

***Heating, Ventilation, Air Conditioning,
and Refrigeration
Program of Study with
Complementary Course Standards***



This document was prepared by:

Office of Career Readiness, Adult Learning, and Education Options
Nevada Department of Education
755 N. Roop Street, Suite 201
Carson City, NV 89701

www.doe.nv.gov

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Vision

All Nevada students are equipped and feel empowered to attain their vision of success

Mission

To improve student achievement and educator effectiveness by ensuring opportunities, facilitating learning, and promoting excellence



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Standards Development Members

| Name | Occupation/Title | Stakeholder Affiliation | School/Organization |
|----------------|------------------|--------------------------------------|-----------------------------------------------|
| Wes Evans | Instructor | Secondary Educator | Applied Technology Center, Reno |
| Crystal Naegle | Department Chair | Postsecondary Educator | College of Southern Nevada, Las Vegas |
| Scott Oxborrow | P M / Estimator | Business and Industry Representative | Snyder Mechanical, Elko |
| Todd Padgett | Instructor | Secondary Educator | Elko High School, Elko County School District |
| Kevin Putman | Instructor | Postsecondary Educator | College of Southern Nevada, Las Vegas |
| Heather Steel | CTE Director | Secondary Educator | Elko County School District |

Business and Industry Validation

All CTE standards developed through the Nevada Department of Education are validated by business and industry through one or more of the following processes: (1) the standards are developed by a team consisting of business and industry representatives, or (2) a separate review panel is coordinated with industry experts to ensure the standards include the proper content, or (3) nationally recognized standards currently endorsed by business and industry.

The Heating, Ventilation, Air Conditioning, and Refrigeration standards were validated through active participation of business and industry representatives on the development team.

The Heating, Ventilation, Air Conditioning, and Refrigeration standards are adapted from the NCCER HVACR Craft Standards.

Introduction

The standards in this document are designed to clearly state what the student should know and be able to do upon completion of an advanced high school Heating, Ventilation, Air Conditioning, and Refrigeration program. These standards are designed for a two-credit course sequence that prepares the student for a technical assessment directly aligned to the standards.

These exit-level standards are designed for the student to complete all standards through their completion of a program of study. These standards are intended to guide curriculum objectives for a program of study.

The standards are organized as follows:

- **Content Standards** are general statements that identify major areas of knowledge, understanding, and the skills students are expected to learn in key subject and career areas by the end of the program.
- **Performance Standards** follow each content standard. Performance standards identify the more specific components of each content standard and define the expected abilities of students within each content standard.
- **Performance Indicators** are very specific criteria statements for determining whether a student meets the performance standard. Performance indicators may also be used as learning outcomes, which teachers can identify as they plan their program learning objectives. The indicators are followed by designations that reflect the course sequence (e.g., L1 for the first-year course of a two-year program and L2 for the second-year, C is to designate the indicators to be taught in the complementary courses) as referenced in the Core Course Sequence table.

The crosswalks and alignments are located in the Heating, Ventilation, Air Conditioning, and Refrigeration Supplemental Program Resources document. These will show where the performance indicators support the Nevada Academic Content Standards. For individual course descriptions, please refer to the Supplemental Program Resources document or the Nevada CTE Catalog.

All students are encouraged to participate in the career and technical student organization (CTSO) that relates to the Heating, Ventilation, Air Conditioning, and Refrigeration program. CTSOs are co-curricular national organizations that directly reinforce learning in the CTE classroom through curriculum resources, competitive events, and leadership development. CTSOs provide students the ability to apply academic and technical knowledge, develop communication and teamwork skills, and cultivate leadership skills to ensure college and career readiness.

The Employability Skills for Career Readiness identify the skills needed to be successful in all careers and must be taught as an integrated component of all CTE course sequences. These standards are available in a separate document.

The **Standards Reference Code** is only used to identify or align performance indicators listed in the standards to daily lesson plans, curriculum documents, or national standards. The Standards Reference Code is an abbreviated name for the program, and the content standard, performance standard and performance indicator are referenced in the program standards. This abbreviated code for identifying standards uses each of these items. For example, HVACR is the Standards Reference Code for Heating, Ventilation, Air Conditioning, and Refrigeration. For Content Standard 2, Performance Standard 3 and Performance Indicator 4 the Standards Reference Code would be HVACR.2.3.4.

Heating, Ventilation, Air Conditioning, and Refrigeration

Program Information

Program of Study: Heating, Ventilation, Air Conditioning, and Refrigeration

Standards Reference Code: HVACR

Career Cluster: Architecture and Construction

Career Pathway(s): Maintenance/Operations

Program Length: 2-year, completed sequentially

CTSO: SkillsUSA

Program Structure Required Program of Study Courses

The core course sequencing is provided in the following table. Complementary Courses are available and provided later in this document. The following courses provide a completed program of study. The Lab is a complementary course available concurrently with the Heating, Ventilation, Air Conditioning, and Refrigeration II course.

