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ABSTRACT

This guide contains information on the knowledge and skills identified by industry as essential to the job performance of heating, air-conditioning, and refrigeration technicians. It is intended to assist training providers in public and private institutions, as well as in industry, to develop and implement training that will provide workers with the competencies needed to gain employment as technicians and to advance within the field. The publication contains six sections. The first section defines skill standards, provides suggestions for using them, and explains how they were developed. The second section lists the core knowledge standards in communication, mathematics, and science. The third section lists the core occupational skills standards in these areas: safety and environment, electrical principles, electric motors, controls, refrigeration, heating, air conditioning, and piping. Occupation-specific skill standards for residential and light commercial heating, air conditioning, and heat pumps, and commercial conditioned-air systems and refrigeration are listed in the fourth section. In the fifth section, standards for workplace behaviors, including ethics, environment, communication, professionalism, and problem solving, are provided. The final section contains skill standards matrixes for core skills and occupational skills. An appendix contains a skills matrix that relates all the skill standards to various residential and commercial applications. (KC)

HEATING, AIR-CONDITIONING, AND REFRIGERATION TECHNICIAN

NATIONAL SKILL STANDARDS

KNOWLEDGE, SKILLS, AND STANDARDS

This publication includes the material contained in the previously released ***National Skill Standards for Heating, Air-Conditioning, and Refrigeration Technicians, Volume One: Skills and Knowledge.***

This project is supported in part by a grant from the Business and Education Standards Program of the Carl D. Perkins Vocational and Applied Technology Education Act, Office of Vocational and Adult Education, United States Department of Education.

Heating, Air-Conditioning, and Refrigeration Technician

National Skill Standards

Developed in Concert With

Heating, Air-Conditioning, and Refrigeration Policy Advisory Committee

and

V-TECS
Southern Association of Colleges and Schools
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Preface

Why Skill Standards Are Critical

America's economic well-being depends on its collective ability to meet globally-competitive standards for manufacturing and performance. *Skill Standards for Heating, Air Conditioning, and Refrigeration Technicians* represents one of 16 projects funded by the U. S. Department of Education to identify the technical skills, knowledge, and workplace behaviors needed by technicians if the heating, air conditioning, and refrigeration industry in the United States is to remain competitive.

Manufacturers have improved the efficiency of their heating, air conditioning, and refrigeration equipment. In addition to environmental regulations, these technical advances require technicians to acquire a more sophisticated set of skills to install, maintain, and service this more energy-efficient and environmentally-friendly equipment.

How Skill Standards Emerged

This publication was developed through the collaborative efforts of stakeholders in the heating, air conditioning, and refrigeration industry working with V-TECS staff. A Policy Advisory Committee comprised of representatives from manufacturing, trade associations, labor organizations, and education provided counsel and assistance to the project staff charged with identifying skill standards.

In addition to their own expertise, the Policy Advisory Committee identified other technical experts recognized by peers for their knowledge, experience, and analytical abilities. These technicians, contractors, trainers, and educators worked with the project staff to ensure the accurate and complete identification of skill standards. They provided the knowledge and expertise required to ferret out what productive technicians know and do.

In line with the recommendation of the Policy Advisory Committee, the study classified the industry according to the time honored categories of residential, light commercial, commercial air-conditioning, and commercial refrigeration. Categories reflect the relative size of the equipment and the function performed. The type of tasks performed by technicians was classified into four functional areas—installation, maintenance, repair, and operations.

Purpose and Intended Uses of This Publication

The purpose of this publication is to convey the knowledge and skills identified by industry as essential to the job performance of heating, air-conditioning, and refrigeration technicians. The document is intended to assist training providers in public and private institutions, as well as in industry to develop and implement curriculum and training content that will provide workers with the competencies needed to gain employment as technicians and to advance within the field.

Acknowledgments

We thank the individuals who served on the Policy Advisory Committee and as technical advisors. They were always ready to educate and offer splendid advice. Without their efforts, dedication, and expertise, this document would not be available to its users.

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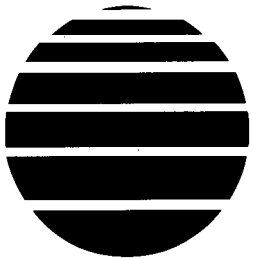

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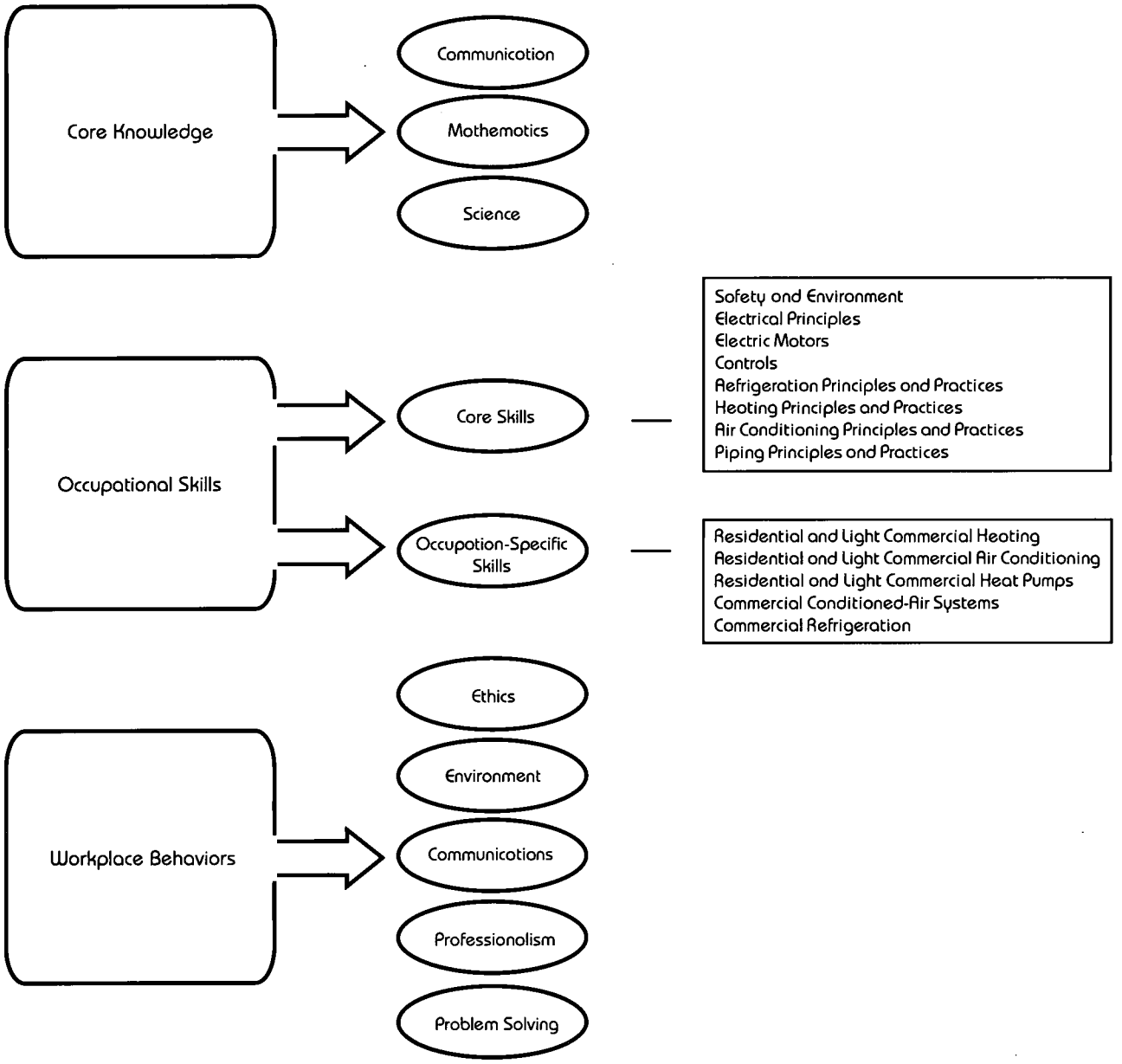
Organization of Skills for Heating, Air Conditioning, and Refrigeration Technicians



Introduction

What Are Skill Standards?

What must technicians know and do to be productive? What knowledge do they possess? What technical skills are required and where and when are they utilized? These are the questions that form the basis of this study.

For this inquiry, skill standards are defined as the body of knowledge, the technical skills, and the workplace behaviors required of productive, successful technicians.

The skill standards were divided into three separate but interdependent areas: Core Knowledge, Occupational Skills, and Workplace Behaviors. Occupational Skills were further subdivided into Core Skills and Occupation-Specific Skills.

Using Skill Standards

Students, technicians, educators, trainers, industry and management are the primary stakeholders in the heating, air conditioning, and refrigeration industry. How they use skill standards, however, will vary according to their individual needs.

Individuals

Skill standards help individuals develop a clear idea of what is expected of technicians. For students considering a career in the heating, air conditioning, and refrigeration field, the skill standards will assist in matching their personal knowledge, abilities, and interests to the knowledge and skills required of successful technicians.

Skill standards will help technicians identify the skills and knowledges required for continued success and assess their individual needs for additional training.

Training Providers

Skill standards establish a clear set of performance expectations that help both educators and trainers. They assist in the design, development, and delivery of student recruiting strategies, appropriate curriculum, and training consistent with industry needs. In the future, training providers can expect skill standards to be the basis for development of national credentialling systems for technicians and programs.

Industry and Management

Skill standards provide a basis for management in making decisions on recruiting, hiring, training, assigning, compensating and promoting technicians.

Developmental Process

The development of the skill standards emphasized input from the heating, air-conditioning, and refrigeration industry. The major phases included

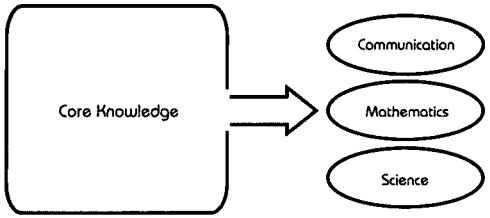
- Convening a Policy Advisory Committee with members representing industry, trade associations, labor organizations, and education and training agencies to provide direction and information to the project.
- Developing a list of tasks performed by heating, air-conditioning and refrigeration technicians, a standard of performance for each task, and a procedure for performing the task. The information was acquired through interviews and work sessions with technicians and instructors.
- Identifying the knowledge associated with the performance of each task.
- Delineating the skill standards using information obtained during the occupational analysis.
- Presenting the skill standards to the Policy Advisory Committee for review, refinement, and approval.

Standards

Standards are an important complement to this inventory of skills. Standards identify the indicators of successful skill attainment. In this publication, the standard is inferred in the skill statement associated with knowledge and workplace behaviors. However, standards have been written for psychomotor skill statements. These standards are indicated by a vertical line immediately to left of the statement.

It is difficult to develop standards that fulfill the needs of every user or user group of this publication. Broadly stated skills dictate broadly stated standards. It is generally accepted that true performance standards can only be written at the work activity or task level. At best, standards developed at the skill level can only identify indicators of skill performance. Standards written for broadly based skills are severely limited in describing with precision the outcomes of the skill when that skill can be performed in unlimited settings and contexts each with its particular outcome.

Even with these caveats, the standards provide a benefit that is important to the user of this publication.



Core Knowledge

To merely possess basic reading, writing, and arithmetic skills in a technician's world is not enough—technicians must apply this knowledge every day.

Core Knowledge is familiarity, awareness, or understanding of principles and fundamentals that forms the foundation to develop the more advanced knowledge and skills required in the workplace. Core Knowledge is categorized according to communication, mathematics, and science in this study.

