of critical thinking skills to evaluate media and oral presentations
- LM12 Consider prior knowledge and experiences when attempting to understand the meaning of new texts
- LM13 Appreciate rhythmic and time patterns of speech and literature
- LM14 Select viewing and listening materials to support written text
- LM15 Evaluate media and oral presentations analytically and critically
- LM16 Organize prior knowledge and experiences to comprehend new texts
- LM17 Organize and use viewing and listening materials to support written text

### ***Subunit: Listening/Visual Literacy—Application***

#### Competencies:

- LA1 Listen attentively during oral reading
- LA2 Use media as stimuli for learning and thinking
- LA3 Develop knowledge of structure through art, music, and literature
- LA4 Use electronic media to enhance and highlight language learning
- LA5 Listen and view for entertainment and enjoyment
- LA6 Use technology and other media (e.g., videos, posters, maps, graphs, t-shirts) as means of expressing ideas

### ***Subunit: Listening/Visual Literacy—Multidisciplinary***

#### Competencies:

- LM1 Facilitate learning across curriculum through critical listening and viewing
- LM2 Engage in individual, small-group, and whole-group listening and viewing activities
- LM3 Develop language arts (e.g., viewing, listening) projects collaboratively
- LM4 Investigate language and cultural differences through listening and viewing activities
- LM5 Participate in a community of learners through productive listening

***Subunit: Oral Communication—Structure***

## Competencies:

- OS1 Refine oral communication skills (e.g., voice modulation, eye contact, body language)
- OS2 Demonstrate knowledge of grammar, usage, and syntax when presenting
- OS3 Select topics and vocabulary suitable to audience
- OS4 Organize notes and ideas for speaking (e.g., cause-effect, chronological, exemplification)
- OS5 Use language imaginatively (e.g., word games, puns, limericks)
- OS6 Modulate voice to enhance meaning when interpreting literature orally
- OS7 Organize notes and ideas for formal, semiformal, and informal presentations of information
- OS8 Refine speaking techniques for formal, semiformal, and informal settings
- OS9 Develop repertoire of organizational strategies for presenting information orally
- OS10 Expand vocabulary to fit topic
- OS11 Select topics suitable to audience, situation, and purpose
- OS12 Select appropriate strategies when organizing notes and ideas for speaking

***Subunit: Oral Communications—Meaning Construction***

## Competencies:

- OM1 Make connections between prior knowledge and new information for oral presentations
- OM2 Participate in informal speaking activities (e.g., offering opinions, supporting statements, questions, clarification, entertainment)
- OM3 Use interviewing techniques to gather information
- OM4 Communicate orally to entertain and to inform
- OM5 Participate in group communication activities (e.g., debates, panel discussions, negotiations, book-sharing, roundtables, cooperative/collaborative groups)
- OM6 Take and organize notes when preparing speech/presentation
- OM7 Interpret texts orally to illustrate meaning
- OM8 Respond to needs of various audiences
- OM9 Gather and assess information for speaking
- OM10 Communicate orally to inform and persuade
- OM11 Prepare and deliver formal speech/presentation
- OM12 Participate in a variety of oral interpretations
- OM13 Assess needs of audience, and adjust language and presentation according to their knowledge
- OM14 Analyze and synthesize information for speaking
- OM15 Describe effectiveness of a literary selection
- OM16 Describe topic or idea in order to clarify personal/audience thinking
- OM17 Analyze and synthesize information gathered from a variety of sources (e.g., interviews, hypermedia, reference works) for speaking
- OM18 Describe validity and/or quality of a literary selection and justify selection
- OM19 Interpret orally a variety of literature
- OM20 Describe topic or idea to clarify meaning for others

***Subunit: Oral Communication—Application***

## Competencies:

- OA1 Become proficient at using interviewing techniques
- OA2 Give an oral interpretation for a specific audience
- OA3 Develop and apply oral communication skills for cooperative/collaborative learning
- OA4 Use oral communication for a variety of purposes and audiences (e.g., negotiations, book reviews, rationales)
- OA5 Develop and apply decision-making strategies
- OA6 Practice interviewing techniques
- OA7 Apply interviewing techniques to purposeful interviews
- OA8 Focus oral interpretation on a specific audience

***Subunit: Oral Communications—Multidisciplinary***

Competencies:

- OM1 Value thinking and language of others
- OM2 Develop oral projects collaboratively
- OM3 Be involved in individual, small-group, and whole-group language activities
- OM4 Participate actively in a community of learners
- OM5 Investigate language and cultural differences through oral language activities

**Unit: Mathematics Skills**

***Subunit: Numbers and Number Relations***

Competencies:

- NR1 Compare, order, and determine equivalence of real numbers
- NR2 Estimate answers, compute, and solve problems involving real numbers
- NR3 Compare and contrast real number system, rational number system, and whole number system
- NR4 Extend knowledge to complex number system, and develop facility with its operation