Core Course Sequence (R) with Lab Course(s) (C)

| Required/ Complementary | Course Title | Abbreviated Name |
|----------------------------|------------------------------------------------------------------|------------------|
| R | Heating, Ventilation, Air Conditioning, and Refrigeration I | HVACR I |
| R | Heating, Ventilation, Air Conditioning, and Refrigeration II | HVACR II |
| C | Heating, Ventilation, Air Conditioning, and Refrigeration II LAB | HVACR II L |

CONTENT STANDARD 1.0: INTEGRATE CAREER AND TECHNICAL STUDENT ORGANIZATIONS (CTSOs)

Performance Standard 1.1: Explore the History and Organization of CTSOs

- 1.1.1 Discuss the requirements of CTSO participation/involvement as described in Carl D. Perkins Law (Level1 (L1), Level 2 (L2), Complementary (C))
- 1.1.2 Research nationally recognized CTSOs (L1, L2, C)
- 1.1.3 Investigate the impact of federal and state government regarding the progression and operation of CTSOs (e.g., Federal Statutes and Regulations, Nevada Administrative Code [NAC], Nevada Revised Statutes [NRS]) (L1, L2, C)

Performance Standard 1.2: Develop Leadership Skills

- 1.2.1 Discuss the purpose of parliamentary procedure (L1, L2, C)
- 1.2.2 Demonstrate the proper use of parliamentary procedure (L1, L2, C)
- 1.2.3 Differentiate between an office and a committee (L1, L2, C)
- 1.2.4 Discuss the importance of participation in local, regional, state, and national conferences, events, and competitions (L1, L2, C)
- 1.2.5 Participate in local, regional, state, or national conferences, events, or competitions (L1, L2, C)
- 1.2.6 Describe the importance of a constitution and bylaws to the operation of a CTSO chapter (L1, L2, C)

Performance Standard 1.3: Participate in Community Service

- 1.3.1 Explore opportunities in community service-related work-based learning (WBL) (L1, L2, C)
- 1.3.2 Participate in a service learning (program related) and/or community service project or activity (L1, L2, C)
- 1.3.3 Engage with business and industry partners for community service (L1, L2, C)

Performance Standard 1.4: Develop Professional and Career Skills

- 1.4.1 Demonstrate college and career readiness (e.g., applications, resumes, interview skills, presentation skills) (L1, L2, C)
- 1.4.2 Describe the appropriate professional/workplace attire and its importance (L1, L2, C)
- 1.4.3 Investigate industry-standard credentials/certifications available within this Career Cluster™ (L1, L2, C)
- 1.4.4 Participate in authentic contextualized instructional activities (L1, L2, C)
- 1.4.5 Demonstrate technical skills in various student organization activities/events (L1, L2, C)

Performance Standard 1.5: Understand the Relevance of Career and Technical Education (CTE)

- 1.5.1 Make a connection between program standards to career pathway(s) (L1, L2, C)
- 1.5.2 Explain the importance of participation and completion of a program of study (L1, L2, C)
- 1.5.3 Promote community awareness of local student organizations associated with CTE programs (L1, L2, C)

CONTENT STANDARD 2.0: IDENTIFY AND UTILIZE SAFETY PROCEDURES AND PROPER TOOLS

Performance Standard 2.1: Demonstrate General Lab Safety Rules and Procedures

- 2.1.1 Describe general shop safety rules and procedures (L1)
- 2.1.2 Understand OSHA (Occupational Safety and Health Administration) standards and relate them to Heating, Ventilation, Air Conditioning, and Refrigeration (HVACR) safety rule standards (L1)
- 2.1.3 Comply with the required use of safety glasses, ear protection, gloves, and shoes during lab/shop activities (i.e., personal protective equipment - PPE) (L1)
- 2.1.4 Utilize safe procedures for handling of tools and equipment (L1)
- 2.1.5 Operate lab equipment according to safety guidelines (L1)
- 2.1.6 Identify and use proper lifting procedures and proper use of support equipment (L1)
- 2.1.7 Utilize proper ventilation procedures for working within the lab/shop area (L1)
- 2.1.8 Identify marked safety areas (L1)
- 2.1.9 Identify the location and the types of fire extinguishers and other fire safety equipment (L1)
- 2.1.10 Demonstrate knowledge of procedures for using fire extinguishers and other fire safety equipment (L1)
- 2.1.11 Identify the location and use of eye wash stations (L1)
- 2.1.12 Identify the location of the posted evacuation routes (L1)
- 2.1.13 Identify and wear appropriate clothing for lab/shop activities (L1)
- 2.1.14 Demonstrate safe lab/shop practices (e.g., secure hair, secure/remove jewelry/ties) (L1)
- 2.1.15 Demonstrate knowledge of the safety aspects of low and high voltage circuits (L1)
- 2.1.16 Locate and interpret safety data sheets (SDS) (L1)
- 2.1.17 Prepare time or job cards, reports, or records (L1)
- 2.1.18 Perform housekeeping duties (L1)
- 2.1.19 Follow verbal instructions to complete work assignments (L1)
- 2.1.20 Follow written instructions to complete work assignments (L1)

Performance Standard 2.2: Identify and Utilize Proper Tools

- 2.2.1 Identify tools and their appropriate usage (L1)
- 2.2.2 Identify standard and metric designation (L1)
- 2.2.3 Demonstrate the proper techniques when using hand tools (L1)
- 2.2.4 Demonstrate safe handling and use of appropriate tools (L1)
- 2.2.5 Demonstrate proper cleaning, storage, and maintenance of tools and equipment (L1)