Communication

Technicians must comprehend and use a variety of communication techniques in their work including the ability to

- Read and comprehend technical materials such as codes and regulations, installation, maintenance, and service manuals, flowcharts, tables, graphs, schematics, and decision trees.
- Maintain technical and diagnostic notes, compile data and information to complete reports, forms, records, warranties, contracts, and invoices, and compose technical reports.
- Provide information, discuss problems, solutions, and options, and required resources with workplace associates and customers.
- Identify and locate manuals and other information resources required for installation, maintenance, and service.
- Solve problems by using diagnostic data, technical information, and system knowledge.
- Apply interpersonal skills such as listening, team building, and conflict resolution.
- Apply basic keyboarding skills and the ability to use standard application software.

Mathematics

Technicians must comprehend and apply an array of math concepts in performing their duties including the ability to

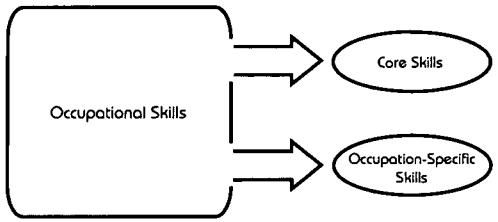
- Add, subtract, multiply, and divide decimals, fractions, mixed, and whole numbers
- Convert decimals, fractions, ratios, and percentages.
- Compute formulas and equations such as volumes, pressures, and degrees.
- Convert one measurement system to another.
- Calculate percentage of increase or decrease, mark up or discount.

- Identify geometric figures; distinguish angles, circles, and arcs; and discern perpendicular (plumb) and horizontal (level) lines and planes.
- Measure distance, angles, circles, and arcs.
- Measure temperature, weight, volume, and pressure.
- Interpret graphs, scales, and gauge indications.
- Use a calculator.

Science

Technicians must know the scientific principles that are central to the operation of the equipment they install and service. Technicians must

- Demonstrate an understanding of the principles of heat and heat transfer including heat gain/heat loss calculations.
- Demonstrate an understanding of the principles of combustion.
- Demonstrate an understanding of the concepts of temperature, air properties, psychrometrics, and their measurement.
- Demonstrate an understanding of the concept of pressure and its measurement.
- Demonstrate an understanding of enthalpy.
- Demonstrate an understanding of the principles of electricity including alternating and direct current, electrical ground, series and parallel circuits, and conductors and insulators.
- Demonstrate an understanding of the principles of electrical measurement including voltage, amperes, and resistance.
- Demonstrate an understanding of the principles of magnetism and its application in electrical motors and control systems.
- Demonstrate an understanding of the physical properties of matter and the principles of phases and states of matter.
- Demonstrate an understanding of the properties of gases and their response to changes in temperature and pressure.
- Demonstrate an understanding of the basics of chemical reactions and the effect of chemical concentration upon them.
- Demonstrate an understanding of the problem solving process including identification of the symptoms, accumulation of pertinent information, development of a hypothesis or solution, completion of corrective action, and checking of results.
- Demonstrate an understanding of physical and chemical properties of the commonly used substances in the industry such as refrigerants and hydrocarbons, and their effect upon the environment.



Core Skills

Core Skills represent the basic knowledge and technical skills needed by heating, air conditioning, and refrigeration technicians to perform according to the industry standards.

Safety and Environment

- Understand and apply safety regulations and procedures.
- Understand and apply federal, state, and local regulations for disposing of hazardous materials.
- Understand and apply Environmental Protection Agency (EPA) regulations on venting, recovery, reclaiming, and recycling refrigerants.
- Understand and apply the Department of Transportation (DOT) regulations on the transportation and handling of hazardous materials.
- Understand and apply Occupational Safety and Health Administration (OSHA) regulations.
- Understand and apply Environmental Protection Agency (EPA) regulations on indoor air quality and nitrous-oxide.

Electrical Principles

- Understand and apply the principles of alternating and direct current.
- Understand and recognize the common single and three phase voltage systems including 230v, 60hz, single phase; 208v, 60hz, three phase; 230v, 60hz, three phase; and 460v, 60hz, three phase.
- Understand and apply the principles of series, parallel, and compound circuits.
- Understand and apply the principles and relationships of Ohm's, Kirchhoff's, and Watt's laws as they apply to series, parallel, and compound circuits.
- Read and interpret voltage, ampere, ohm, megohm, and watt meters.
- Read and interpret schematic drawings.
- Develop schematics from electrical label/line diagrams.
- Read and interpret electrical codes.

- Understand and apply the properties and behaviors of electrical conductors and insulators.
- Understand and apply the principles of electrical circuit protection including fuses, circuit breakers, and disconnect switches.
- Understand and apply the principles of single and three phase transformers.
- Understand and apply electrical grounding principles.
- Understand and apply the principles of electrical measurement.
- Troubleshoot electrical circuits.
- Install electrical power and control circuits.
- Install and connect the components of electrical circuits.

Electric Motors

- Understand and apply the operating principles of electric motors.
- Understand and recognize the application of various types of electric motors.
- Understand and recognize the application of various types of capacitors.
- Understand the principles and operation of electric motor protection devices.
- Understand and interpret electric motor specifications.
- Install and connect electric motors.
- Perform electric motor maintenance.
- Troubleshoot electric motors.

Controls

- Understand and apply the principles of safety and operating control devices; for example, pressure switches, thermostats, etc.
- Understand and apply the principles of electromechanical control devices; for example, relays, contactors, magnetic starters, timers, sequencers, etc.
- Understand and apply the principles of electronic control devices; for example, ignition modules, electronic timers, etc.
- Understand and apply the principles of safety and control circuits.
- Install/service mechanical control devices.
- Install/service electromechanical control devices.
- Troubleshoot mechanical control devices.
- Troubleshoot electromechanical devices.
- Troubleshoot electronic control devices.

Refrigeration Principles and Practices

- Understand and apply the theory of heat.
- Understand and apply the properties of refrigerants.
- Understand and apply the mechanical refrigeration cycle.
- Understand and apply pressure/temperature curves and charts.
- Understand and apply the principles and the operation of compressors.
- Understand and apply the principles and operation of condensers.
- Understand and apply the principles and operation of metering devices.
- Understand and apply the principles and operation of evaporators.
- Understand the operation of refrigeration system accessories; for example, receivers, accumulators, filter/dryers, sight glasses, valves, etc.
- Perform leak tests.
- Evacuate and measure the vacuum level of refrigeration systems
- Recover refrigerants.
- Charge refrigeration systems.
- Recycle refrigerants.
- Troubleshoot mechanical refrigeration systems.

Heating Principles and Practices

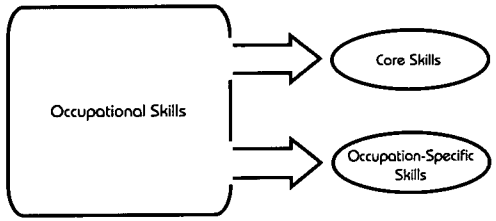
- Understand and apply the principles of fuel system design.
- Understand and apply the principles of air and hydronic distribution and delivery system design.
- Understand and apply the principles and operation of electric resistance heat systems.
- Understand and apply the principles and operation of gas-fired forced-air heating systems.
- Understand and apply the principles of electric heat pump systems.
- Understand and apply the principles and operation of oil-fired forced air heating systems.
- Understand and apply the principles and operation of gas-fired hydronic heat systems.
- Understand and apply the principles and operation of oil-fired hydronic heat systems.
- Understand and apply the principles of venting and drain systems.
- Understand and apply the principles of pipe sizing and layout for both fuel and heat distribution.

Air Conditioning Principles and Practices

- Understand and apply the principles of air-conditioning including temperature, humidity, and air movement, etc.
- Understand and apply the principles of air distribution and delivery systems.
- Understand and apply the principles of condensate drain systems.
- Understand and apply the principles of air filtration systems.
- Design air distribution systems.

Piping Principles and Practices

- Understand and apply the principles of piping systems including the factors that affect pipe selection, pipe size, and system design.
- Understand and select the proper fitting or valve for specific applications; for example, globe valves, gate valves, angle valves, check valves, elbows, tees, unions, couplings, half unions, etc.
- Understand and apply the principles of pipe accessories; for example, flanges, isolators, hangers, expansion joints, expansion, loops, supports, insulation, etc.
- Perform copper tubing operations including cutting, flaring, soldering, brazing, bending, swagging, etc.
- Perform steel pipe operations including cutting, reaming, threading, connecting, etc.
- Perform PVC pipe operations including cutting, connecting, etc.



Occupation-Specific Skills

Occupation-Specific Skills represent the knowledge and technical skills needed by heating, air conditioning, and refrigeration technicians to install, maintain, repair and operate equipment. This project grouped Occupation-Specific Skills in five categories: Residential/Light Commercial Heating, Residential/Light Commercial Air Conditioning, Heat Pumps, Commercial Conditioned-Air Systems, and Commercial Refrigeration.

Residential and Light Commercial Heating

- Understand and apply the principles of fuel system design.
- Understand and apply the principles of air distribution system design.
- Understand and apply the principles and operation of electric resistance heat systems.
- Understand and apply the principles and operation of gas-fired forced-air heating systems.
- Understand and apply the principles and operation of oil-fired forced air heating systems.
- Understand and apply the principles and operation of gas-fired hydronic heat systems.
- Understand and apply the principles and operation of oil-fired hydronic heat systems.
- Understand and apply the principles of venting and drain systems.
- Understand and apply the principles of pipe sizing and layout including liquid propane and natural gas and oil.
- Understand and apply the principles of humidification.
- Install/service gas-fired forced air heating systems.
- Install/service oil-fired forced air heating systems.
- Install/service hydronic heat systems.
- Fabricate/install/service venting and drain systems.
- Install/service humidifiers.
- Troubleshoot gas-fired forced air heating systems.
- Troubleshoot oil-fired forced air heating systems.
- Troubleshoot hydronic heat systems.
- Troubleshoot venting and drain systems.

Residential and Light Commercial Air Conditioning

- Understand and apply the principles of air conditioning including temperature, humidity, and air movement, etc.
- Understand and apply the principles of air distribution systems.
- Understand and apply the principles of condensate drain systems.
- Understand and apply the principles of air filtration systems.
- Design air distribution and delivery systems.
- Fabricate and insulate air distribution systems.
- Install air distribution systems.
- Install/service condensate drain systems.
- Install/service air filtration systems.
- Install/service split air-conditioning systems.
- Install/service packaged air-conditioning systems.
- Install/service evaporative coolers.
- Troubleshoot air-conditioning systems.
- Troubleshoot evaporative coolers.
- Troubleshoot condensate drain systems.
- Troubleshoot air filtration systems.

Residential and Light Commercial Heat Pumps

- Understand and apply the principles of vapor compression heat pump cycles.
- Understand and apply the principles of supplementary heat.
- Understand and apply the relationship of outdoor ambient temperature to heating capacity.
- Understand and apply the electrical circuitry of air to air, water to air, and ground to air heat pumps.
- Understand and apply the principles and operation of defrost controls in heat pump systems; for example, electronic demand defrost, pressure, time/temperature, time, etc.
- Understand and apply the principles of the balance point of heat pumps.
- Interpret the balance chart and plot the balance point of a heat pump.
- Design air distribution and delivery systems.
- Fabricate and insulate air distribution systems.
- Install/service vapor compression heat pump systems.
- Troubleshoot vapor compression mechanical heat pump systems.

