

***HEATING, VENTILATION,  
AIR CONDITIONING, AND REFRIGERATION  
STANDARDS***



This document was prepared by:

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

[www.doe.nv.gov](http://www.doe.nv.gov)

**Draft for review** by the Nevada State Board of Education on  
**November 12, 2020**

The Nevada Department of Education does not discriminate on the basis of race, color, religion, national origin, sex, disability, sexual orientation, gender identity or expression, or age in its programs and activities and provides equal access to the Boy Scouts and other designated youth groups.

For inquiries, contact the Equity Coordinator at (775) 687-9200.

**NEVADA STATE BOARD OF EDUCATION**

Elaine Wynn .....	President
Mark Newburn .....	Vice President
Robert Blakely .....	Member
Katherine Dockweiler .....	Member
Tamara Hudson .....	Member
Cathy McAdoo .....	Member
Kevin Melcher .....	Member
Dawn Miller .....	Member
Felicia Ortiz .....	Member
Wayne Workman .....	Member
Alex Gallegos .....	Student Representative

**NEVADA DEPARTMENT OF EDUCATION**

Jhone M. Ebert  
Superintendent of Public Instruction

Craig Statucki, Director  
Office of Career Readiness, Adult Learning & Education Options

**VISION**

*All Nevadans ready for success in the 21st century*

**MISSION**

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



TABLE OF CONTENTS

Nevada State Board of Education / Nevada Department of Education ..... iii

Acknowledgements / Standards Development Members / Business and Industry Validation /  
Project Coordinator .....vii

Introduction .....ix

Content Standard 1.0 Lab Organization and Safety Procedures ..... 1

Content Standard 2.0 General Heating, Ventilation, Air Conditioning, and Refrigeration Skills ..... 2

Content Standard 3.0 Introduction to Heating, Ventilation, Air Conditioning, and Refrigeration ..... 4

Content Standard 4.0 Electricity ..... 5

Content Standard 5.0 Thermodynamics and Heat Transfer ..... 6

Content Standard 6.0 Heating and Combustion ..... 8

Content Standard 7.0 Refrigeration Systems ..... 9

Content Standard 8.0 Piping Principles ..... 10

Content Standard 9.0 Compressors ..... 12

Content Standard 10.0 Aspects of Refrigerants ..... 13

Content Standard 11.0 Metering Devices ..... 15

Crosswalks and Alignments ..... 17

### **ACKNOWLEDGEMENTS**

The development of Nevada career and technical standards and assessments is a collaborative effort sponsored by the Office of Career Readiness, Adult Learning & Education Options at the Department of Education and the Career and Technical Education Consortium of States. The Department of Education relies on teachers and industry representatives who have the technical expertise and teaching experience to develop standards and performance indicators that truly measure student skill attainment. Most important, however, is recognition of the time, expertise and great diligence provided by the writing team members in developing the career and technical standards for Heating, Ventilation, Air Conditioning, and Refrigeration.

### **STANDARDS DEVELOPMENT MEMBERS**

Wes Evans	Instructor	Applied Technology Center, Reno
Scott Oxborrow	Business & Industry	Snyder Mechanical, Las Vegas
Crystal Naegle	Department Chair	College of Southern Nevada, Las Vegas
Todd Padgett	Instructor	Elko High School, Elko
Kevin Putman	Instructor	College of Southern Nevada, Las Vegas
Heather Steel	CTE Director	Elko High School, Elko

### **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 was coordinated with industry experts to ensure the standards include the proper content; or (3) the adoption of nationally-recognized standards endorsed by business and industry.

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

The Heating, Ventilation, Air Conditioning, and Refrigeration (HVACR) standards were adapted from the nationally recognized standards approved by the National Center for Construction Education and Research (NCCER).

### **PROJECT COORDINATOR**

Denise Burton, Education Programs Professional  
Skilled and Technical Sciences  
Office of Career Readiness, Adult Learning & Education Options  
Nevada Department of Education

## 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 (HVACR) 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 crosswalk and alignment section of the document shows where the performance indicators support the Nevada Academic Content Standards. Where correlation with an academic content standard exists, students in the Heating, Ventilation, Air Conditioning, and Refrigeration (HVACR) program perform learning activities that support, either directly or indirectly, achievement of the academic content standards that are listed.

All students are encouraged to participate in the career and technical student organization (CTSO) that relates to the Heating, Ventilation, Air Conditioning, and Refrigeration (HVACR) 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 “soft 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 (HVACR). For Content Standard 2, Performance Standard 3 and Performance Indicator 4 the Standards Reference Code would be HVACR.2.3.4.