Performance Standard 2.3: Identify and Utilize Power Tools and Equipment

- 2.3.1 Identify power tools and their appropriate usage (L1)
- 2.3.2 Identify equipment and their appropriate usage (L1)
- 2.3.3 Demonstrate the proper techniques when using power tools and equipment (L1)
- 2.3.4 Demonstrate safe handling and use of appropriate power tools and equipment (L1)
- 2.3.5 Demonstrate proper cleaning, storage, and maintenance of power tools and equipment (L1)

CONTENT STANDARD 3.0: PERFORM GENERAL HVACR SKILLS

Performance Standard 3.1: Demonstrate Print Reading Practices

- 3.1.1 Identify and explain basic construction drawing terms, components, and symbols (L1)
- 3.1.2 Identify various types of construction drawings (L1)
- 3.1.3 Identify and describe the purpose of the five basic construction drawing components (L1)
- 3.1.4 Identify and explain the use of dimensions and various drawing scales (L1)
- 3.1.5 Interpret schematic diagrams (e.g., plumbing, electrical, mechanical) (L1)
- 3.1.6 Identify and describe how to use architect's scales (L1)

Performance Standard 3.2: Apply Math Skills to HVACR Applications

- 3.2.1 Add, subtract, multiply, and divide whole numbers, with and without a calculator (L1)
- 3.2.2 Use a standard ruler, a metric ruler, and a measuring tape to measure (L1)
- 3.2.3 Add, subtract, multiply, and divide fractions (L1)
- 3.2.4 Add, subtract, multiply, and divide decimals, with and without a calculator (L1)
- 3.2.5 Convert decimals to percentages and percentages to decimals (L1)
- 3.2.6 Convert fractions to decimals and decimals to fractions (L1)
- 3.2.7 Explain the various measurement systems in the construction trades (L1)
- 3.2.8 Calculate standard and metric units of length, weight, volume, and temperature (L1)
- 3.2.9 Utilize geometric principles used in the construction industry (e.g., distances, area, volume) (L1)
- 3.2.10 Identify and describe characteristics of a circle, types of angles, and polygons (L1)
- 3.2.11 Calculate various values associated with triangles (L1)
- 3.2.12 Identify units of measure in the inch-pound and metric systems (L1)
- 3.2.13 Convert length, area, and volume values (L1)
- 3.2.14 Convert pressure and temperature values (L1)
- 3.2.15 Define algebraic terms in the context of HVACR (L1)
- 3.2.16 Solve basic algebra equations using the sequence of operations related to HVACR calculations (L1)

Performance Standard 3.3: Utilize Materials Handling Techniques

- 3.3.1 Describe the basic concepts of material handling and common safety precautions (L1)
- 3.3.2 Define a load (L1)
- 3.3.3 Establish a pre-task plan prior to moving a load (L1)
- 3.3.4 Select appropriate materials-handling equipment for the task (L1)
- 3.3.5 Utilize proper materials-handling techniques and equipment (L1)
- 3.3.6 Recognize hazards and follow safety procedures required for materials handling (L1)

Performance Standard 3.4: Explore HVACR Career Opportunities

- 3.4.1 Research high-skill, high-wage, high-demand career opportunities for craft professionals in this industry (L1)
- 3.4.2 Research postsecondary training opportunities and requirements (L12)
- 3.4.3 Identify the responsibilities and characteristics needed to be a successful HVACR technician (L1)
- 3.4.4 Identify residential, commercial, and industrial career opportunities (L1)
- 3.4.5 Describe opportunities provided by equipment manufacturers (L1)

CONTENT STANDARD 4.0: INTRODUCTION TO HEATING, VENTILATION, AIR CONDITIONING, AND REFRIGERATION

Performance Standard 4.1: Explain Basic Principles of Heating, Ventilation, Air Conditioning, and Refrigeration

- 4.1.1 Explain the principles of heating (L1)
- 4.1.2 Explain the principles of ventilation (L1)
- 4.1.3 Explain the principles of air conditioning (L1)
- 4.1.4 Explain the principles of refrigeration (L1)

Performance Standard 4.2: Describe the Principles That Guide HVACR Installation and Service Techniques

- 4.2.1 Identify common safety principles and organizations (L1)
- 4.2.2 Describe the importance of LEED (Leadership in Energy and Environmental Design) construction and energy management (L1)
- 4.2.3 Describe trade licensing and certification requirements (L1)
- 4.2.4 Identify important codes and permits (L1)

CONTENT STANDARD 5.0: INTRODUCTION TO ELECTRICITY

Performance Standard 5.1: Describe the Fundamentals of Electricity

- 5.1.1 Explain how electrical power is created and distributed (L1)
- 5.1.2 Describe the difference between alternating current and direct current (L1)
- 5.1.3 Identify general electrical safety practices (L1)
- 5.1.4 Describe the OSHA requirements and procedures related to electrical lockout/tagout (L1)