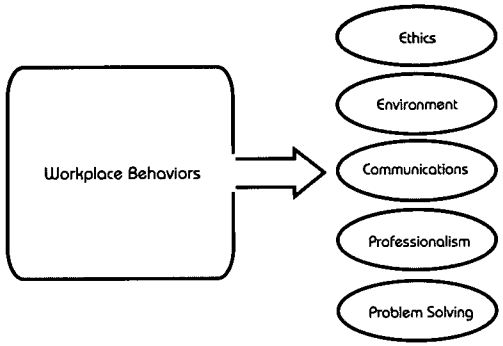
Commercial Conditioned-Air Systems

- Understand and apply the principles of cooling towers.
- Understand and apply the principles of pneumatic control devices; for example, thermostats, pneumatic actuators, pneumatic switches, pneumatic relays, etc.
- Understand and apply the principles of pumps and circulators.
- Understand and apply the principles of low and high pressure gas-fired boilers.
- Understand and apply the principles of low and high pressure oil-fired boilers.
- Understand and apply the principles of steam condensers and traps.
- Understand and apply the principles of water-cooled condensers and accessories.
- Understand and apply the principles of desiccant cooling and dehumidification systems.
- Understand and apply the principles of liquid chillers and accessories.
- Understand and apply the principles of air distribution and delivery systems.
- Understand and apply the principles of water distribution systems.
- Understand and apply the principles of commercial conditioned-air control systems.
- Install/maintain/service pneumatic control devices.
- Install/service pumps and circulators.
- Install/align shafts in fans, pumps, and open type compressors.
- Install/service cooling towers and accessories.
- Install/service water-cooled condensers and accessories.
- Install/service liquid chillers and accessories.
- Install/service air distribution systems and accessories.
- Install/service water distribution systems and accessories.
- Install/service commercial conditioned-air control systems.
- Perform scheduled monitoring/testing procedures of commercial conditioned-air systems.
- Perform preventative inspection and maintenance procedures of commercial conditioned-air systems.
- Perform commercial conditioned-air system start-up procedures.
- Perform commercial conditioned-air system shut-down procedures.
- Troubleshoot pneumatic control devices.

- Troubleshoot pumps and circulators.
- Troubleshoot cooling towers and accessories.
- Troubleshoot water-cooled condensers and accessories.
- Troubleshoot liquid chillers and accessories.
- Troubleshoot air distribution systems and accessories.
- Troubleshoot water distribution systems and accessories.
- Troubleshoot commercial conditioned-air control systems.

Commercial Refrigeration

- Understand and apply the principles of high, medium, low, and ultra-low temperature commercial refrigeration and their applications.
- Understand and apply the principles of mechanical refrigeration systems in commercial refrigeration; for example, walk-in coolers, walk-in freezers, reach-in cases, multiple evaporator systems, packaged refrigeration systems, etc.
- Understand and apply the principles of electric and hot gas defrost systems in commercial refrigeration systems.
- Understand and apply the principles of flake and cube ice makers.
- Understand and apply the principles of water coolers.
- Understand and apply the principles of specific refrigeration system components used in commercial refrigeration; for example, low ambient controls, evaporator pressure regulators, crankcase pressure regulators, etc.
- Understand and apply the principles of load calculation and piping designs in commercial refrigeration systems.
- Calculate the load, design the piping system, and design the control system of a commercial refrigeration system.
- Install/service commercial refrigeration systems.
- Install/service ice makers.
- Install/service water coolers.
- Troubleshoot high temperature commercial refrigeration systems.
- Troubleshoot medium temperature commercial refrigeration systems.
- Troubleshoot low temperature commercial refrigeration systems.
- Troubleshoot ultra-low temperature commercial refrigeration systems.
- Troubleshoot ice makers.
- Troubleshoot water coolers.



Workplace Behaviors

Workplace Behaviors identify a variety of characteristics and related behaviors required of technicians. Although Workplace Behaviors are not directly linked to technical competence, they are definitely essential for technicians to be hired and to remain employable. Workplace Behaviors play a critical role because they reflect both tangible and non-tangible elements by which employers, peers, and customers actually judge a technician.

This project classified Workplace Behaviors into five categories: Ethics, Environment, Communication, Professionalism, and Problem Solving.

Ethics

- Understand and adhere to the conduct rules of the company.
- Assume responsibility for decisions and actions.
- Demonstrate a willingness to learn.
- Demonstrate ability to work as a team member.
- Display initiative.
- Perform quality work.
- Exhibit pride in quality work.
- Comply with established rules, regulations, and policies.
- Adhere to fair pricing standards.
- Maintain work hours and schedule.
- Practice cost effectiveness.
- Practice time management.

Environment

- Understand and apply environmental and occupational safety practices and regulations.
- Identify hazardous substances in the work area.
- Maintain work area.
- Respond to emergencies.

Communication

- Communicate orally with others.
- Follow oral and written directions.

- Display listening skills.
- Interpret body language.
- Prepare written communication.
- Utilize telephone etiquette.

Professionalism

- Accept responsibilities of an employee.
- Assess business image, products and/or services.
- Assume responsibility for awareness of technological and regulatory changes.
- Converse in work-related terminology.
- Display a positive attitude.
- Follow company dress and appearance standards.
- Participate in employment orientation.
- Treat people with respect.
- Understand and apply the responsibilities of an employer/management.
- Display safe and courteous driving practices.

Problem Solving

- Employ reasoning skills.
- Evaluate results of implemented option.
- Evaluate options.
- Identify solutions to a problem and their impact.
- Identify the problem.
- Organize workloads.
- Select and implement a solution to a problem.
- Set priorities.

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Skill Standards Matrix

Core Skills

SAFETY AND ENVIRONMENT
CORE OCCUPATIONAL KNOWLEDGE
• Understand and apply safety regulations and procedures.
• Understand and apply federal, state, and local regulations for disposing of hazardous materials.
• Understand and apply Environmental Protection Agency (EPA) regulations on venting, recovery, reclaiming, and recycling refrigerants.
• Understand and apply the Department of Transportation (DOT) regulations on the transportation and handling of hazardous materials.
• Understand and apply Occupational Safety and Health Administration (OSHA) regulations.
• Understand and apply Environmental Protection Agency (EPA) regulations on indoor air quality and nitrous-oxide.

ELECTRICAL PRINCIPLES

CORE OCCUPATIONAL KNOWLEDGE

- Understand and apply the principles of alternating and direct current.
- Understand and recognize the common single and three phase voltage systems including 230v, 60hz, single phase; 208v, 60hz, three phase; 230v, 60hz, three phase; and 460v, 60hz, three phase.
- Understand and apply the principles of series, parallel, and compound circuits.
- Understand and apply the principles and relationships of Ohm's, Kirchhoff's, and Watt's laws as they apply to series, parallel, and compound circuits.
- Read and interpret voltage, ampere, ohm, megohm, and watt meters.
- Read and interpret schematic drawings.
- Develop schematics from electrical label/line diagrams.
- Read and interpret electrical codes.
- Understand and apply the properties and behaviors of electrical conductors and insulators.
- Understand and apply the principles of electrical circuit protection including fuses, circuit breakers, and disconnect switches.
- Understand and apply the principles of single and three phase transformers.
- Understand and apply electrical grounding principles.
- Understand and apply the principles of electrical measurement.

SKILL	STANDARD
Troubleshoot electrical circuits.	Diagnostic procedures must be systematic, comprehensive, and complete. The path of the circuit(s) must be checked for continuity, the load, source, and switch(s) must be checked. Problem(s) with the circuit(s) must be documented and a plan for repair must be formulated.
Install electrical power and control circuits.	Electrical power and control circuits must be installed according to job specifications, manufacturer's specifications, and electrical codes. Circuits must be specified type for intended service and application. Wiring must be mechanically secure and electrical continuity must be established. Applicable safety procedures must be followed.
Install and connect the components of electrical circuits.	Electrical components must be installed and connected according to manufacturer's specifications and electrical code. Component must be mechanically secure, and electrical continuity must be established. Components must perform functions specified by manufacturer. Applicable safety procedures must be followed.

ELECTRIC MOTORS

CORE OCCUPATIONAL KNOWLEDGE

- Understand and apply the operating principles of electric motors.
- Understand and recognize the application of various types of electric motors.
- Understand and recognize the application of various types of capacitors.
- Understand the principles and operation of electric motor protection devices.
- Understand and interpret electric motor specifications.

SKILL	STANDARD
Install and connect electric motors.	The motor must be connected to the power source according to manufacturer's specifications and electrical codes and have a code-approved ground. Connections must be mechanically secure, and electrical continuity must be established. Motor must operate as specified without unwarranted vibration. Applicable safety procedures must be followed.
Perform electric motor maintenance.	The motor must be cleaned of debris and lubricated according to manufacturer's specifications. The drive belts must be aligned and tensioned as necessary. Applicable safety procedures must be followed.
Troubleshoot electric motors.	Diagnostic procedures must be systematic, comprehensive, and complete and follow the manufacturer's diagnostic chart when available. If the electric motor does not operate after establishing electrical potential, check the starting component, bearings, and windings. Problem(s) with the devices and their subsystems must be documented.

CONTROLS

CORE OCCUPATIONAL KNOWLEDGE

- Understand and apply the principles of safety and operating control devices; for example, pressure switches, thermostats, etc.
- Understand and apply the principles of electromechanical control devices; for example, relays, contactors, magnetic starters, timers, sequencers, etc.
- Understand and apply the principles of electronic control devices; for example, ignition modules, electronic timers, etc.
- Understand and apply the principles of safety and control circuits.

SKILL	STANDARD
Install/service mechanical control devices.	Mechanical control devices must be installed according to job and manufacturer's specifications and must comply with applicable codes. The devices must be mechanically secure and all electrical or control circuits must provide the voltage and control specified. Preventive maintenance must be performed in accordance with manufacturer's specification. If a mechanical control device(s) requires service, the problem must be diagnosed and all components or subsystems out of manufacturer's specifications must be identified. Repaired or replaced components must perform according to manufacturer's specifications and the system must perform as specified.
Install/service electromechanical control devices.	Electromechanical control devices must be installed according to job and manufacturer's specifications and must comply with applicable codes. The devices must be mechanically secure and all electrical or control circuits must provide the voltage and control specified. Preventive maintenance must be performed in accordance with manufacturer's specification. If an electromechanical control device(s) requires service, the problem must be diagnosed and all components or subsystems out of manufacturer's specifications must be identified. Repaired or replaced components must perform according to manufacturer's specifications and the system must perform as specified.
Troubleshoot mechanical control devices.	Diagnostic procedures must be systematic, comprehensive, and complete and follow manufacturer's diagnostic chart when available. Electrical characteristics, pressures, and temperatures or other diagnostic characteristics outside of the device(s) or their subsystem's normal parameters must be noted. System components operating out of manufacturer's specifications must be identified. Problem(s) with the devices and their subsystem must be documented and a plan for repair must be formulated.

CONTROLS (continued)	
SKILL	**STANDARD**
Troubleshoot electromechanical devices.	Diagnostic procedures must be systematic, comprehensive, and complete and follow manufacturer's diagnostic chart when available. Electrical characteristics, pressures, and temperatures or other diagnostic characteristics outside of the device(s) or their subsystem's normal parameters must be noted. Problem(s) with the devices and their subsystems must be documented and a plan for repair must be formulated.
Troubleshoot electronic control devices.	Diagnostic procedures must be systematic, comprehensive, and complete and follow manufacturer's diagnostic chart when available. Electrical characteristics, pressures, and temperatures or other diagnostic characteristics outside the device(s) or their subsystem's normal parameters must be noted. Problem(s) with the devices and their subsystems must be documented and a plan for the repair must be formulated.

REFRIGERATION PRINCIPLES AND PRACTICES

CORE OCCUPATIONAL KNOWLEDGE

- Understand and apply the theory of heat.
- Understand and apply the properties of refrigerants.
- Understand and apply the mechanical refrigeration cycle.
- Understand and apply pressure/temperature curves and charts.
- Understand and apply the principles and the operation of compressors.
- Understand and apply the principles and operation of condensers.
- Understand and apply the principles and operation of metering devices.
- Understand and apply the principles and operation of evaporators.
- Understand the operation of refrigeration system accessories; for example, receivers, accumulators, filter/dryers, sight glasses, valves, etc.