***Subunit: Measurement***

Competencies:

- M1 Estimate and use measurements
- M2 Understand the need for measurement and the probability that any measurement is accurate to some designated specification
- M3 Understand and apply measurements related to power and work
- M4 Understand and apply measurement concepts of distance-rate-time problems and acceleration problems with real-world experiments
- M5 Use real experiments to investigate elasticity, heat, sound, electricity, magnetism, light, acceleration, velocity, energy, and gravity
- M6 Use real-world problem situations involving mass and weight
- M7 Use real-world problem situations involving simple harmonic motion
- M8 Establish ratios with and without common units
- M9 Construct and interpret maps, tables, charts, and graphs as they relate to real-world mathematics
- M10 Understand and solve rate-change problems
- M11 Understand and solve right triangle relationships as they relate to measurement—specifically those that deal with the Pythagorean theorem
- M12 Graph and interpret ordered pairs
- M13 Compute total sales from a variety of items
- M14 Comprehend and compute rates of growth or decay
- M15 Comprehend, compute, and interpret real problems involving annuities
- M16 Develop an ability to identify real problems and provide possible solutions
- M17 Express and apply different types of measurement scales
- M18 Determine area and volume

NOTE: The math subunit on problem solving was not included on this list since it should be a continuing thread throughout all instruction rather than a separate set of competencies.

***Subunit: Estimation and Mental Computation***

## Competencies:

- E1 Use estimation to eliminate choices in multiple-choice tests
- E2 Use estimation to determine reasonableness of problem situations in a wide variety of applications
- E3 Estimate shape of graphs of various functions and algebraic expressions
- E4 Use mental computation when computer and calculator are inappropriate

***Subunit: Data Analysis and Probability***

## Competencies:

- D1 Organize data into tables, charts, and graphs
- D2 Understand and apply measures of central tendency, variability, and correlation
- D3 Use curve fitting to predict from data
- D4 Use experimental or theoretical probability, as appropriate, to represent and solve problems involving uncertainty
- D5 Use computer simulations and random number generators to estimate probabilities
- D6 Test hypotheses using appropriate statistics
- D7 Read, interpret, and use tables, charts, and graphs to identify patterns, note trends, draw conclusions, and make predictions
- D8 Identify probabilities of events involving unbiased objects
- D9 Use sampling and recognize its role in statistical claims
- D10 Design a statistical experiment to study problem, conduct experiment, and interpret and communicate outcomes
- D11 Describe normal curve in general terms, and use its properties
- D12 Create and interpret discrete probability distributions
- D13 Understand concept of random variable
- D14 Apply concept of random variable to generate and interpret probability distributions, including binomial, uniform, normal, and chi square

***Subunit: Algebra***

## Competencies:

- A1 Describe problem situations by using and relating numerical, symbolic, and graphical representations
- A2 Use language and notation of functions in symbolic and graphing settings
- A3 Recognize, relate, and use the equivalent ideas of zeros of a function, roots of an equation, and solution of an equation in terms of graphical and symbolic representations
- A4 Describe and use logic of equivalence in working with equations, inequalities, and functions
- A5 Develop graphical techniques of solution for problem situations involving functions
- A6 Explore and describe characterizing features of functions
- A7 Make arguments and proofs in algebraic settings
- A8 Factor difference of two squares
- A9 Determine slope, midpoint, and distance
- A10 Explore and combine rational functions
- A11 Explore factoring techniques
- A12 Solve quadratic equations by factoring and formula
- A13 Set up and solve linear equations
- A14 Solve systems of linear equations with two variables
- A15 Describe geometric situations and phenomena using variables, equations, and functions
- A16 Describe measures of central tendency, mean, median, mode, and variance algebraically and graphically
- A17 Represent inequalities on the number line and in the coordinate plane
- A18 Use coordinate arguments in making geometric proofs

- A19 Symbolize transformations of figures and graphs
- A20 Explore geometric basis for functions of trigonometry
- A21 Graph linear functions
- A22 Develop and use vectors to represent direction and magnitude, including operations
- A23 Use polar and parametric equations to describe, graph, and solve problem situations
- A24 Represent sequences and series as functions both algebraically and graphically
- A25 Explore recursive functions and procedures using spreadsheets, other computer utilities, and notions appropriate to these problem situations
- A26 Describe and solve algebraic situations with matrices
- A27 Describe and use inverse relationship between functions, including exponential and logarithmic
- A28 Analyze and describe errors (and their sources) that can be made when using computers and calculators to solve problems
- A29 Decide whether problem situation is best solved using computer, calculator, paper and pencil, or mental arithmetic/estimation techniques
- A30 Explore relationships between complex numbers and vectors
- A31 Make arguments concerning limits, convergence and divergence in contexts involving sequences, series, and other types of functions
- A32 Represent transformations in the plane with matrices
- A33 Contrast and compare algebras of rational, real, and complex numbers with characteristics of a matrix algebra system
- A34 Construct polynomial approximations of a function over specified intervals of convergence
- A35 Examine complex numbers as zeros of functions
- A36 Translate verbal statements into symbolic language
- A37 Simplify algebraic expressions
- A38 Use laws and exponents (including scientific notation)
- A39 Expand and extend idea of vectors and linear algebra to higher dimensional situations
- A40 Use the idea of independent basis elements for a vector space and associated fundamental concepts of finite dimensional linear algebra
- A41 Develop and communicate arguments about limit situations
- A42 Use matrices to describe and apply transformations
- A43 Develop and use polar and parametric equations to represent problem situations
- A44 Explore proofs by mathematical induction