Performance Standard 5.2: Explain Basic Electrical Theory

- 5.2.1 Define voltage, current, resistance, and power and describe how they are related (L1)
- 5.2.2 Use Ohm's law to calculate the current, voltage, and resistance in a circuit (L1)
- 5.2.3 Use the power formula to calculate how much power is consumed by a circuit (L1)
- 5.2.4 Describe the differences between series and parallel circuits and calculate circuit loads for each type (L1)

Performance Standard 5.3: Describe How Electrical Measuring Instruments Are Used in HVACR Work

- 5.3.1 Describe how voltage, current, and resistance are measured (L1)

Performance Standard 5.4: Identify Electrical Components Used in HVACR Systems and Describe Their Functions

- 5.4.1 Identify and describe various load and control devices and explain how they are represented on circuit diagrams (L1)
- 5.4.2 Identify and describe various control devices and explain how they are represented on circuit diagrams (L1)

CONTENT STANDARD 6.0: THERMODYNAMICS AND HEAT TRANSFER

Performance Standard 6.1: Explore the Science of Refrigeration and Heating

- 6.1.1 Define matter and heat (L1)
- 6.1.2 Explain the direction and rate of heat flow (L1)
- 6.1.3 Describe the three methods of heat transfer (L1)
- 6.1.4 Identify the reference points of temperature (L1)
- 6.1.5 Explain the difference between heat and temperature (L1)
- 6.1.6 Explain the difference between latent and sensible heat (L1)
- 6.1.7 Explain the change of state of matter (L1)
- 6.1.8 Explain heat/cool storage (L1)
- 6.1.9 Define specific heat (L1)
- 6.1.10 Define sensible heat (L1)
- 6.1.11 Define latent heat of fusion (L1)
- 6.1.12 Define latent heat of vaporization (L1)
- 6.1.13 Define enthalpy (L1)
- 6.1.14 Define saturation temperature (dew point temperature) (L1)
- 6.1.15 Define water vapor pressure (L1)
- 6.1.16 Explain the direction and rate of moisture transfer (L1)
- 6.1.17 Calculate the BTUs required to change ice to steam (L1)

Performance Standard 6.2: Explore the Science of Fluids and Pressures as They Relate to Air Conditioning and Refrigeration

- 6.2.1 Explain the relationship of pressures and fluids at saturation temperatures (L1)
- 6.2.2 Use the P/T Chart to determine the difference between temperature and pressure (L1)
- 6.2.3 Define pressure (L1)
- 6.2.4 Explain atmospheric pressure (L1)
- 6.2.5 Explain the purpose of compound gauges (L1)
- 6.2.6 Explain the purpose of bourdon tubes (L1)
- 6.2.7 Explain barometric pressure (L1)
- 6.2.8 Explain absolute pressure (L1)
- 6.2.9 Explain gauge pressure (L1)
- 6.2.10 Explain inches of mercury absolute (L1)
- 6.2.11 Explain micron (L1)

Performance Standard 6.3: Understand the Relationship of the Components of the Refrigeration Cycle

- 6.3.1 Properly use basic air conditioning and refrigeration related tools (L1)
- 6.3.2 Properly use power tools used in air conditioning and refrigeration (L1)
- 6.3.3 Identify the four major components and their types within the vapor compression refrigeration system (L1)
- 6.3.4 Describe the state and conditions of the refrigerant during a cycle (L1)
- 6.3.5 Explain the importance of superheat and subcooling (L1)
- 6.3.6 Explain the functions and types of the four major components of a refrigeration system (L1)
- 6.3.7 List the components that separate the high side from the low side of the system (L1)
- 6.3.8 Use the temperature/enthalpy (T-H) chart to determine the state of the refrigerant within the mechanical system (L1)

CONTENT STANDARD 7.0: HEATING AND COMBUSTION

Performance Standard 7.1: Explain Fundamental Concepts of Heating and Combustion

- 7.1.1 Describe the heat transfer process (L1)
- 7.1.2 Identify gas fuels and their combustion characteristics (L1)

Performance Standard 7.2: Describe Various Heating Systems

- 7.2.1 Describe the types of gas furnaces and how they operate (L1)
- 7.2.2 Identify and describe the equipment and controls used in gas furnaces (L1)
- 7.2.3 Describe the basic installation and maintenance requirements for gas furnaces (L1)
- 7.2.4 Describe the operation of hydronic heating systems (L1)
- 7.2.5 Describe the operation of electrical heating equipment (L1)

CONTENT STANDARD 8.0: REFRIGERATION SYSTEMS

Performance Standard 8.1: Explain Fundamental Concepts of the Refrigeration Cycle

- 8.1.1 Describe how heat affects the state of substances (L1)
- 8.1.2 Explain how heat is transferred from one substance to another (L1)
- 8.1.3 Describe pressure-temperature relationships (L1)
- 8.1.4 Describe basic refrigerant flow and the changes of state occurring in the refrigeration cycle (L1)
- 8.1.5 Identify common instruments used to measure pressure and temperature (L1)

Performance Standard 8.2: Understand the Relationship of Refrigerants in the Refrigeration Cycle

- 8.2.1 Identify fluorocarbon refrigerants (L1)
- 8.2.2 Describe the use of ammonia as a refrigerant (L1)
- 8.2.3 Identify various refrigerant containers and their safe handling requirements (L1)