SKILL	STANDARD
Perform leak tests.	Leaks must be detected, if present. Leak detector must be operated according to manufacturer's instructions. Applicable safety procedures must be followed.
Evacuate and measure the vacuum level of refrigeration systems.	Refrigeration circuit must be evacuated to specified vacuum level using industry acceptable procedures. Applicable safety procedure must be followed.
Recover refrigerants.	Refrigerant must be recovered using a certified-refrigerant recovery unit. All refrigerant must be captured and the system evacuated to EPA specification for the class of system.
Charge refrigeration systems.	The mechanical refrigeration systems must be charged with the correct refrigerant to manufacturer's specifications using manufacturer's charging information. If manufacturer's specifications are not available, accepted industry standards must be observed. When charging the system, the technician must comply with the applicable environmental and building codes and safety procedures must be observed.
Recycle refrigerants.	Recovered refrigerant must be cleaned by separating any oil from the refrigerant and passing through filter/dryers to reducing acids, moisture, and other contaminants.

REFRIGERATION PRINCIPLES AND PRACTICES (continued)	
SKILL	**STANDARD**
Troubleshoot mechanical refrigeration systems.	Diagnostic procedures must be systematic, comprehensive, and complete and follow manufacturer's diagnostic chart when available. Electrical characteristics, pressures, and temperatures or other diagnostic characteristics outside of the refrigeration system's normal operating parameters must be noted. System components and devices operating out of manufacturer's specifications must be identified and a plan for repair must be formulated.

HEATING PRINCIPLES AND PRACTICES

CORE OCCUPATIONAL KNOWLEDGE

- Understand and apply the principles of fuel system design.
- Understand and apply the principles of air and hydronic distribution and delivery system design.
- Understand and apply the principles and operation of electric resistance heat systems.
- Understand and apply the principles and operation of gas-fired forced-air heating systems.
- Understand and apply the principles of electric heat pump systems.
- Understand and apply the principles and operation of oil-fired forced air heating systems.
- Understand and apply the principles and operation of gas-fired hydronic heat systems.
- Understand and apply the principles and operation of oil-fired hydronic heat systems.
- Understand and apply the principles of venting and drain systems.
- Understand and apply the principles of pipe sizing and layout for both fuel and heat distribution.

AIR CONDITIONING PRINCIPLES AND PRACTICES

CORE OCCUPATIONAL KNOWLEDGE	
• Understand and apply the principles of air-conditioning including temperature, humidity, and air movement, etc. • Understand and apply the principles of air distribution and delivery systems. • Understand and apply the principles of condensate drain systems. • Understand and apply the principles of air filtration systems.	
SKILL	**STANDARD**
Design air distribution systems.	The air distribution and delivery system must be designed to conform to all applicable codes. The system must provide airflow to rooms consistent with heat loss/heat gain calculations.

PIPING PRINCIPLES AND PRACTICES

CORE OCCUPATIONAL KNOWLEDGE

- Understand and apply the principles of piping systems including the factors that affect pipe selection, pipe size, and system design.
- Understand and select the proper fitting or valve for specific applications; for example, globe valves, gate valves, angle valves, check valves, elbows, tees, unions, couplings, half unions, etc.
- Understand and apply the principles of pipe accessories; for example, flanges, isolators, hangers, expansion joints, expansion, loops, supports, insulation, etc.

SKILL	STANDARD
Perform copper tubing operations including cutting, flaring, soldering, brazing, bending, swagging, etc.	Copper pipe and tubing operations must be made according to manufacturer's specifications, job specifications, and codes. When connecting copper pipe or tubing with in-line devices or other piping, the proper and acceptable method for joining must be used. When joined, the pipe or tubing must be cut square, the interior must be deburred, must be bottomed in the connection, and the joint must be tight with no leaks. Tube bends must be smooth and turned to specified angle. Tubing must not flatten or kink in bends. Runs must conform to job requirements. Clamps and supports must be installed securely and must be spaced to hold pipe and tubing with specified pitch without sagging between clamps and supports.
Perform steel pipe operations including cutting, reaming, threading, connecting, etc.	Steel pipe operations must be made according to manufacturer's specifications, job specifications, and codes. When joining steel pipe with in-line devices or other pipe, the pipe must be cut square and deburred and must be threaded with required number of threads. Thread sealant must be applied to pipe so as not to enter inside of pipe when joint is made. Joint must be made up without leaking. Runs must conform to job requirements. Clamps and supports must be installed securely and must be spaced to hold pipe with specified pitch without sagging between clamps and supports. Applicable safety procedures must be followed.
Perform PVC pipe operations including cutting, connecting, etc.	PVC pipe operations must be made according to job and manufacturer's specifications, and applicable codes. When joining PVC pipe with in-line devices or other pipe, the pipe must be cut square and deburred, and joined according to manufacturer's specifications. Joint must not leak. Pipe runs must conform to job requirements. Clamps and supports must be installed securely and must be spaced to hold pipe with specified pitch without sagging between clamps and supports. Applicable safety procedures must be followed.

Skill Standards Matrix

Occupation-Specific Skills

RESIDENTIAL AND LIGHT COMMERCIAL HEATING
OCCUPATION-SPECIFIC KNOWLEDGE
• Understand and apply the principles of fuel system design.
• Understand and apply the principles of air distribution system design.
• Understand and apply the principles and operation of electric resistance heat systems.
• Understand and apply the principles and operation of gas-fired forced-air heating systems.
• Understand and apply the principles and operation of oil-fired forced air heating systems.
• Understand and apply the principles and operation of gas-fired hydronic heat systems.
• Understand and apply the principles and operation of oil-fired hydronic heat systems.
• Understand and apply the principles of venting and drain systems.
• Understand and apply the principles of pipe sizing and layout including liquid propane and natural gas and oil.
• Understand and apply the principles of humidification.

RESIDENTIAL AND LIGHT COMMERCIAL HEATING (continued)	
SKILL	**STANDARD**
Install/service gas-fired forced air heating systems.	The gas-fired forced air heating system must be installed according to job and manufacturer's specifications and must comply with applicable codes. The gas-fired furnace must be mechanically secure, vented properly, and all electrical or control circuits must provide the voltage and control specified. The gas-fired forced air heating system must perform to specifications, run quietly, and provide the air flow required by the system. All safety devices must function correctly. Preventive maintenance must be performed in accordance with manufacturer's specification and schedule. If the gas-fired forced air heating system requires service, the problem must be diagnosed and all components or subsystems out of manufacturer's specifications must be identified. Repaired or replaced components must perform according to manufacturer's specifications and the system must perform as specified. Applicable safety procedures must be followed.
Install/service oil-fired forced air heating systems.	The oil-fired forced air heating system must be installed according to job and manufacturer's specifications and must comply with applicable codes. The oil-fired furnace must be mechanically secure, vented properly, and all electrical or control circuits must provide the voltage and control specified. The oil-fired forced air heating system must perform to specifications, run quietly and provide the air flow required by the system. All safety devices must function correctly. Preventive maintenance must be performed in accordance with manufacturer's specification and schedule. If the oil-fired forced air heating system requires service, the problem must be diagnosed and all components or subsystems out of manufacturer's specifications must be identified. Repaired or replaced components must perform according to manufacturer's specifications and the system must perform as specified. Applicable safety procedures must be followed.
Install/service hydronic heat systems.	The gas-fired or oil-fired hydronic heating system must be installed according to manufacturer's specifications, job specifications, and applicable codes. The boiler, hydronic circulating devices and piping must be sized to meet structure's heating requirements and provide domestic hot-water requirements. The hydronic system must be filled according to manufacturer's specifications and in accordance with manufacturer's procedures. The automatic feeder, expansion tank, and zone valves, air vent, and pressure relief valve(s) must not leak and must perform according to manufacturer's specifications. If the gas-fired or oil-fired hydronic heating system requires service, the problem must be diagnosed and all components or subsystems out of manufacturer's specifications must be identified. Repaired or replaced components must perform according to manufacturer's specifications and the system must perform as specified. Applicable safety procedures must be followed.

RESIDENTIAL AND LIGHT COMMERCIAL HEATING (continued)	
SKILL	**STANDARD**
Fabricate/install/service venting and drain systems.	Vents and drains must be fabricated to comply with job specifications, SMACNA standards, and applicable codes. All seams and joints must be secure with no leakage. The vents and drains must be installed and supported according to job and code specifications. If venting and drain systems require service, all subsystems and/or components not performing to specifications must be identified and repaired or replaced. The systems must perform as specified. Applicable safety procedures must be followed.
Install/service humidifiers.	Humidifier must be installed according to job and manufacturer's specifications. Unit must operate quietly and respond to the humidistat's signals. It must not leak or overflow. If the humidifier requires service, the problem must be diagnosed and all components or subsystems out of manufacturer's specifications must be identified. Repaired or replaced components must perform according to manufacturer's specifications and the system must perform as specified. Applicable safety procedures must be followed.
Troubleshoot gas-fired forced air heating systems.	Diagnostic procedures must be systematic, comprehensive, complete, and follow manufacturer's diagnostic chart when available. Electrical characteristics, pressures, and temperatures or other diagnostic characteristics outside of the gas-fired forced-air system's normal operating parameters must be noted. Gas valves, ignition modules, pilot light assemblies, blower fans, thermostats, filters, and other system components and safety devices system components operating out of manufacturer's specifications must be identified and a plan for repair must be formulated.
Troubleshoot oil-fired forced air heating systems.	Diagnostic procedures must be systematic, comprehensive, complete, and follow manufacturer's diagnostic chart when available. Electrical characteristics, pressures, and temperatures or other diagnostic characteristics outside of the oil-fired forced-air system's normal operating parameters must be noted. Oil pumps, blower fans, thermostats, filters, and other system components and safety devices operating out of manufacturer's specifications must be identified and a plan for repair must be formulated.
Troubleshoot hydronic heat systems.	Diagnostic procedures must be systematic, comprehensive, complete, and follow manufacturer's diagnostic chart when available. Electrical characteristics, pressures, and temperatures or other diagnostic characteristics outside of the gas or oil-fired hydronic heating system's normal operating parameters must be noted. Circulators and pumps, zone valves, air vents, pressure relief valves and other system components and safety devices operating out of manufacturer's specifications must be identified and a plan for repair must be formulated.
Troubleshoot venting and drain systems.	Diagnostic procedures must be systematic, comprehensive, complete, and follow manufacturer's diagnostic chart when available. Any restriction to flow or leakage must be identified and a plan to repair must be formulated.

RESIDENTIAL AND LIGHT COMMERCIAL AIR CONDITIONING

OCCUPATION-SPECIFIC KNOWLEDGE

- Understand and apply the principles of air conditioning including temperature, humidity, and air movement, etc.
- Understand and apply the principles of air distribution systems.
- Understand and apply the principles of condensate drain systems.
- Understand and apply the principles of air filtration systems.