### ***Subunit: Geometry***

#### Competencies:

- G1 Create and interpret drawings of three-dimensional objects
- G2 Represent problem situations with geometric models and apply properties of figures
- G3 Apply Pythagorean theorem
- G4 Demonstrate knowledge of angles and parallel and perpendicular lines
- G5 Explore inductive and deductive reasoning through applications to various subject areas
- G6 Translate between synthetic and coordinate representations
- G7 Identify congruent and similar figures using transformation with computer programs
- G8 Deduce properties of figures using transformations and coordinates
- G9 Use deductive reasoning
- G10 Explore compass and straightedge constructions in context of geometric theorems
- G11 Demonstrate knowledge of and ability to use proof
- G12 Use variety of proof techniques (e.g., synthetic, transformational, and coordinate)
- G13 Use variety of proof formats, including T-proof (i.e., two-column) and paragraph proof
- G14 Explore different proof strategies
- G15 Investigate different proofs of theorems
- G16 Develop knowledge of an axiomatic system
- G17 Apply transformations and coordinates in problem solving
- G18 Represent problem situations with geometric models, and apply properties of figures

- G19 Deduce properties of figures using vectors
- G20 Analyze properties of Euclidean transformations, and relate translations to vectors
- G21 Apply vectors in problem solving
- G22 Develop further knowledge of axiomatic systems by investigating and comparing various geometries

### ***Subunit: Patterns, Relations, and Functions***

#### Competencies:

- P1 Model real-world phenomena with polynomial and exponential functions
- P2 Explore relationship between zeros and intercepts of functions
- P3 Translate among tables, algebraic expressions, and graphs of functions
- P4 Use graphing calculator or computer to generate graph of a function
- P5 Explore relationship between a linear function and its inverse
- P6 Describe and use characteristics of polynomial functions in problem-solving situations
- P7 Explore conic sections, and graph using graphing calculator or computer
- P8 Apply trigonometric functions to problem situations involving triangles
- P9 Discover general relationships between algebraic description of conic, kind of conic, and special properties of that conic
- P10 Explore periodic real-world phenomena using sine and cosine functions
- P11 Analyze effects of parameter changes on graphs
- P12 Use graphing calculator or computer to graph functions
- P13 Develop a knowledge of rational and transcendental functions
- P14 Understand connections between trigonometric and circular functions
- P15 Use circular functions to model periodic real-world functions
- P16 Solve trigonometric equations, and verify trigonometric identities
- P17 Understand connections between trigonometric functions and polar coordinates, exponential functions, logarithmic functions, complex numbers, and series
- P18 Model real-world phenomena with a variety of functions
- P19 Graph using polar coordinates
- P20 Explore graphs in three dimensions
- P21 Explore functions of several variables
- P22 Explore recursive functions using spreadsheets and/or programming languages

## **Unit: Science Skills**

### ***Subunit: Scientific Inquiry***

#### Competencies:

- Q1 Check the appropriateness and accuracy of measures and computations using various strategies (e.g., estimations, unit analysis, determination of significant figures)
- Q2 Use ratios, proportions, and probabilities in appropriate problem situations
- Q3 Translate information from and represent information in various forms with equal ease (e.g., tables, charts, graphs, diagrams, geometric figures)
- Q4 Use existing algebraic formulas and create new ones in appropriate problem-solving situations
- Q5 Estimate and justify probabilities of outcomes of familiar situations based on experimentation and other strategies
- Q6 Invent apparatus and mechanical tools needed to perform unique tasks in various situations
- Q7 Identify, compare, and contrast different modes of inquiry, habits of mind, and attitudes and dispositions
- Q8 Design investigations that are safe and ethical (i.e., obtain consent and inform others of potential outcomes, risks, and benefits; and show evidence of concern for the health and safety of humans and non-human species)