Performance Standard 8.3: Identify Major Components of Cooling Systems and How They Function

- 8.3.1 Identify various types of compressors (L1)
- 8.3.2 Identify different types of condensers (L1)
- 8.3.3 Identify different types of evaporators (L1)
- 8.3.4 Describe the devices used to meter refrigerant flow (L1)
- 8.3.5 Discuss basic refrigerant piping concepts (L1)
- 8.3.6 Identify various accessories used in refrigerant circuits (L1)

Performance Standard 8.4: Identify the Common Controls Used in Cooling Systems

- 8.4.1 Identify common primary and secondary controls (L1)

CONTENT STANDARD 9.0: PIPING PRINCIPLES

Performance Standard 9.1: Recognize and Identify Different Types of Copper Tubing and Their Related Fittings

- 9.1.1 Identify and describe copper tubing characteristics (L2)
- 9.1.2 Identify various copper fittings (L2)

Performance Standard 9.2: Describe and Demonstrate How to Join Copper Tubing Mechanically

- 9.2.1 Measure, cut, and bend copper tubing to prepare it for joining (L2)
- 9.2.2 Describe and demonstrate the methods and tools used to join copper tubing (L2)
- 9.2.3 Describe common hangers and supports associated with copper tubing installations (L2)

Performance Standard 9.3: Recognize Different Types of Plastic Piping and Show How it can be Joined

- 9.3.1 Identify different types of plastic piping (L2)
- 9.3.2 Identify the tools and products needed and demonstrate how to join plastic piping (L2)

Performance Standard 9.4: Describe and Demonstrate the Safe Process of Soldering Copper Tubing

- 9.4.1 Describe and demonstrate the use of the PPE, tools, and materials needed to solder copper tubing (L2)
- 9.4.2 Describe and demonstrate the preparation required for soldering (L2)
- 9.4.3 Describe and demonstrate the soldering process (L2)

Performance Standard 9.5: Describe and Demonstrate the Safe Process of Brazing Copper Tubing

- 9.5.1 Describe and demonstrate the use of the PPE, tools, and materials needed to braze copper tubing (L2)
- 9.5.2 Describe and demonstrate the preparation used for brazing (L2)
- 9.5.3 Describe and demonstrate the brazing process (L2)
- 9.5.4 Describe and demonstrate the process of brazing copper tubing to dissimilar metals (L2)

Performance Standard 9.6: Describe and Identify the Various Types of Steel Pipe and Fitting

- 9.6.1 Identify the characteristics and uses of steel pipe (L2)
- 9.6.2 Describe how pipe threads are classified and measured (L2)
- 9.6.3 Identify the various types of fittings used on steel pipe and describe how they are used (L2)
- 9.6.4 Describe how to properly measure lengths of steel pipe (L2)

Performance Standard 9.7: Describe the Tools and Methods Used to Cut and Thread Steel Pipe

- 9.7.1 Identify pipe cutting and reaming tools and describe how they are used (L2)
- 9.7.2 Identify threading tools and describe how they are used (L2)

Performance Standard 9.8: Explain and Demonstrate the Methods of Installing and Mechanically Joining Steel Pipe

- 9.8.1 Explain and demonstrate the methods and use of the tools to connect threaded pipe (L2)
- 9.8.2 Explain and demonstrate an understanding of pipe grooving methods (L2)
- 9.8.3 Describe how to assemble flanged steel pipe (L2)
- 9.8.4 Describe how to correctly install steel pipe (L2)

CONTENT STANDARD 10.0: COMPRESSORS

Performance Standard 10.1: Identify and Describe Various Approaches to Compressor Capacity Control

- 10.1.1 Identify and describe capacity control methods for reciprocating and scroll compressors (L2)
- 10.1.2 Identify and describe capacity control methods for screw and centrifugal compressors (L2)

Performance Standard 10.2: Describe the Common Causes of Compressor Failures

- 10.2.1 Describe compressor failures related to the refrigerant circuit (L2)
- 10.2.2 Describe compressor failures related to electrical issues (L2)

Performance Standard 10.3: Identify and Explain the Operation of Various Compressor Protection Devices

- 10.3.1 Identify and explain the operation of various overload devices (L2)
- 10.3.2 Identify and explain the operation of other compressor protection devices (L2)

Performance Standard 10.4: Explain How to Analyze the Operation of a Hermetic Compressor

- 10.4.1 Explain how to evaluate the mechanical operation of an operable compressor (L2)
- 10.4.2 Explain how to evaluate the electrical operation of an operable compressor (L2)

CONTENT STANDARD 11.0: ASPECTS OF REFRIGERANTS

Performance Standard 11.1: Describe the Desirable Characteristics of Refrigerants and the Various Applications that Require These Characteristics

- 11.1.1 Describe the desirable characteristics of refrigerants (L2)
- 11.1.2 Identify various applications that require specific refrigerant characteristics (L2)

Performance Standard 11.2: Identify Various Refrigerant Classifications and Describe Their Environmental Impact

- 11.2.1 Identify the primary chemical classifications of common characteristics (L2)
- 11.2.2 Describe the environmental concerns associated with refrigerants (L2)
- 11.2.3 Identify and describe compounded and blended azeotropic, near-azeotropic, and zeotropic refrigerants (L2)
- 11.2.4 Identify various refrigerant classifications and cylinder colors (L2)