SKILL	STANDARD
Design air distribution and delivery systems.	The air distribution and delivery system must be designed to conform to all applicable codes. The system must provide airflow to rooms consistent with heat loss/heat gain calculations.
Fabricate and insulate air distribution systems.	Duct must be fabricated and insulated to comply with job specifications and SMACNA standards. All seams must be secure. Applicable safety procedures must be followed.
Install air distribution systems.	The air distribution trunk and branches must be installed in accordance with the air distribution and delivery plan and applicable codes. The trunk and branches must be installed and supported securely. Branches must be connected to the trunk and joints must be sealed to insure no air leakage. Applicable safety procedures must be followed.
Install/service condensate drain systems.	The condensate drain system must be installed according to job and manufacturer's specifications and must comply with applicable codes. The system must be mechanically secure and all electrical or control circuits must provide the voltage and control specified. Preventive maintenance must be performed in accordance with manufacturer's specification and schedule. If a condensate drain system requires service, all subsystems and/or components not performing to specifications must be identified and repaired or replaced. The system must perform as specified. Applicable safety procedures must be followed.
Install/service air filtration systems.	The air filtration system must be installed according to manufacturer's specifications and job specifications. The system must be mechanically secure and all electrical or control circuits must provide the voltage and control specified. Air filtration elements must be cleaned or replaced in accordance with manufacturer's specification, schedule, or as needed. If the air filtration system requires service, all subsystems and/or components not performing to specifications must be identified and repaired or replaced. The system must perform as specified. Applicable safety procedures must be followed.

RESIDENTIAL AND LIGHT COMMERCIAL AIR CONDITIONING (continued)	
SKILL	**STANDARD**
Install/service split air-conditioning systems.	The air conditioning system must be installed according to job and manufacturer's specifications and must comply with applicable codes. The unit must be mechanically secure and all electrical or control circuits must provide the voltage and control specified. The air conditioning unit must be charged as necessary, perform quietly, to specifications, and provide the air flow required by the system. All safety devices must function correctly. The condensate drain must meet manufacturer's specifications and applicable codes. Preventive maintenance must be performed in accordance with manufacturer's specifications and schedule. If a unit requires service, the problem must be diagnosed and all components or subsystems out of manufacturer's specifications must be identified. Repaired or replaced components must perform according to manufacturer's specifications and the system must be perform as specified. Applicable safety procedures must be followed.
Install/service packaged air-conditioning systems.	The air conditioning system must be installed according to job and manufacturer's specifications and must comply with applicable codes. The unit must be mechanically secure and all electrical or control circuits must provide the voltage and control specified. The air conditioning unit must perform quietly, to specifications, and provide the air flow required by the system. All safety devices must function correctly. The condensate drain must meet manufacturer's specifications and applicable codes. Preventive maintenance must be performed in accordance with manufacturer's specifications and schedule. If a unit requires service, the problem must be diagnosed and all components or subsystems out of manufacturer's specifications must be identified. The unit must be charged, repaired or replaced components must perform according to manufacturer's specifications and the system must be perform as specified. Applicable safety procedures must be followed.
Install/service evaporative coolers.	The evaporative cooler must be installed according to job and manufacturer's specifications and must comply with applicable codes. The unit must be mechanically secure and all electrical or control circuits must provide the voltage and control specified. The evaporative cooler must perform quietly, to specifications, and provide the air flow required by the system, and all safety devices must function correctly. The water delivery pipe and overflow drain must meet manufacturer's specifications and applicable codes. Preventive maintenance must be performed in accordance with manufacturer's specifications and schedule. If a unit requires service, the problem must be diagnosed and all components or subsystems out of manufacturer's specifications must be identified. Repaired or replaced components must perform according to manufacturer's specifications and the system must be perform as specified. Applicable safety procedures must be followed.

RESIDENTIAL AND LIGHT COMMERCIAL AIR CONDITIONING (continued)	
SKILL	**STANDARD**
Troubleshoot air-conditioning systems.	Diagnostic procedures must be systematic, comprehensive, complete, and follow manufacturer's diagnostic chart when available. Electrical characteristics, pressures, and temperatures or other diagnostic characteristics outside of the air conditioning system's normal operating parameters must be noted. Blower fans, thermostats, filters, safety devices, and other system components operating out of manufacturer's specifications must be identified and a plan for repair must be formulated.
Troubleshoot evaporative coolers.	Diagnostic procedures must be systematic, comprehensive, complete, and follow manufacturer's diagnostic chart when available. Electrical characteristics, pressures, or other diagnostic characteristics outside of the evaporative cooler's normal operating parameters must be noted. Pumps, blower fans, thermostats, filters, safety devices, and other system components operating out of manufacturer's specifications must be identified and a plan for repair must be formulated.
Troubleshoot condensate drain systems.	Diagnostic procedures must be systematic, comprehensive, and complete. Any restriction to condensate flow through the drain or one the drains' components must be identified and a plan for repair must be formulated.
Troubleshoot air filtration systems.	Diagnostic procedures must be systematic, comprehensive, complete, and follow manufacturer's diagnostic chart when available. Electrical characteristics, air flow, or other diagnostic characteristics outside of the air filtration's normal operating parameters must be noted. Any system components operating out of manufacturer's specifications must be identified and a plan for repair must be formulated.

RESIDENTIAL AND LIGHT COMMERCIAL HEAT PUMPS

OCCUPATION-SPECIFIC KNOWLEDGE

- Understand and apply the principles of vapor compression heat pump cycles.
- Understand and apply the principles of supplementary heat.
- Understand and apply the relationship of outdoor ambient temperature to heating capacity.
- Understand and apply the electrical circuitry of air to air, water to air, and ground to air heat pumps.
- Understand and apply the principles and operation of defrost controls in heat pump systems; for example, electronic demand defrost, pressure, time/temperature, time, etc.
- Understand and apply the principles of the balance point of heat pumps.

SKILL	STANDARD
Interpret the balance chart and plot the balance point of a heat pump.	A chart of heat gain/heat loss and equipment capacity must be constructed and the balance point determined. Supplemental heat stages must be determined and set in the equipment.
Design air distribution and delivery systems.	The air distribution and delivery system must be designed to conform to all applicable codes. The system must provide airflow to rooms consistent with heat loss/heat gain calculations.
Fabricate and insulate air distribution systems.	Duct must be fabricated and insulated to comply with job specifications and SMACNA standards. All seams must be secure. Applicable safety procedures must be followed.
Install/service vapor compression heat pump systems.	The vapor compression heat pump system must be installed according to job and manufacturer's specifications and must comply with applicable codes. The unit must be mechanically secure and all electrical or control circuits must provide the voltage and control specified. The heat pump unit and its supplementary heat system must perform quietly, to specifications, and provide the air flow required by the system. All safety devices must function correctly. The condensate drain must meet manufacturer's specifications and applicable codes. Preventive maintenance must be performed in accordance with manufacturer's specifications and schedule. If a unit requires service, the problem must be diagnosed and all components or subsystems out of manufacturer's specifications must be identified. Repaired or replaced components must perform according to manufacturer's specifications and the system must be perform as specified. Applicable safety procedures must be followed.

RESIDENTIAL AND LIGHT COMMERCIAL HEAT PUMPS (continued)	
SKILL	**STANDARD**
Troubleshoot vapor compression mechanical heat pump systems.	Diagnostic procedures must be systematic, comprehensive, complete, and follow manufacturer's diagnostic chart when available. Electrical characteristics, pressures, and temperatures or other diagnostic characteristics outside of the air conditioning system's normal operating parameters must be noted. Blower fans, thermostats, filters, safety devices, and other system components operating out of manufacturer's specifications must be identified and a plan for repair must be formulated.

COMMERCIAL CONDITIONED-AIR SYSTEMS

OCCUPATION-SPECIFIC KNOWLEDGE

- Understand and apply the principles of cooling towers.
- Understand and apply the principles of pneumatic control devices; for example, thermostats, pneumatic actuators, pneumatic switches, pneumatic relays, etc.
- Understand and apply the principles of pumps and circulators.
- Understand and apply the principles of low and high pressure gas-fired boilers.
- Understand and apply the principles of low and high pressure oil-fired boilers.
- Understand and apply the principles of steam condensers and traps.
- Understand and apply the principles of water-cooled condensers and accessories.
- Understand and apply the principles of desiccant cooling and dehumidification systems.
- Understand and apply the principles of liquid chillers and accessories.
- Understand and apply the principles of air distribution and delivery systems.
- Understand and apply the principles of water distribution systems.
- Understand and apply the principles of commercial conditioned-air control systems.

SKILL	STANDARD
Install/maintain/service pneumatic control devices.	The pneumatic control devices must be installed according to manufacturer's and job specifications. Pneumatic control devices (valve actuators, relays, thermostatic receivers, receiver controllers, etc.) must operate properly and cause the system components to interact maintaining the selected conditions in the conditioned space. Preventive maintenance must be performed in accordance with manufacturer's specifications and schedule. If the pneumatic control devices require repair, the problem must be diagnosed and all components or subsystems out of specification must be identified. Repaired or replaced components must perform according to manufacturer's specifications and the system must be perform as specified. Applicable safety procedures must be followed.

COMMERCIAL CONDITIONED-AIR SYSTEMS (continued)

SKILL	STANDARD
Install/service pumps and circulators.	The pumps and circulators must be installed according to manufacturer's and job specifications. Pumps and circulators must operate quietly with minimum vibration and must deliver the required flow at required pressure without leakage. Preventive maintenance must be performed in accordance with manufacturer's specifications and schedule. If the pumps and circulators require repair, the problem(s) must be diagnosed and all components or subsystems out of specification must be identified. Repaired or replaced components must perform according to manufacturer's specifications and the system must be perform as specified. Applicable safety procedures must be followed.
Install/align shafts in fans, pumps, and open type compressors.	The shafts must be installed according to manufacturer's and job specifications. Shafts must operate quietly with minimum vibration. The shaft and its drive components must be aligned and tensioned correctly. Preventive maintenance must be performed in accordance with manufacturer's specifications and schedule. If shafts or their drive components require repair, the problem must be diagnosed and all components out of specification must be identified. Repaired or replaced components must perform according to manufacturer's specifications and the system must be perform as specified. Applicable safety procedures must be followed.
Install/service cooling towers and accessories.	The water tower and its accessories must be installed according to job and manufacturer's specifications and applicable codes. The water tower and its accessories (pumps, chemical feed, strainers, etc.) must operate to specifications. Preventive maintenance must be performed in accordance with manufacturer's specifications and schedule. If the water tower and its accessories require repair, the problem must be diagnosed and all components or subsystems out of specification must be identified. Repaired or replaced components must perform according to manufacturer's specifications and the system must be perform as specified. Applicable safety procedures must be followed.
Install/service water-cooled condensers and accessories.	The water condenser and its accessories must be installed according to job and manufacturer's specifications and applicable codes. The water condenser and its accessories (pumps, filters, etc.) must operate to specifications. Preventive maintenance must be performed in accordance with manufacturer's specifications and schedule. If the water condenser and its accessories require repair, the problem must be diagnosed and all components or subsystems out of specification must be identified. Repaired or replaced components must perform according to manufacturer's specifications and the system must be performed as specified. Applicable safety procedures must be followed.