- Q9 Make and read scale drawings, maps, models, and other representations to aid planning and understanding
- Q10 Seek elaboration and justification of data and ideas, and reflect on alternative interpretations of the information
- Q11 Use appropriate units for counts and measures
- Q12 Create and use databases (electronic and other) to collect, organize, and verify data and observations
- Q13 Design and conduct investigations with multiple variables
- Q14 Communicate the results of investigations clearly in a variety of situations
- Q15 Examine relationships in nature, offer alternative explanations for the observations, and collect evidence that can be used to help judge among explanations
- Q16 Trace the development (e.g., history, controversy, and ramifications) of various theories, focusing on supporting evidence and modification with new evidence
- Q17 Select, invent, and use tools, including analog and digital instruments, to make and record direct measurements
- Q18 Observe and document events and characteristics of complex systems
- Q19 Explain the influence of perspective (e.g., spatial, temporal, and social) on observation and subsequent interpretations
- Q20 Create multiple representations of the same data using a variety of symbols, descriptive languages, mathematical concepts, and graphic techniques
- Q21 Generate testable hypotheses for observations of complex systems and interactions
- Q22 Document potentially hazardous conditions and associated risks in selected homes and public areas
- Q23 Participate in public debates, relying on documented and verified data to construct and represent a position on scientific issues
- Q24 Construct and test models of physical, biological, social, and geological systems
- Q25 Read, verify, debate, and, where necessary, refute research published in popular or technical journals of science (e.g., *Discover*, *Omni*, *Popular Mechanics*)
- Q26 Explore discrepant events and develop and test explanations of what was observed
- Q27 Conduct theory-based research using surveys, observational instruments, and other methods
- Q28 Modify personal opinions, interpretations, explanations, and conclusions based on new information
- Q29 Analyze error and develop explanations in various domains
- Q30 Formulate taxonomic schemes based upon multivariate models that help to explain similarities and differences in form, distribution, behavior, survival, and origin of objects and organisms
- Q31 Demonstrate various logical connections between related concepts (e.g., entropy, conservation of energy)
- Q32 Account for discrepancies between theories and observations
- Q33 Analyze the changes within a system when inputs, outputs, and interactions are altered
- Q34 Create, standardize, and document procedures
- Q35 Determine the sources of significant disparities between the predicted and recorded results, and change research procedures to minimize disparities
- Q36 Research, locate, and propose applications for abstract patterns (e.g., fractals, Fibonacci sequences, string theory, orbitals)
- Q37 Recognize and utilize classification systems for particles, elements, compounds, phenomena, organisms, and others for exploring and predicting properties and behaviors
- Q38 Suggest and defend alternative experimental designs and data explanations (e.g., sampling, controls, safeguards)
- Q39 Recognize and communicate differences between questions that can be investigated in a scientific way and those that rely on other ways of knowing
- Q40 Draw conclusions based on the relationships among data analysis, experimental design, and possible models and theories
- Q41 Suggest new questions as a result of reflection on and discussions about own scientific investigations
- Q42 Investigate, assess, and comment on strengths and weakness of the descriptive and predictive powers of science
- Q43 Create new information from representations of data in a variety of forms (e.g., symbols, descriptive languages, graphic formats) utilizing a variety of techniques (e.g., interpolations, extrapolations, linear regressions, central tendencies, correlations)