Performance Standard 11.3: Explain How to Use Pressure-Temperature (PT) Charts to Calculate Superheat and Subcooling

- 11.3.1 Explain how to use PT charts for compound, azeotropic, and near-azeotropic refrigerants (L2)
- 11.3.2 Explain how to use PT charts for zeotropic refrigerants (L2)

Performance Standard 11.4: Identify and Describe Lubricating Oils and Issues Related to Their Function

- 11.4.1 Identify the important characteristics of refrigerant oils (L2)
- 11.4.2 Compare mineral-based and synthetic oils (L2)
- 11.4.3 Describe the movement of oil through the refrigerant circuit (L2)
- 11.4.4 Describe oil contamination and its sources (L2)
- 11.4.5 Describe common practices associated with handling, charging, and removing oils (L2)

Performance Standard 11.5: Describe Considerations Related to Refrigerant Conversions

- 11.5.1 Identify issues of concern in all refrigerant conversions (L2)
- 11.5.2 Describe common practices related to refrigerant conversions (L2)

Performance Standard 11.6: Describe the Equipment and Approaches Used to Leak Test Refrigerant Circuits

- 11.6.1 Describe the various methods used to detect refrigerant leaks (L2)
- 11.6.2 Describe how leak detection is approached based on the current refrigerant charge in the system (L2)

Performance Standard 11.7: Describe Refrigerant Containment and Management Requirements and the Equipment Used to Recover Refrigerants

- 11.7.1 Identify the basic refrigerant containment requirements of Section 608 of the Clean Air Act (L2)
- 11.7.2 Identify and explain how to operate refrigerant recovery and recycling equipment (L2)

Performance Standard 11.8: Explain the Related Principles and Identify the Equipment Used to Evacuate Refrigerant Circuits

- 11.8.1 Explain the basic principles of refrigerant circuit evacuation (L2)
- 11.8.2 Identify and explain how to operate vacuum pumps to evacuate a system (L2)

Performance Standard 11.9: Describe the Procedures for Charging Refrigerant Circuits

- 11.9.1 Identify and describe the equipment and components related to refrigerant charging (L2)
- 11.9.2 Explain how to properly charge various types of refrigerants using the appropriate method (L2)

CONTENT STANDARD 12.0: METERING DEVICES

Performance Standard 12.1: Explain the Function of Refrigerant Metering Devices and Their Effect on Refrigerants

- 12.1.1 Explain the function of metering devices (L2)
- 12.1.2 Describe how refrigerants react as they pass through a metering device (L2)
- 12.1.3 Identify distributors and explain their relationship to metering device performance and operation (L2)

Performance Standard 12.2: Identify Fixed Metering Devices and Explain How They Function

- 12.2.1 Identify and explain how fixed orifice metering devices function (L2)
- 12.2.2 Identify and explain how capillary tubes function (L2)
- 12.2.3 Describe common problems associated with fixed metering devices (L2)

Performance Standard 12.3: Identify Types of Expansion Valves and Explain How They Operate

- 12.3.1 Identify and explain the operation of manual expansion valves (L2)
- 12.3.2 Identify and explain the operation of automatic expansion valves (L2)
- 12.3.3 Identify and explain the operation of thermal expansion valves (L2)
- 12.3.4 Identify and explain the operation of electric and electronically controlled expansion valves (L2)
- 12.3.5 Describe common problems associated with all types of expansion valves (L2)

Complementary Course(s)

State Complementary Skill Standards

The state complementary skill standards are designed to clearly state what the student should know and be able to do upon completion of a complementary course related to their career and technical education (CTE) program of study. The standards are designed for the student to complete all standards through their completion of the **one-year** complementary course(s). **Completion of the qualifying Program of Study is required prior to enrollment in a complementary course.**

Employability Skills for Career Readiness Standards

Students have completed all program content standards and will pursue advanced study through investigation and in-depth research.

Complementary Course Standards Contributing Members

| Course Contribution(s) | Name | Occupation/Title | Stakeholder Affiliation | School/Organization |
|------------------------------------------------------------------------|----------------|------------------|--------------------------------------|-----------------------------------------------|
| Intermediate Heating, Ventilation, Air Conditioning, and Refrigeration | Wes Evans | Instructor | Secondary Educator | Applied Technology Center, Reno |
| Intermediate Heating, Ventilation, Air Conditioning, and Refrigeration | Crystal Naegle | Department Chair | Postsecondary Educator | College of Southern Nevada, Las Vegas |
| Intermediate Heating, Ventilation, Air Conditioning, and Refrigeration | Scott Oxborrow | P.M. / Estimator | Business and Industry Representative | Snyder Mechanical, Elko |
| Intermediate Heating, Ventilation, Air Conditioning, and Refrigeration | Todd Padgett | Instructor | Secondary Educator | Elko High School, Elko County School District |
| Intermediate Heating, Ventilation, Air Conditioning, and Refrigeration | Kevin Putman | Instructor | Postsecondary Educator | College of Southern Nevada, Las Vegas |
| Intermediate Heating, Ventilation, Air Conditioning, and Refrigeration | Heather Steel | CTE Director | Secondary Educator | Elko County School District |

Business and Industry Validation

All CTE standards developed through the Nevada Department of Education are validated by business and industry through one or more of the following processes: (1) the standards are developed by a team consisting of business and industry representatives, or (2) a separate review panel is coordinated with industry experts to ensure the standards include the proper content, or (3) nationally recognized standards currently endorsed by business and industry.