COMMERCIAL CONDITIONED-AIR SYSTEMS (continued)

SKILL	STANDARD
Install/service liquid chillers and accessories.	The liquid chiller and its accessories must be installed according to job and manufacturer's specifications and applicable codes. The liquid chiller and its accessories (pumps, filters, etc.) must operate to specifications. Preventive maintenance must be performed in accordance with manufacturer's specifications and schedule. If the liquid chiller and its accessories require repair, the problem must be diagnosed and all components or subsystems out of specification must be identified. Repaired or replaced components must perform according to manufacturer's specifications and the system must be perform as specified. Applicable safety procedures must be followed.
Install/service air distribution systems and accessories.	The air distribution system's trunk and branches must be installed in accordance with the air distribution and delivery plan and applicable codes. The trunk and branches must be installed and supported securely. Joints must be sealed to insure no air leakage. All accessories must be installed according to manufacturer's specification and applicable codes. The accessories must perform as specified. Preventive maintenance must be performed in accordance with manufacturer's specifications and schedule. If the system requires service, the problem must be diagnosed and all components or subsystems out of specification must be identified. Repaired or replaced components must perform according to manufacturer's specifications and the system must be perform as specified. Applicable safety procedures must be followed.
Install/service water distribution systems and accessories.	The water distribution system must be installed in accordance with the water distribution and delivery plan and applicable codes. The pipe must be installed in a secure manner, supported to conform with good practices and applicable codes. All accessories must be installed according to manufacturer's specification and applicable codes and must perform as specified. Preventive maintenance must be performed in accordance with manufacturer's specifications and schedule. If the system requires service, the problem must be diagnosed and all components or subsystems out of specification must be identified. Repaired or replaced components must perform according to manufacturer's specifications and the system must be perform as specified. Applicable safety procedures must be followed.
Install/service commercial conditioned-air control systems.	The commercial conditioned-air system must be installed according to job and manufacturer's specifications and must comply with applicable codes. The system must be mechanically secure and all electrical or control circuits must provide the voltage and control specified. The system including heating units, refrigeration units, and air handlers must perform to specifications and all safety devices must function correctly. Electronic, electrical, pneumatic, and mechanical control devices must perform as specified. Preventive maintenance must be performed in accordance with manufacturer's specifications and schedule. If a unit requires service, the problem must be diagnosed and all components or subsystems out of manufacturer's specifications must be identified. Repaired or replaced components must perform according to manufacturer's specifications and the system must be perform as specified. Applicable safety procedures must be followed.

COMMERCIAL CONDITIONED-AIR SYSTEMS (continued)

SKILL	STANDARD
Perform scheduled monitoring/testing procedures of commercial conditioned-air systems.	The commercial conditioned air system's pressures, temperatures, performance, and safety control systems must be monitored/tested according to site and manufacturer's procedures and schedules. Subsystems and components including boiler water level, boiler pressure/temperature, stack temperatures, pump pressures, flame monitor, feed tank, and combustion must be monitored/tested as scheduled and results recorded in the appropriate logs. Other safety related systems including water cut-off, continuous blowdown, safety relief valves, and steam traps must be inspected, monitored, and tested according to site schedules. Liquid chillers, air compressors, cooling towers, air handlers, emergency generators, and other system components must be monitored, tested, or inspected according to site and manufacturer's schedule. Results of monitoring, testing, or inspecting must be recorded and deviations from normal operating status must be reported and appropriate action taken.
Perform preventative inspection and maintenance procedures of commercial conditioned-air systems.	Preventative maintenance for each component of the commercial conditioned-air system must be performed as scheduled or required by site and/or manufacturer's procedures. Components and their instruments and controls including boilers, pumps, feed tanks, valves, and safety-related controls, gauges, and relief valves must be inspected and preventative maintenance activities performed as required. Liquid chillers, air compressors, cooling towers, air handlers, emergency generators, and other system components must be inspected and preventative maintenance activities accomplished according to site and manufacturer's procedures. Results of inspections and preventative maintenance must be recorded and deviations from normal operating status must be reported and appropriate action taken.
Perform commercial conditioned-air system start-up procedures.	Start-up of conditioned-air systems must adhere to the documented start-up procedures for the system. Start-up procedures including monitoring, testing, and documenting must be complete and in the sequence prescribed by the start-up manual. Any characteristics outside the normal values of the system requires halting the start-up process and returning the system to a shut-down status. Applicable safety procedures must be followed.
Perform commercial conditioned-air system shut-down procedures.	Shut-down of conditioned-air systems must adhere to the documented shut-down procedures for the system. Shut-down procedures including monitoring, testing, and documenting must be complete and in the sequence proscribed by the shut-down manual. Any characteristics outside the normal values of the system requires documenting the problem. Applicable safety procedures must be followed.
Troubleshoot pneumatic control devices.	Diagnostic procedures must be systematic, comprehensive, complete, and follow manufacturer's diagnostic chart when available. Any characteristics outside of the pneumatic control system and its devices' normal operating parameters must be identified and a plan for repair formulated.

COMMERCIAL CONDITIONED-AIR SYSTEMS (continued)	
SKILL	**STANDARD**
Troubleshoot pumps and circulators.	Diagnostic procedures must be systematic, comprehensive, complete, and follow manufacturer's diagnostic chart when available. The pump/circulator's electrical characteristics, output flow and pressures, or other diagnostic characteristics outside of the component's normal operating parameters must be identified and a plan for repair must be formulated.
Troubleshoot cooling towers and accessories.	Diagnostic procedures must be systematic, comprehensive, complete, and follow manufacturer's diagnostic chart when available. The cooling tower and its accessories (pumps, chemical feeds, strainers, etc.) electrical characteristics, temperatures, pressures or other diagnostic characteristics outside of the component's normal operating parameters must be identified and a plan for repair must be formulated.
Troubleshoot water-cooled condensers and accessories.	Diagnostic procedures must be systematic, comprehensive, complete, and follow manufacturer's diagnostic chart when available. The water-cooled condenser and its accessories' electrical characteristics, pressures, and temperatures or other diagnostic characteristics outside of the component's normal operating parameters must be identified and a plan for repair must be formulated. The system must be inspected for cleanliness and mineral deposit build-up. If the system is contaminated or has excessive deposit build-up, the system must be cleaned.
Troubleshoot liquid chillers and accessories.	Diagnostic procedures must be systematic, comprehensive, complete and follow manufacturer's diagnostic chart when available. The liquid chiller and its accessories' electrical characteristics, pressures, and temperatures or other diagnostic characteristics outside of the component's normal operating parameters must be identified and a plan for repair must be formulated. The system must be inspected for cleanliness and mineral deposit build-up. If the system is contaminated or has excessive deposit build-up, the system must be cleaned.
Troubleshoot air distribution systems and accessories.	Diagnostic procedures must be systematic, comprehensive, complete, and follow manufacturer's diagnostic chart when available. The air distribution system and its accessories' electrical characteristics, pressures, and temperatures or other diagnostic characteristics outside of the component's normal operating parameters must be identified and a plan for repair must be formulated.
Troubleshoot water distribution systems and accessories.	Diagnostic procedures must be systematic, comprehensive, complete, and follow manufacturer's diagnostic chart when available. The water distribution system and its accessories' electrical characteristics, pressures, temperatures or other diagnostic characteristics outside of the component's normal operating parameters must be identified and a plan for repair must be formulated.

COMMERCIAL CONDITIONED-AIR SYSTEMS (continued)	
SKILL	**STANDARD**
Troubleshoot commercial conditioned-air control systems.	Diagnostic procedures must be systematic, comprehensive, complete, and follow manufacturer's diagnostic chart when available. Electrical characteristics, pressures, temperatures or other diagnostic characteristics outside of the commercial conditioned-air system's normal operating parameters must be noted. Boilers, air handlers, liquid chillers, cooling towers, water-cooled condensers, circulators and pumps, zone valves, air vents, pressure relief valves and other system components and safety devices operating out of manufacturer's specifications must be identified and a plan for repair must be formulated.

COMMERCIAL REFRIGERATION

OCCUPATION-SPECIFIC KNOWLEDGE

- Understand and apply the principles of high, medium, low, and ultra-low temperature commercial refrigeration and their applications.
- Understand and apply the principles of mechanical refrigeration systems in commercial refrigeration; for example, walk-in coolers, walk-in freezers, reach-in cases, multiple evaporator systems, packaged refrigeration systems, etc.
- Understand and apply the principles of electric and hot gas defrost systems in commercial refrigeration systems.
- Understand and apply the principles of flake and cube ice makers.
- Understand and apply the principles of water coolers.
- Understand and apply the principles of specific refrigeration system components used in commercial refrigeration; for example, low ambient controls, evaporator pressure regulators, crankcase pressure regulators, etc.
- Understand and apply the principles of load calculation and piping designs in commercial refrigeration systems.

SKILL	STANDARD
Calculate the load, design the piping system, and design the control system of a commercial refrigeration system.	The design of the commercial refrigeration system must meet the refrigeration needs of the area and conform to all applicable codes. Heat gain/heat loss must be calculated for each zone. The air distribution and delivery system must be designed to provide air flow required by the zone(s). The piping system for delivering cooling media must be designed to meet the needs of the zone(s) and their specific equipment and system. The control system must be design to provide control of the temperature required in the zone and the defrost and other requirements of the refrigeration system.
Install/service commercial refrigeration systems.	The commercial refrigeration system must be installed according to job and manufacturer's specifications and must comply with applicable codes. The unit must be mechanically secure and all electrical or control circuits must provide the voltage and control specified. The refrigeration system must perform quietly and to specifications, all safety devices must function correctly, and provide the temperatures required by the specifications. Preventive maintenance must be performed in accordance with manufacturer's specifications and schedule. If a unit requires service, the problem must be diagnosed and all components or subsystems out of manufacturer's specifications must be identified. Repaired or replaced components must perform according to manufacturer's specifications and the system must perform as specified. Applicable safety procedures must be followed.

COMMERCIAL REFRIGERATION (continued)

SKILL	STANDARD
Install/service ice makers.	The ice maker must be installed according to job and manufacturer's specifications and must comply with applicable codes. The unit must be mechanically secure and must comply with applicable electrical or plumbing codes. The ice maker must perform quietly and to design specifications. The water must be clean and the water level adjusted to specifications. The water supply and condensate drain must meet manufacturer's specifications and applicable codes. The units defrost system must perform to specifications. Preventive maintenance must be performed in accordance with manufacturer's specifications and schedule. If a unit requires service, the problem must be diagnosed and all components or subsystems out of manufacturer's specifications must be identified. Repaired or replaced components must perform according to manufacturer's specifications and the system must perform as specified when returned to duty. Applicable safety procedures must be followed.
Install/service water coolers.	The water cooler must be installed according to job and manufacturer's specifications and must comply with applicable codes. The unit must be mechanically secure with no leaks and must comply with applicable electrical or plumbing codes. The unit must perform quietly and cool water to design specifications. Preventive maintenance must be performed in accordance with manufacturer's specifications and schedule. If a unit requires service, the problem must be diagnosed and all components or subsystems out of manufacturer's specifications must be identified. Repaired or replaced components must perform according to manufacturer's specifications and the system must perform as specified when returned to service. Applicable safety procedures must be followed.
Troubleshoot high temperature commercial refrigeration systems.	Diagnostic procedures must be systematic, comprehensive, complete, and follow manufacturer's diagnostic chart when available. Electrical characteristics, pressures, and temperatures or other diagnostic characteristics outside of the refrigeration system's normal operating parameters must be noted. Blower fans, thermostats, filters, and other system components and safety devices system components operating out of manufacturer's specifications must be identified and a plan for repair must be formulated.
Troubleshoot medium temperature commercial refrigeration systems.	Diagnostic procedures must be systematic, comprehensive, complete, and follow manufacturer's diagnostic chart when available. Electrical characteristics, pressures, and temperatures or other diagnostic characteristics outside of the refrigeration system's normal operating parameters must be noted. Blower fans, thermostats, filters, and other system components and safety devices system components operating out of manufacturer's specifications must be identified and a plan for repair must be formulated.