***Subunit: Scientific Knowledge***

## Competencies:

- K1 Investigate various types of dynamic equilibrium (e.g., biological, geological, mechanical, chemical)
- K2 Investigate the relationship between the rates of energy exchange and the relative energy level of components within systems (e.g., trophic levels of ecosystems, osmosis, rate of heating and cooling, storms)
- K3 Investigate patterns in the natural world (e.g., heredity, crystalline structures, population and resource distributions, diffraction, dispersion, polarization)
- K4 Investigate models and theories that help to explain the interactions of components in systems (e.g., conservation of mass, energy, and momentum; foodwebs; natural selection; entropy; plate tectonics; chaos; relativity; social-psychology)
- K5 Investigate degrees of kinship among organisms and groups of organisms
- K6 Investigate the limits of the definition of life, and investigate organisms and physical systems that exist at or near these limits (e.g., viruses, quarks, black holes)
- K7 Investigate estimates and measurements of a wide range of distances and rates of change
- K8 Investigate the historical development of theories of change over time (e.g., natural selection, continental drift, the big bang, geologic change)
- K9 Investigate physical and chemical changes in living and nonliving systems (e.g., photosynthesis, weathering processes, glaciation, thermal effects of materials, energy cells)
- K10 Investigate simulations of nuclear change (e.g., radioactivity, half life, carbon dating)
- K11 Investigate conservation principles associated with physical, chemical, and nuclear changes
- K12 Formulate descriptions of the impacts of various forms of mechanical and electromagnetic waves on various organisms and objects
- K13 Formulate models and hypotheses for patterns in the natural world (e.g., earth structures, transportation systems, migrations, communications, constellations)
- K14 Formulate explanations for the influences of objects and organisms on each other over time
- K15 Formulate and interpret explanations for change phenomena (e.g., mass extinctions, stellar evolution, punctuated equilibrium, molecular synthesis)
- K16 Formulate and interpret explanations for the magnitudes of diversity at different periods of geologic time (e.g., mutation, global cataclysms, continental drift, competition, mass extinctions)
- K17 Formulate interpretations of the structure, function, and diversity in a variety of organisms and physical systems (e.g., DNA and RNA variants, nucleons, interaction particles)
- K18 Formulate understandings of geologic time (e.g., millennia, periods, epochs)
- K19 Formulate an understanding of the historical development of the model of the universe (e.g., Aristotle, Ptolemy, Copernicus, Brahe, Kepler, Galileo, Newton, Einstein)
- K20 Formulate explanations and representations of the production, transmission, and conservation of energy in biological and physical systems (e.g., weather, volcanism, earthquakes, electricity, magnetism, cellular respiration)
- K21 Formulate models and hypotheses about patterns in the natural world (e.g., social behavior, molecular structure, energy transformation, entropy, randomness, aging, chaos, hormonal cycles)
- K22 Formulate interpretations of the relationship between energy exchange and the interfaces between components within systems
- K23a Formulate estimations for the range of energies within and between various phenomena (e.g., thermal, electromagnetic, thermonuclear, chemical, electrical)
- K23b Formulate explanations for the historical development of descriptions of motions interactions and transformations of matter and energy (e.g., classical Newtonian mechanics, special and general relativity, chaos)
- K24 Formulate models that can be used to describe fundamental molecular interactions in living and non-living systems (e.g., cell membranes, semiconductors).
- K25 Formulate an understanding of the degree of relationship among organisms and objects based on molecular structure (e.g., proteins, nucleic acids)
- K26 Formulate hypotheses and models that may account for observable events (e.g., electricity and magnetism, gravitation, atoms, bonding, chemical reactions, quantum effects, energy flow on biological systems, predator-prey relationships)



- K27 Formulate models and hypotheses about change over time (e.g., natural selection, speciation, punctuated equilibrium, phyletic gradualism, stellar evolution, plate tectonics, radioactive decay, quantum mechanical theory)
- K28 Formulate lists of limitations, and propose refinements of standard classification systems (e.g., periodic table, IUPAC, Linnean, standard model)
- K29 Formulate specific cases of limitations and possible exceptions of theories and principles regarding the interactions of moving objects and organisms (e.g., fluid flow in vessels, motion near the speed of light, Heisenberg uncertainty principle, meteorological prediction, local variation and diversity, earthquake prediction, energy transport in cellular respiration)
- K30 Formulate plans and contingencies that can be used to accommodate for changes to and stresses on systems (e.g., wildlife and habitat management, corrosion prevention, noise abatement, structure design)
- K31 Formulate models of molecular, atomic, ionic, and subatomic structures and the physical and biological implications of these structures (e.g., genes, nucleons, quarks)
- K32 Formulate estimates for a wide range of measurements and scales (e.g., angstroms to light years)
- K33 Formulate and interpret representations of time from origin to present accounting for phenomena of scale (e.g., smoothness, punctuations, chaos)
- K34 Formulate interpretations of the historical development of various theories of possible causes of diversity among physical and biological phenomena (e.g., the works of Aristotle, Mendel, Darwin, McClintock)
- K35 Formulate models and hypotheses that can be used to explain the interactions of components within technological and ecological systems

***Subunit: Conditions for Learning Science***

Competencies:

- C1 Participate actively in dialogue about and resolution of community issues
- C2 Assess information from various countries in the original language or translated form to ascertain the perspectives of many cultures
- C3 Analyze the scientific ideas presented in science fiction stories and films
- C4 Perform and repeat investigations to verify data, determine regularity, and reduce the impact of experimental error
- C5 Present the results of investigations in a variety of forums
- C6 Contribute to the decisions regarding topics for investigation
- C7 Use various creative means to communicate interpretations of scientific ideas, concepts, phenomena, and events
- C8 Consider the scientific thinking and language of others
- C9 Individually and collaboratively produce clearly written representations of investigative results
- C10 Fulfill responsibilities as part of a research group
- C11 Select and utilize resources by various criteria (e.g., efficiency, effectiveness, health, safety) that are appropriate to the investigations being conducted by groups
- C12 Present persuasive argument based on the scientific aspects of controversial issues
- C13 Collect, store, retrieve, and manipulate information with available technologies that may range from hand processes up through computer applications
- C14 Investigate social issues with a scientific perspective (e.g., human rights, wellness, economics, futurism, environmental ethics)
- C15 Keep journals of observations and inferences made over an extended period of time, and reflect upon the impact of these recorded ideas on own thinking and actions
- C16 Examine the intellect, perspectives, and ethics of notable scientists
- C17 Collect and analyze observations made over extended periods of time and compare these to scientific theories
- C18 Create presentations of scientific understandings using diverse modes of expressions
- C19 Conduct formal scientific debates in the classroom