The Intermediate Heating, Ventilation, Air Conditioning, and Refrigeration complementary standards for Heating, Ventilation, Air Conditioning, and Refrigeration program of study were validated through active participation of business and industry representatives on the development team.

Complementary Course Information for Heating, Ventilation, Air Conditioning, and Refrigeration

Program Information

Qualifying Program of Study: Heating, Ventilation, Air Conditioning, and Refrigeration

Career Cluster: Architecture and Construction

Career Pathway(s): Maintenance/Operations

CTSO: SkillsUSA

Grade Level: 11-12

Program Structure for Complementary Course(s)

The complementary courses are provided in the following table. **The qualifying program of study must be completed prior to enrolling in the complementary course(s)** (except labs that are done concurrently with the second-year course). A program does not have to utilize the complementary courses for students to complete their program of study.

Complementary Course(s)

| Required/ Complementary | Course Title | Abbreviated Name |
|----------------------------|----------------------------------------------------------------------------|------------------|
| C | Intermediate Heating, Ventilation, Air Conditioning, and Refrigeration | INT HVACR |
| C | Heating, Ventilation, Air Conditioning, and Refrigeration Advanced Studies | HVACR AS |
| C | Industry-Recognized Credential – Architecture and Construction | IRC HVACR |
| C | CTE Work Experience – Architecture and Construction | WORK EXPER CONST |

Complementary Course Standards
Intermediate Heating, Ventilation, Air Conditioning and Refrigeration

CONTENT STANDARD 1.0: AIR DISTRIBUTION SYSTEMS

Performance Standard 1.1: Describe Factors Related to Air Movement and Its Measurement in Air Distribution Systems

- 1.1.1 Describe how pressure, velocity, and volume are interrelated in air flow
- 1.1.2 Describe air distribution in a typical residential system
- 1.1.3 Identify common air measurement instruments

Performance Standard 1.2: Describe the Mechanical Equipment and Materials Used to Create Air Distribution Systems

- 1.2.1 Describe various blower types and applications
- 1.2.2 Describe various fan designs and applications
- 1.2.3 Demonstrate an understanding of the fan laws
- 1.2.4 Describe common duct materials and fittings
- 1.2.5 Identify the characteristics of common grilles, registers, and dampers

Performance Standard 1.3: Identify the Different Approaches to Air Distribution System Design and Energy Conservation

- 1.3.1 Identify various air distribution system layouts
- 1.3.2 Describe heating and cooling air movement resulting from various air distribution system designs
- 1.3.3 Explain how to maximize energy efficiency through the proper sealing and testing of air distribution systems

CONTENT STANDARD 2.0: HEAT PUMPS

Performance Standard 2.1: Explain Heat Pump Operating Principles and Their Related Performance Ratings

- 2.1.1 Explain how heat pumps can extract heat from air and water
- 2.1.2 Describe the Coefficient of Performance (COP) and how it is determined
- 2.1.3 Describe the Heating Seasonal Performance Factor (HSPF) and how it is determined
- 2.1.4 Describe the Seasonal Energy Efficiency Ratio (SEER) and how it is determined

Performance Standard 2.2: Describe the Operation of Heat Pump Systems

- 2.2.1 Describe the refrigeration cycle of heat pumps
- 2.2.2 Identify the various types of heat pump systems
- 2.2.3 Describe the basic control strategies for heat pumps and defrost cycles
- 2.2.4 Identify unit components that are important to heat pump operation
- 2.2.5 Describe sources of supplemental and/or emergency heat used in heat pump systems

Performance Standard 2.3: Identify Common Installation Practices Associated with Heat Pumps

- 2.3.1 Explain how electric heating equipment operates
- 2.3.2 Identify the major components of an electric heater

Performance Standard 2.4: Describe the Operation of Electric Heating Equipment Commonly Used with Heat Pumps

- 2.4.1 Identify installation practices associated with split systems
- 2.4.2 Identify installation practices associated with packaged systems

CONTENT STANDARD 3.0: COMMON TYPES OF DUCT WORK

Performance Standard 3.1: Identify Various Methods of Joining Sheet Metal

- 3.1.1 Identify various types of steel sheet metals
- 3.1.2 Identify various types of alloy sheet metals

Performance Standard 3.2: Identify Various Types of Alloy Sheet Metals

- 3.2.1 Identify various types of duct seams
- 3.2.2 Identify various methods of duct component connection

Performance Standard 3.3: Describe the Methods Used to Suspend and Support Sheet Metal Duct

- 3.3.1 Describe methods used to suspend sheet metal duct
- 3.3.2 Describe methods used to support sheet metal duct

Performance Standard 3.4: Describe Methods Used to Insulate and Attenuate Sheet Metal Duct