COMMERCIAL REFRIGERATION (continued)

SKILL	STANDARD
Troubleshoot low temperature commercial refrigeration systems.	Diagnostic procedures must be systematic, comprehensive, complete, and follow manufacturer's diagnostic chart when available. Electrical characteristics, pressures, and temperatures or other diagnostic characteristics outside of the refrigeration system's normal operating parameters must be noted. Blower fans, thermostats, filters, and other system components and safety devices system components operating out of manufacturer's specifications must be identified and a plan for repair must be formulated.
Troubleshoot ultra-low temperature commercial refrigeration systems.	Diagnostic procedures must be systematic, comprehensive, complete, and follow manufacturer's diagnostic chart when available. Electrical characteristics, pressures, and temperatures or other diagnostic characteristics outside of the refrigeration system's normal operating parameters must be noted. Blower fans, thermostats, filters, and other system components and safety devices system components operating out of manufacturer's specifications must be identified and a plan for repair must be formulated.
Troubleshoot ice makers.	Diagnostic procedures must be systematic, comprehensive, complete, and follow manufacturer's diagnostic chart when available. Electrical characteristics, pressures, and temperatures or other diagnostic characteristics outside of ice maker's normal operating parameters must be noted. Blower fans, thermostats, filters, and other system components and safety devices system components operating out of manufacturer's specifications must be identified and a plan for repair must be formulated.
Troubleshoot water coolers.	Diagnostic procedures must be systematic, comprehensive, complete, and follow manufacturer's diagnostic chart when available. Electrical characteristics, pressures, and temperatures or other diagnostic characteristics outside of the water cooler's normal operating parameters must be noted. Thermostats, filters, and other system components and safety devices system components operating out of manufacturer's specifications must be identified and a plan for repair must be formulated.

Appendix
Skills Matrix

Appendix
Skills Matrix

NATIONAL SKILL STANDARDS HEATING, AIR CONDITIONING, AND REFRIGERATION TECHNICIANS																			
Skills	Residential and Light Commercial								Commercial										
	Heating							A/C	Heating				A/C	Refrigeration		
	Warm Air		Hydronic		Heat Pump				Warm Air		Hydronic					
	Gas Fired	Oil Fired	Gas Fired	Oil Fired	Air	Water	Ground	A/C	Gas Fired	Oil Fired	Gas Fired	Oil Fired		High	Medium	Low
Core Skills																
Safety and Environmental																
1 Understand and apply safety regulations and procedures.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
2 Understand and apply federal, state, and local regulations for desposing of hazardous materials.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
3 Understand and apply Environmental Protection Agency (E. P. A.) regulations on venting, recovery, reclaiming, and recycling refrigerants.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
4 Understand and apply the Department of Transportation (D. O. T.) regulations on the transportation and handling of hazardous materials.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
5 Understand and apply the Occupation Safety and Health Act's (OSHA) regulations.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
6 Understand and apply Environmental Protection Agency (EPA) regulation on indoor air quality and nitrous-oxide.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Electrical																
Principles																
1 Understand and apply the principles of alternating and direct current.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
2 Understand and recognize the common single and three phase voltage systems including 230v, 60hz, single phase; 208v, 60hz, three phase; 230v, 60hz, three phase; and 460v, 60hz, three phase systems.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
3 Understand and apply the principles of series, parallel, and compound circuits.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
4 Understand and apply the principles and relationships of Ohm's, Kirchhoff's, and Watt's laws as they apply to series, parallel, and compound circuits.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
5 Read and interpret voltage, ampere, Ohm, megohm, and watt meters.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
6 Read and interpret schematic drawings.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
7 Develop schematics from electrical label and line diagrams.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
8 Read and interpret electrical codes.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
9 Understand and apply the properties and behaviors of electrical conductors and insulators.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
10 Understand and apply the principles of electrical circuit protection including fuses, circuit breakers, and disconnect switches.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●

Appendix
Skills Matrix

NATIONAL SKILL STANDARDS HEATING, AIR CONDITIONING, AND REFRIGERATION TECHNICIANS																		
Skills		Residential and Light Commercial								Commercial								
		Heating						A/C		Heating				A/C	Refrigeration			
		Warm Air		Hydronic		Heat Pump				Warm Air		Hydronic						
		Gas Fired	Oil Fired	Gas Fired	Oil Fired	Air	Water	Ground	A/C	Gas Fired	Oil Fired	Gas Fired	Oil Fired		High	Medium	Low	
11	Understand and apply the principles of single and three phase transformers.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
12	Understand and apply electrical grounding principles.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
13	Understand and apply the principles of electrical measurement.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
14	Troubleshoot electrical circuits.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
15	Install electrical power and control circuits.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
16	Install and connect the components of electrical circuits.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
Electric Motors																		
1	Understand and apply the operating principles of electric motors.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
2	Understand and recognize the application of various types of electric motors.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
3	Understand and recognize the application of various types of capacitors.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
4	Understand the principles and operation of electric motor protection devices.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
5	Understand and interpret electric motor specifications.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
6	Install and connect electric motors.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
7	Perform electric motor maintenance.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
8	Troubleshoot electric motors.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
Controls																		
1	Understand and apply the principles of safety and operating control devices; for example, pressure switches, thermostats, etc.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
2	Understand and apply the principles of electromechanical control devices; for example, relays, contractors, magnetic starters, timers, sequences, etc.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
3	Understand and apply the principles of electronic control devices; for example, ignition modules, electronic timers, etc.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
4	Understand and apply the principles of safety and control circuits.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	

Appendix
Skills Matrix

NATIONAL SKILL STANDARDS HEATING, AIR CONDITIONING, AND REFRIGERATION TECHNICIANS		Residential and Light Commercial								Commercial							
		Heating							A/C	Heating				A/C	Refrigeration		
		Warm Air		Hydronic		Heat Pump				Warm Air		Hydronic					
	Skills	Gas Fired	Oil Fired	Gas Fired	Oil Fired	Air	Water	Ground	A/C	Gas Fired	Oil Fired	Gas Fired	Oil Fired		High	Medium	Low
5	Install/service mechanical control devices.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
6	Install/service electromechanical control devices.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
7	Troubleshoot mechanical control devices.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
8	Troubleshoot electromechanical devices.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
9	Troubleshoot electronic control devices.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	Mechanical																
Refrigeration Principles and Practices																	
1	Understand and apply the theory of heat.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
2	Understand and apply the properties of refrigerants.					●	●	●	●					●	●	●	●
3	Understand and apply the mechanical refrigeration cycle.					●	●	●	●					●	●	●	●
4	Understand and apply pressure/temperature curves and charts.					●	●	●	●					●	●	●	●
5	Understand and apply the principles and the operation of compressors.					●	●	●	●					●	●	●	●
6	Understand and apply the principles and operation of condensers.					●	●	●	●					●	●	●	●
7	Understand and apply the principles and operation of metering devices.					●	●	●	●					●	●	●	●
8	Understand and apply the principles and operation of evaporators.					●	●	●	●					●	●	●	●
9	Understand the operation of refrigeration system accessories; for example, receivers, accumulators, filter/dryers, sight glasses, valves, etc.					●	●	●	●					●	●	●	●
10	Perform leak tests.					●	●	●	●					●	●	●	●
11	Evacuate and measure the vacuum level of refrigeration systems.					●	●	●	●					●	●	●	●
12	Recover refrigerants.					●	●	●	●					●	●	●	●
13	Charge refrigeration systems.					●	●	●	●					●	●	●	●

Appendix
Skills Matrix

NATIONAL SKILL STANDARDS

HEATING, AIR CONDITIONING, AND REFRIGERATION TECHNICIANS

Skills	Residential and Light Commercial								Commercial						
	Heating							A/C	Heating				A/C	Refrigeration	
	Warm Air		Hydronic		Heat Pump				Warm Air		Hydronic				
	Gas Fired	Oil Fired	Gas Fired	Oil Fired	Air	Water	Ground	A/C	Gas Fired	Oil Fired	Gas Fired	Oil Fired		High	Medium	Low
14 Recycle refrigerants.					●	●	●	●					●	●	●	●
15 Troubleshoot mechanical refrigeration systems.					●	●	●	●					●	●	●	●
Heating Principles and Practices																
1 Understand and apply the principles of fuel system design.	●	●	●	●	●	●	●		●	●	●	●				
2 Understand and apply the principles of air and hydronic distribution and delivery system design.	●	●	●	●	●	●	●		●	●	●	●				
3 Understand and apply the principles and operation of electric resistance heat systems.					●	●	●									
4 Understand and apply the principles and operation of gas-fired forced-air heating systems.	●								●							
5 Understand and apply the principles and operation of oil-fired forced-air heat systems.		●								●						
6 Understand and apply the principles of electric heat pump systems.					●	●	●									
7 Understand and apply the principles and operation of gas-fired hydronic heat systems.			●								●					
8 Understand and apply the principles and operation of oil-fired hydronic heat systems.				●								●				
9 Understand and apply the principles of venting and drain systems.	●	●	●	●	●	●	●		●	●	●	●				
10 Understand and apply the principles of pipe sizing and layout for both fuel and heat distribution.	●	●	●	●	●	●	●		●	●	●	●				
Air Conditioning Principles and Practices																
1 Understand and apply the principles of air-conditioning including temperature, humidity, and air movement, etc.					●	●	●	●					●			
2 Understand and apply the principles of air distribution and delivery systems.					●	●	●	●					●			
3 Understand and apply the principles of condensate drain systems.					●	●	●	●					●			
4 Understand and apply the principles of air filtration systems.	●	●			●	●	●	●	●	●			●			
5 Design air distribution systems.	●	●			●	●	●	●	●	●			●			

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Skills Matrix

NATIONAL SKILL STANDARDS

HEATING, AIR CONDITIONING, AND REFRIGERATION TECHNICIANS

Skills	Residential and Light Commercial								Commercial						
	Heating						A/C		Heating				A/C	Refrigeration	
	Warm Air		Hydronic		Heat Pump				Warm Air		Hydronic				
	Gas Fired	Oil Fired	Gas Fired	Oil Fired	Air	Water	Ground	A/C	Gas Fired	Oil Fired	Gas Fired	Oil Fired		High	Medium	Low
Piping Principles and Practices																
1 Understand and apply the principles of piping systems including the factors that affect pipe selection, pipe size, and system design.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
2 Understand and select the proper fitting or valve for specific applications; for example, globe valves, gate valves, angle valves, check valves, elbows, tees, unions, couplings, half unions, etc.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
3 Understand and apply the principles of pipe accessories; for example, flanges, isolators, hangers, expansion joints, expansion, loops, supports, insulation, etc.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
4 Perform copper tubing operations including cutting, flaring, soldering, brazing, bending, swaging, etc.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
5 Perform steel pipe operations including cutting, reaming, threading, connecting, etc.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
6 Perform PVC pipe operations including cutting, connecting, etc.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Occupation Specific Skills																
Residential and Light Commercial Heating																
1 Understand and apply the principles of fuel system design.	●	●	●	●	●	●	●		●	●	●	●				
2 Understand and apply the principles of air distribution system design.	●	●	●	●	●	●	●	●	●	●	●	●	●			
3 Understand and apply the principles and operation of electric resistance heat systems.					●											
4 Understand and apply the principles and operation of gas-fired forced-air heating systems.	●				●				●							
5 Understand and apply the principles and operation of oil-fired forced air heating systems.		●								●						
6 Understand and apply the principles and operation of gas-fired hydronic heat systems.			●								●					
7 Understand and apply the principles and operation of oil-fired hydronic heat systems.				●								●				
8 Understand and apply the principles of venting and drain systems.	●	●	●	●	●				●	●	●	●				
9 Understand and apply the principles of pipe sizing and layout including liquid propane and natural gas and oil.	●	●	●	●	●				●	●	●	●				
10 Understand and apply the principles of humidification.	●	●	●	●	●	●	●		●	●	●	●				
11 Install/service gas-fired forced air heating systems.	●				●				●							