- C20 Wonder about the likelihood of events that may occur by chance or coincidence
- C21 Plan and conduct field trips and experiences for small and large groups
- C22 Analyze the historical context that leads to and has led to scientific theories
- C23 Seek information on topics of personal scientific interest from a variety of sources
- C24 Conduct learner-developed investigations independently and collaboratively over periods of weeks and months
- C25 Listen attentively and critically to presentations of scientific information made by others
- C26 Conduct analyses of propaganda related to scientific issues
- C27 Perform investigations that require observations over varying periods of time
- C28 Experience scientific concepts as interpreted by other cultures through multimedia and local and global specialists
- C29 Access appropriate technology to perform complicated, time-consuming tasks
- C30 Relate historical accounts of science to the cultural context in which they were written
- C31 Work as a contributing member of a collaborative research group
- C32 Examine the influences of social and political structures and realities that contribute to inquiry about scientific issues
- C33 Use technology (e.g., desktop publishing, teleconferencing, networking) to communicate scientific ideas
- C34 Explore and analyze a variety of perspectives on science (e.g., works by men and women of many racial, ethnic, and cultural groups)
- C35 Lead groups of learners of various ages in designing, planning, and conducting science activities
- C36 Respect the scientific thinking of others and self
- C37 Recognize and contrast different epistemologies
- C38 Develop possible courses of action in response to scientific issues of local and global concern
- C39 Determine the validity of research conclusions in relation to the design, performance, and results
- C40 Develop multimedia presentations of group and individual research projects and investigations appropriate for a variety of audiences and forums
- C41 Produce interesting and scientifically correct stories and present them using various modes of expression
- C42 Reflect on the ideas and content found in own journal records
- C43 Examine ambiguous results and formulate explanations
- C44 Recognize and synthesize the contributions to scientific thought of individuals from many cultures
- C45 Construct models and simulations of the component structures and functions of living and nonliving entities
- C46 Lead multi-age groups in the examination of and planned resolution for scientific issues
- C47 Recognize and choose members of research teams based upon the merit of their ideas and skills
- C48 Construct a portfolio of products, documentation, and self-evaluations of own abilities, skills, and experiences
- C49 Synthesize scientific information from a variety of sources
- C50 Evaluate and prioritize scientific issues based upon risk-benefit analyses
- C51 Refine scientific skills from a variety of experiences

### ***Subunit: Applications for Science Learning***

#### Competencies:

- A1 Answer student-determined questions by designing databases and drawing inferences from the analyses of the information in these databases
- A2 Make personal behavior decisions by interpreting information that has a scientific basis
- A3 Propose courses of action that will validate and demonstrate personal understandings of scientific principles
- A4 Guide other learners in their understanding of the interactions of technologies and society at various periods in time
- A5 Promote and carry out practices that contribute to a sustainable environment

- A6 Study and propose improvements in public services and systems in own community
- A7 Choose consumer materials utilizing personal and environmental risk and benefit information
- A8 Make inferences and draw conclusions using databases, spreadsheets, and other technologies
- A9 Do simple troubleshooting on common electrical and mechanical systems, identifying and eliminating possible causes of malfunctions
- A10 Construct devices that perform simple, repetitive actions
- A11 Investigate the functionality of various geometric shapes in the natural world and the designed world (e.g., translations from spherical to plane representations cause distortions; triangular shapes contribute to rigidity and stability in structures; round shapes minimize boundary for a given capacity)
- A12 Make decisions regarding personal and public health
- A13 Evaluate the social and ecological risks and benefits resulting from the use of various consumer products
- A14 Analyze the contributions of advances in technology through history to own everyday life
- A15 Identify and reduce risks and threats to a sustainable environment
- A16 Extend the limits of human capabilities using technological enhancements
- A17 Use and recognize various propaganda techniques
- A18 Solve unique problems using the results of systematic analyses
- A19 Choose everyday consumer products that utilize recent innovation and pass appropriate performance criteria
- A20 Refine personal career interests through investigations of the diversity of manufacturing, research, service, and invention processes
- A21 Predict and investigate the working of toys and tools while controlling and manipulating variables (e.g., friction, gravity, forces)
- A22 Write, follow, modify, and extend instructions (e.g., equations, algorithms, formulas, flow diagrams, illustrations)
- A23 Create products, make inferences, and draw conclusions using databases, spreadsheets, and other technologies
- A24 Predict various scenarios and propose solutions to community issues using scientific information (e.g., actuarial tables, census data, topographic maps, incidence data, climatic data)
- A25 Use scientific evidence to consider options and formulate positions about the health and safety of others and self
- A26 Search for, use, create, and store objects and information using various strategies and methods of organization and access
- A27 Research and write environmental impact statements of own design
- A28 Compare school-based science perspectives with those gained through cutting-edge technological applications
- A29 Design management plans for natural and human-altered environments (e.g., woodlots, patios, lots, lawns, farmlands, forests)
- A30 Refine personal career interests
- A31 Promote public awareness of the interaction of technology with social issues
- A32 Advocate and propose courses of action for local and global scientific issues using global networks
- A33 Use appropriate technologies to prepare and present the findings of investigations incorporating tables, graphs, diagrams, and text
- A34 Make informed consumer choices by evaluating and prioritizing information, evidence, and strategies
- A35 Develop an informed point of view that allows for validation or refutation of the scientific statements and claims of advocates before pursuing courses of action (e.g., contributing support, signing petitions, casting votes)
- A36 Differentiate between observations and inferences in the exploration of evidence related to personal, scientific, and community issues
- A37 Develop and write environmental impact, and safety and hygiene management plans
- A38 Use technology to collect, analyze, and communicate information (e.g., electronic networks, desktop publishing, remote sensing, graphing calculators, satellite telemetry, and others)
- A39 Design, construct, and market inventions