- 3.4.1 Describe the selection and installation of duct lining products
- 3.4.2 Describe the selection and installation of external duct wraps

Performance Standard 3.5: Identify Various Sheet Metal Duct Accessories and Describe Their Installation

- 3.5.1 Identify and describe the installation of various types of dampers
- 3.5.2 Identify and describe the installation of duct takeoffs and access doors

Performance Standard 3.6: Identify Different Types of Flexible Duct and Explain How it is Installed

- 3.6.1 Identify different types of flexible duct
- 3.6.2 Explain how flexible duct is connected and supported

Performance Standard 3.7: Describe the Standards and Application Considerations Related to Fiberglass Duct

- 3.7.1 Identify the standards related to fiberglass duct
- 3.7.2 Identify application considerations related to fiberglass duct

Performance Standard 3.8: Describe the Methods Used to Fabricate and Repair Fiberglass Duct

- 3.8.1 Describe how to close and join fiberglass duct using various methods
- 3.8.2 Describe how to repair both minor and major fiberglass duct damage

Performance Standard 3.9: Describe the Methods Used to Suspend and Support Fiberglass Duct Systems

- 3.9.1 Describe methods used to suspend and support fiberglass duct
- 3.9.2 Describe methods used to suspend and support fiberglass duct fittings and risers

Performance Standard 3.10: Describe Fabric-Based Air Distribution Products and Their Installation Methods

- 3.10.1 Identify various types and designs of fabric-based air distribution products
- 3.10.2 Describe the various methods of installing and suspending fabric-based air distribution products

CONTENT STANDARD 4.0: COMMERCIAL AIRSIDE SYSTEMS

Performance Standard 4.1: Identify the Characteristics and Components of Various Airflow Sources

- 4.1.1 Describe the typical operating characteristics of a commercial airside system
- 4.1.2 Describe the purpose and function of ventilation and exhaust systems
- 4.1.3 Explain how to size a thermal expansion valve

Performance Standard 4.2: Describe the Various Approaches Used in Commercial Air Distribution

- 4.2.1 Describe single-zone constant volume system operation
- 4.2.2 Describe multi-zone constant volume system operation
- 4.2.3 Describe variable volume, variable temperature (VVT) system operation
- 4.2.4 Describe variable air volume (VAV) system operation

Performance Standard 4.3: Describe Common Air Terminal Operation and Related Air Delivery Devices

- 4.3.1 Explain the basic operation of VVT and single-duct VAV terminal devices
- 4.3.2 Explain the basic operation of fan powered VAV terminals
- 4.3.3 Identify various styles of commercial grilles and registers

Performance Standard 4.4: Identify the Characteristics and Components of Various Airflow Sources

- 4.4.1 Describe the various forms and components of packaged systems
- 4.4.2 Describe the various forms and components of air handling units
- 4.4.3 Describe the purpose and function of economizers
- 4.4.4 Describe common accessories used with commercial airside systems

CONTENT STANDARD 5.0: INDOOR AIR QUALITY

Performance Standard 5.1: Explain the Importance of Indoor Air Quality and the Factors to be Controlled

- 5.1.1 Identify the factors related to the quality of indoor air
- 5.1.2 Describe the elements of human comfort and their relationship to air properties

Performance Standard 5.2: Describe the Processes and Equipment Used to Control Humidity Levels

- 5.2.1 Explain the relationship between air and moisture content
- 5.2.2 Describe the processes and equipment used to humidify and dehumidify air

Performance Standard 5.3: Describe the Equipment and Devices Used to Control Air Cleanliness

- 5.3.1 Identify the various types of media-based air filters
- 5.3.2 Describe the operation of non-media-based air filtration and purification equipment

Performance Standard 5.4: Identify the Equipment Used to Provide and Control the Introduction of Fresh Air into Buildings

- 5.4.1 Explain how dampers and economizers are used to control the introduction of fresh air
- 5.4.2 Describe the function and operation of energy and heat recovery ventilation systems

CONTENT STANDARD 6.0: HYDRONIC SYSTEMS

Performance Standard 6.1: Describe Hydronic Systems and the Principles of Closed-System Water Flow

- 6.1.1 Describe the basic properties of water and the significance of its contents
- 6.1.2 Describe the relationship between water flow and system pressures

Performance Standard 6.2: Describe the Primary Types of Hot-Water Heating Systems and Their Components

- 6.2.1 Identify gravity and forced hydronic systems
- 6.2.2 Describe the different types of boilers used
- 6.2.3 Identify primary boiler components
- 6.2.4 Identify common components related to air and water control

Performance Standard 6.3: Identify Various Hot-Water Heating Piping Systems and the Terminal Devices Used

- 6.3.1 Describe the characteristics of one- and two-pipe systems
- 6.3.2 Describe the function of hot-water zoning systems
- 6.3.3 Identify various hot-water heating system terminal devices

Performance Standard 6.4: Describe the Methods and Devices Used to Select Pumps and Balance Water Flow in Hydronic Systems

- 6.4.1 Identify the devices used to measure and control water flow in hydronic systems
- 6.4.2 Describe how circulating pumps are selected based on required flow rates
- 6.4.3 Explain how to measure pump pressures and system flow rates in an operating system