Appendix
Skills Matrix

NATIONAL SKILL STANDARDS

HEATING, AIR CONDITIONING, AND REFRIGERATION TECHNICIANS

Skills	Residential and Light Commercial								Commercial						
	Heating						A/C		Heating				A/C	Refrigeration	
	Warm Air		Hydronic		Heat Pump				Warm Air		Hydronic				
	Gas Fired	Oil Fired	Gas Fired	Oil Fired	Air	Water	Ground	A/C	Gas Fired	Oil Fired	Gas Fired	Oil Fired		High	Medium	Low
12 Install/service oil-fired forced air heating systems.		●								●						
13 Install/service hydronic heat systems.			●	●							●	●				
14 Fabricate/install/service venting and drain systems.	●	●	●	●	●				●	●	●	●				
15 Install/service humidifiers.	●	●	●	●	●	●	●		●	●	●	●				
16 Troubleshoot gas-fired forced air heating systems.					●				●							
17 Troubleshoot oil-fired forced air heating systems.		●								●						
18 Troubleshoot hydronic heat systems.			●	●							●	●				
19 Troubleshoot venting and drain systems.	●	●	●	●	●				●	●	●	●				
Residential and Light Commercial Air Conditioning																
1 Understand and apply the principles of air-conditioning including temperature, humidity, and air movement, etc.					●	●	●	●					●	●	●	●
2 Understand and apply the principles of air distribution systems.					●	●	●	●					●			
3 Understand and apply the principles of condensate drain systems.					●	●	●	●					●	●	●	●
4 Understand and apply the principles of air filtration systems.	●	●			●	●	●	●	●	●			●			
5 Design air distribution and delivery systems.	●	●			●	●	●	●	●	●			●			
6 Fabricate and insulate air distribution systems.	●	●			●	●	●	●	●	●			●			
7 Install air distribution systems.	●	●			●	●	●	●	●	●			●			
8 Install/service condensate drain systems.					●	●	●	●	●	●			●			
9 Install/service air filtration systems.	●	●			●	●	●	●	●	●			●			
10 Install/service split air-conditioning systems.								●					●			
11 Install/service packaged air-conditioning systems.								●					●			

NATIONAL SKILL STANDARDS HEATING, AIR CONDITIONING, AND REFRIGERATION TECHNICIANS																			
Skills	Residential and Light Commercial								Commercial										
	Heating						A/C		Heating				A/C	Refrigeration					
	Warm Air		Hydronic		Heat Pump				Warm Air		Hydronic								
	Gas Fired	Oil Fired	Gas Fired	Oil Fired	Air	Water	Ground	A/C	Gas Fired	Oil Fired	Gas Fired	Oil Fired		High	Medium	Low			
12 Install/service evaporative coolers.								●					●						
13 Troubleshoot air-conditioning systems.								●					●						
14 Troubleshoot evaporative coolers.								●					●						
15 Troubleshoot condensate drain systems.					●	●	●	●					●						
16 Troubleshoot air filtration systems.	●	●			●	●	●	●	●	●			●						
Residential and Light Commercial Heat Pumps																			
1 Understand and apply the principles of vapor compression heat pump cycles.					●	●	●												
2 Understand and apply the principles of supplementary heat.					●														
3 Understand and apply the relationship of outdoor ambient temperature to heating capacity.					●														
4 Understand and apply the electrical circuitry of air to air, water to air, and ground to air heat pumps.					●	●	●												
5 Understand and apply the principles and operation of defrost controls in heat pump systems; for example, electronic demand defrost, pressure, time/temperature, time, etc.					●														
6 Understand and apply the principles of the balance point of heat pumps.					●	●	●												
7 Interpret the balance chart and plot the balance point of a heat pump.					●	●	●												
8 Design air distribution and delivery systems.	●	●			●	●	●		●	●									
9 Fabricate and insulate air distribution systems.	●	●			●	●	●		●	●									
10 Install/service vapor compression heat pump systems.					●	●	●												
11 Troubleshoot vapor compression heat pump systems.					●	●	●												
Commercial Conditioned Air Systems																			
1 Understand and apply the principles of cooling towers.													●						
2 Understand and apply the principles of pneumatic control devices; for example, thermostats, pneumatic actuators, pneumatic switches, pneumatic relays, etc.											●	●	●						

NATIONAL SKILL STANDARDS HEATING, AIR CONDITIONING, AND REFRIGERATION TECHNICIANS																			
	Skills	Residential and Light Commercial								Commercial									
		Heating						A/C		Heating				A/C	Refrigeration				
		Warm Air		Hydronic		Heat Pump				Warm Air		Hydronic							
		Gas Fired	Oil Fired	Gas Fired	Oil Fired	Air	Water	Ground	A/C	Gas Fired	Oil Fired	Gas Fired	Oil Fired		High	Medium	Low		
3	Understand and apply the principles of pumps and circulators.									●	●	●	●	●					
4	Understand and apply the principles of low and high pressure gas-fired boilers.											●							
5	Understand and apply the principles of low and high pressure oil-fired boilers												●						
6	Understand and apply the principles of steam condensers and traps.											●	●						
7	Understand and apply the principles of water-cooled condensers and accessories.													●					
8	Understand and apply the principles of desiccant cooling and dehumidification systems.									●	●	●	●	●					
9	Understand and apply the principles of liquid chillers and accessories.													●					
10	Understand and apply the principles and of air distribution and delivery systems.									●	●			●					
11	Understand and apply the principles of water distribution systems.											●	●	●					
12	Understand and apply the principles of commercial conditioned-air control systems.									●	●			●					
13	Install/maintain/service pneumatic control devices.									●	●	●	●	●					
14	Install/service pumps and circulators.											●	●	●					
15	Install/align shafts in fans, pumps, and open-type compressors.									●	●	●	●	●					
16	Install/service cooling towers and accessories.													●					
17	Install/service water-cooled condensers and accessories.													●					
18	Install/service liquid chillers and accessories.													●					
19	Install/service air distribution systems and accessories.									●				●					
20	Install/service water distribution systems and accessories.											●	●	●					
21	Install/service commercial conditioned-air control systems									●	●	●	●	●					
22	Perform scheduled monitoring/testing procedures of commercial conditioned-air systems.									●	●	●	●	●					

NATIONAL SKILL STANDARDS HEATING, AIR CONDITIONING, AND REFRIGERATION TECHNICIANS																				
	Skills	Residential and Light Commercial								Commercial										
		Heating						A/C		Heating				A/C	Refrigeration					
		Warm Air		Hydronic		Heat Pump				Warm Air		Hydronic								
		Gas Fired	Oil Fired	Gas Fired	Oil Fired	Air	Water	Ground	A/C	Gas Fired	Oil Fired	Gas Fired	Oil Fired		High	Medium	Low			
23	Perform preventative inspection and maintenance procedures of commercial conditioned-air systems.									●	●	●	●	●						
24	Perform commercial conditioned-air system start-up procedures.									●	●	●	●	●						
25	Perform commercial conditioned-air system shut-down procedures.									●	●	●	●	●						
26	Troubleshoot pneumatic control devices.									●	●	●	●	●						
27	Troubleshoot pumps and circulators.										●	●	●	●						
28	Troubleshoot cooling towers and accessories.													●						
29	Troubleshoot water-cooled condensers and accessories.													●						
30	Troubleshoot liquid chillers and accessories.													●						
31	Troubleshoot air distribution systems and accessories.									●	●			●						
32	Troubleshoot water distribution systems and accessories.											●	●	●						
33	Troubleshoot commercial conditioned-air control systems.									●	●	●	●	●						
Commercial Refrigeration																				
1	Understand and apply the principles of high, medium, low, and ultra-low temperature commercial refrigeration and their applications.														●	●	●			
2	Understand and apply the principles of mechanical refrigeration systems in commercial refrigeration; for example, walk-in coolers, walk-in freezers, reach-in cases, multiple evaporator systems, packaged refrigeration systems, etc.														●	●	●			
3	Understand and apply the principles of electric and hot gas defrost systems in commercial refrigeration systems.															●	●			
4	Understand and apply the principles of flake and cube ice makers.															●	●			
5	Understand and apply the principles of water coolers.														●					
6	Understand and apply the principles of specific refrigeration system components used in commercial refrigeration; for example, low ambient controls, evaporator pressure regulators, crankcase pressure regulators, etc.														●	●	●			
7	Understand and apply the principles of load calculation and piping designs in commercial refrigeration systems.														●	●	●			
8	Calculate the load, design the piping system, and design the control system of a commercial refrigeration system.														●	●	●			

Appendix
Skills Matrix

NATIONAL SKILL STANDARDS HEATING, AIR CONDITIONING, AND REFRIGERATION TECHNICIANS																		
	Skills	Residential and Light Commercial								Commercial								
		Heating						A/C		Heating				A/C	Refrigeration			
		Warm Air		Hydronic		Heat Pump				Warm Air		Hydronic						
		Gas Fired	Oil Fired	Gas Fired	Oil Fired	Air	Water	Ground	A/C	Gas Fired	Oil Fired	Gas Fired	Oil Fired		High	Medium	Low
9	Install/service commercial refrigeration systems.														●	●	●
10	Install/service ice makers.															●	●
11	Install/service water coolers.														●		
12	Troubleshoot high temperature commercial refrigeration systems.														●		
13	Troubleshoot medium temperature commercial refrigeration systems.															●	
14	Troubleshoot low temperature commercial refrigeration systems.																●
15	Troubleshoot ultra-low temperature commercial refrigeration systems.																●
16	Troubleshoot ice makers.															●	●
17	Troubleshoot water coolers.														●		
	Workplace Behaviors																
Work Ethics and Behavior																	
1	Understand and adhere to the conduct rules of the company.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
2	Assume responsibility for decisions and actions.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
3	Demonstrate a willingness to learn.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
4	Demonstrate ability to work as a team member.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
5	Display initiative.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
6	Perform quality work.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
7	Exhibit pride in quality work.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
8	Identify established rules, regulations, and policies.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
9	Adhere to fair pricing standards.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●

NATIONAL SKILL STANDARDS HEATING, AIR CONDITIONING, AND REFRIGERATION TECHNICIANS																		
Skills		Residential and Light Commercial								Commercial								
		Heating						A/C		Heating				A/C	Refrigeration			
		Warm Air		Hydronic		Heat Pump				Warm Air		Hydronic						
		Gas Fired	Oil Fired	Gas Fired	Oil Fired	Air	Water	Ground	A/C	Gas Fired	Oil Fired	Gas Fired	Oil Fired		High	Medium	Low	
10	Maintain work hours and schedule.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
11	Practice cost effectiveness.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
12	Practice time management.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
Work Environment(s)																		
1	Understand and apply environmental and occupational safety practices and regulations.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
2	Identify hazardous substances in the work area.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
3	Maintain work area.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
4	Respond to emergencies.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
Workplace Communications																		
1	Communicate orally with others.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
2	Follow oral and written directions.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
3	Display listening skills.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
4	Interpret body language.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
5	Prepare written communication.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
6	Utilize telephone etiquette.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
Professionalism																		
1	Accept responsibilities of an employee.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
2	Assess business image, products and/or services.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
3	Assume responsibility for awareness of technological and regulatory changes.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
4	Converse in work-related terminology.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	

NATIONAL SKILL STANDARDS HEATING, AIR CONDITIONING, AND REFRIGERATION TECHNICIANS																		
Skills		Residential and Light Commercial								Commercial								
		Heating						A/C		Heating				A/C	Refrigeration			
		Warm Air		Hydronic		Heat Pump				Warm Air		Hydronic						
		Gas Fired	Oil Fired	Gas Fired	Oil Fired	Air	Water	Ground	A/C	Gas Fired	Oil Fired	Gas Fired	Oil Fired		High	Medium	Low
5	Display a positive attitude.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
6	Follow company dress and appearance standards.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
7	Participate in employment orientation.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
8	Treat people with respect.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
9	Understand and apply the responsibilities of an employer/management.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
10	Display safe and courteous driving practices.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Problem Solving																	
1	Employ reasoning skills.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
2	Evaluate results of implemented option.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
3	Evaluate options.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
4	Identify solutions to a problem and their impact.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
5	Identify the problem.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
6	Organize workloads.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
7	Select and implement a solution to a problem.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
8	Set priorities.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●

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