## Academic Competencies: Heating, Ventilation, Air-Conditioning, and Refrigeration

The Heating, Ventilation, Air-Conditioning, and Refrigeration OCAP panel of expert workers (see member list on the inside back cover) identified the following academic competencies (from the total list, pp. 58-72) as most crucial to the entry-level success of an employee in the area of heating, ventilation, air-conditioning, and refrigeration. It is recommended that these competencies be taught in an applied manner for students enrolled in heating, ventilation, air-conditioning, and refrigeration programs.

### Unit: Communications Skills

#### *Subunit: Reading—Structure*

Competencies:

- RS1 Exhibit knowledge of language structure
- RS2 Recognize that there may be more than one interpretation of reading selections
- RS15 Apply an expanding vocabulary gained through reading

#### *Subunit: Reading—Meaning Construction*

Competencies:

- RM3 Read to clarify personal thinking and knowledge
- RM7 Engage in self-selected reading activities
- RM12 Use reading as a possible problem-solving strategy to clarify personal thinking and knowledge
- RM17 Clarify meaning when reading, using knowledge of literary devices, stylistic diction, and other semantic elements
- RM20 Use reference books to find, evaluate, and synthesize information

#### *Subunit: Reading—Application*

Competencies:

- RA1 Select and read material for personal enjoyment and information
- RA7 Extend value of reading, writing, speaking, viewing, and listening by pursuing, through reading, new concepts and interests developed as a result of these activities

#### *Subunit: Reading—Multidisciplinary*

Competencies:

- RM2 Read to facilitate learning across curriculum
- RM9 Read to facilitate content learning

### ***Subunit: Writing—Structure***

Competencies:

- WS2 Clarify word choice according to audience, topic, and purpose
- WS5 Develop writing that contains ordered, related, well-developed paragraphs with sentences of varied lengths and patterns

### ***Subunit: Listening/Visual Literacy—Structure***

Competencies:

- LS3 Recognize correct and appropriate grammar, diction, and syntax
- LS4 Expand vocabulary through listening to and viewing varied media (e.g., recordings, films, music, news broadcasts)

### ***Subunit: Listening/Visual Literacy—Application***

Competencies:

- LA1 Listen attentively during oral reading

### ***Subunit: Oral Communication—Structure***

Competencies:

- OS1 Refine oral communication skills (e.g., voice modulation, eye contact, body language)
- OS2 Demonstrate knowledge of grammar, usage, and syntax when presenting
- OS4 Organize notes and ideas for speaking (e.g., cause-effect, chronological, exemplification)
- OS10 Expand vocabulary to fit topic

### ***Subunit: Oral Communications—Meaning Construction***

Competencies:

- OM1 Make connections between prior knowledge and new information for oral presentations

### ***Subunit: Oral Communication—Application***

Competencies:

- OA5 Develop and apply decision-making strategies

## **Unit: Mathematics Skills**

### ***Subunit: Numbers and Number Relations***

Competencies:

- NR2 Estimate answers, compute, and solve problems involving real numbers

### ***Subunit: Measurement***

Competencies:

- M1 Estimate and use measurements
  - M2 Understand the need for measurement and the probability that any measurement is accurate to some designated specification
  - M3 Understand and apply measurements related to power and work
  - M5 Use real experiments to investigate elasticity, heat, sound, electricity, magnetism, light, acceleration, velocity, energy, and gravity
  - M6 Use real-world problem situations involving mass and weight
  - M8 Establish ratios with and without common units
  - M9 Construct and interpret maps, tables, charts, and graphs as they relate to real-world mathematics
  - M10 Understand and solve rate-change problems
  - M13 Compute total sales from a variety of items
  - M16 Develop an ability to identify real problems and provide possible solutions
- 
- M17 Express and apply different types of measurement scales
  - M18 Determine area and volume

### ***Subunit: Estimation and Mental Computation***

Competencies:

- E1 Use estimation to eliminate choices in multiple-choice tests
- E2 Use estimation to determine reasonableness of problem situations in a wide variety of applications
- E4 Use mental computation when computer and calculator are inappropriate

### ***Subunit: Data Analysis and Probability***

Competencies:

- D1 Organize data into tables, charts, and graphs
- D7 Read, interpret, and use tables, charts, and graphs to identify patterns, note trends, draw conclusions, and make predictions

### ***Subunit: Algebra***

Competencies:

- A1 Describe problem situations by using and relating numerical, symbolic, and graphical representations
- A13 Set up and solve linear equations

### ***Subunit: Geometry***

Competencies:

- G4 Demonstrate knowledge of angles and parallel and perpendicular lines

**Unit: Science Skills**

***Subunit: Scientific Inquiry***

Competencies:

- Q1 Check the appropriateness and accuracy of measures and computations using various strategies (e.g., estimations, unit analysis, determination of significant figures)
- Q2 Use ratios, proportions, and probabilities in appropriate problem situations
- Q3 Translate information from and represent information in various forms with equal ease (e.g., tables, charts, graphs, diagrams, geometric figures)
- Q9 Make and read scale drawings, maps, models, and other representations to aid planning and understanding
- Q11 Use appropriate units for counts and measures
- Q14 Communicate the results of investigations clearly in a variety of situations
- Q17 Select, invent, and use tools, including analog and digital instruments, to make and record direct measurements
- Q18 Observe and document events and characteristics of complex systems
- Q22 Document potentially hazardous conditions and associated risks in selected homes and public areas
- Q33 Analyze the changes within a system when inputs, outputs, and interactions are altered
- Q40 Draw conclusions based on the relationships among data analysis, experimental design, and possible models and theories

***Subunit: Scientific Knowledge***

Competencies:

- K25 Formulate an understanding of the degree of relationship among organisms and objects based on molecular structure (e.g., proteins, nucleic acids)

***Subunit: Applications for Science Learning***

Competencies:

- A9 Do simple troubleshooting on common electrical and mechanical systems, identifying and eliminating possible causes of malfunctions
- A12 Make decisions regarding personal and public health
- A30 Refine personal career interests



## Verification Panels

The Vocational Instructional Materials Laboratory wishes to extend thanks and appreciation to the many representatives of business, industry, labor, and community organizations who donated their time and expertise to the identification and revalidation of competencies.

The following panel was responsible for verifying the occupational competencies on the Heating, Ventilation, Air-Conditioning, and Refrigeration OCAP, identifying those academic competencies that an entry-level employee should possess, and determining the Work Keys academic skill levels required for successful entry into the occupation:

Herman A. Boll, *Boll Electric and Professional Services*, Wheelersburg, Ohio  
 Thomas Cizmar, *Armstrong Air Conditioning, Inc.*, Bellevue, Ohio  
 Jim Friedrich, *Stark Cooling & Heating*, Massillon, Ohio  
 Charles W. Gundlach III, *Gundlach Sheet Metal Works, Inc.*, Sandusky, Ohio  
 James Healy, *NHRAW*, Columbus, Ohio  
 John R. Horger, *John R. Horger Plumbing and Heating, Inc.*, Louisville, Ohio  
 Alan Johnston, *The Ohio State University*, Columbus, Ohio  
 Kenneth W. Manz, *SPX Corp.*, Montpelier, Ohio  
 Frederick G. Paepke, *Bard Manufacturing Co.*, Bryan, Ohio  
 George Pugh, *Pugh Heating*, Toledo, Ohio  
 Bill Sammons, *Mason Supply Co.*, Cincinnati, Ohio  
 Ed Shriver, *Shriver Mechanical Services*, Toledo, Ohio  
 George A. Story, *Copeland Corp.*, Sidney, Ohio  
 Dominic Volpone, *H. J. Ziegler Heating Co., Inc.*, Ashtabula, Ohio

The following panel was responsible for verifying the competencies on the Employability OCAP:

Barbara J. Forster, *Nationwide Insurance*, Columbus, Ohio  
 Joan L. Hall, *Health Management Nursing*, Chesapeake, Ohio  
 Jane Highland, *Southern Ohio Staffing, Inc.*, Chillicothe, Ohio  
 Chuck Jackson, *Butech, Inc.*, Salem, Ohio  
 Garry Kessel, *Medina Auto Parts, Inc.*, Medina, Ohio  
 Joyce A. McMickens, *Ernst & Young*, Cleveland, Ohio  
 Julie C. Payeff, *The Andersons Management Corp.*, Maumee, Ohio  
 Patricia Piper, *Edison Industrial Systems Center*, Toledo, Ohio  
 Gary F. Rybak, *Red Roof Inns, Inc.*, Hilliard, Ohio