**CONTENT STANDARD 1.0: LAB ORGANIZATION AND SAFETY PROCEDURES**

**PERFORMANCE STANDARD 1.1: DEMONSTRATE GENERAL LAB SAFETY RULES AND PROCEDURES**

- 1.1.1 Describe general shop safety rules and procedures
- 1.1.2 Understand OSHA standards and relate them to HVACR safety rule standards
- 1.1.3 Comply with the required use of safety glasses, ear protection, gloves, and shoes during lab/shop activities (i.e., personal protection equipment - PPE)
- 1.1.4 Utilize safe procedures for handling of tools and equipment
- 1.1.5 Operate lab equipment according to safety guidelines
- 1.1.6 Identify and use proper lifting procedures and proper use of support equipment
- 1.1.7 Utilize proper ventilation procedures for working within the lab/shop area
- 1.1.8 Identify marked safety areas
- 1.1.9 Identify the location and the types of fire extinguishers and other fire safety equipment; demonstrate knowledge of procedures for using fire extinguishers and other fire safety equipment
- 1.1.10 Identify the location and use of eye wash stations
- 1.1.11 Identify the location of the posted evacuation routes
- 1.1.12 Identify and wear appropriate clothing for lab/shop activities
- 1.1.13 Demonstrate safe lab/shop practices (e.g., secure hair, secure/remove jewelry/ties)
- 1.1.14 Demonstrate knowledge of the safety aspects of low and high voltage circuits
- 1.1.15 Locate and interpret safety data sheets (SDS)
- 1.1.16 Prepare time or job cards, reports, or records
- 1.1.17 Perform housekeeping duties
- 1.1.18 Follow verbal instructions to complete work assignments
- 1.1.19 Follow written instructions to complete work assignments

**PERFORMANCE STANDARD 1.2: IDENTIFY AND UTILIZE HAND TOOLS**

- 1.2.1 Identify hand tools and their appropriate usage
- 1.2.2 Identify standard and metric designation
- 1.2.3 Demonstrate the proper techniques when using hand tools
- 1.2.4 Demonstrate safe handling and use of appropriate tools
- 1.2.5 Demonstrate proper cleaning, storage, and maintenance of tools

**PERFORMANCE STANDARD 1.3: IDENTIFY AND UTILIZE POWER TOOLS AND EQUIPMENT**

- 1.3.1 Identify power tools and their appropriate usage
- 1.3.2 Identify equipment and their appropriate usage
- 1.3.3 Demonstrate the proper techniques when using power tools and equipment
- 1.3.4 Demonstrate safe handling and use of appropriate power tools and equipment
- 1.3.5 Demonstrate proper cleaning, storage, and maintenance of power tools and equipment

**CONTENT STANDARD 2.0: GENERAL HVACR SKILLS****PERFORMANCE STANDARD 2.1: DEMONSTRATE PRINT READING PRACTICES**

- 2.1.1 Identify and explain basic construction drawing terms, components, and symbols
- 2.1.2 Identify various types of construction drawings
- 2.1.3 Identify and describe the purpose of the five basic construction drawing components
- 2.1.4 Identify and explain the use of dimensions and various drawing scales
- 2.1.5 Interpret schematic diagrams (e.g., plumbing, electrical, mechanical)
- 2.1.6 Identify and describe how to use architect's scales

**PERFORMANCE STANDARD 2.2: APPLY MATH SKILLS TO HVACR APPLICATIONS**

- 2.2.1 Add, subtract, multiply, and divide whole numbers, with and without a calculator
- 2.2.2 Use a standard ruler, a metric ruler, and a measuring tape to measure
- 2.2.3 Add, subtract, multiply, and divide fractions
- 2.2.4 Add, subtract, multiply, and divide decimals, with and without a calculator
- 2.2.5 Convert decimals to percentages and percentages to decimals
- 2.2.6 Convert fractions to decimals and decimals to fractions
- 2.2.7 Explain the various measurement systems in the construction trades
- 2.2.8 Calculate standard and metric units of length, weight, volume, and temperature
- 2.2.9 Utilize geometric principles used in the construction industry (e.g., distances, area, volume)
- 2.2.10 Identify and describe characteristics of a circle, types of angles, and polygons
- 2.2.11 Calculate various values associated with triangles
- 2.2.12 Identify units of measure in the inch-pound and metric systems
- 2.2.13 Convert length, area, and volume values
- 2.2.14 Convert pressure and temperature values
- 2.2.15 Define algebraic terms in the context of HVACR
- 2.2.16 Solve basic algebra equations using the sequence of operations related to HVACR calculations

**PERFORMANCE STANDARD 2.3: UTILIZE MATERIALS HANDLING TECHNIQUES**

- 2.3.1 Describe the basic concepts of material handling and common safety precautions
- 2.3.2 Define a load
- 2.3.3 Establish a pre-task plan prior to moving a load
- 2.3.4 Select appropriate materials-handling equipment for the task
- 2.3.5 Utilize proper materials-handling techniques and equipment
- 2.3.6 Recognize hazards and follow safety procedures required for materials handling

**PERFORMANCE STANDARD 2.4: EXPLORE HVACR CAREER OPPORTUNITIES**

- 2.4.1 Research high-skill, high-wage, high-demand career opportunities for craft professionals in this industry
- 2.4.2 Research postsecondary training opportunities and requirements
- 2.4.3 Identify the responsibilities and characteristics needed to be a successful HVACR technician
- 2.4.4 Identify residential, commercial, and industrial career opportunities
- 2.4.5 Describe opportunities provided by equipment manufacturers



**CONTENT STANDARD 3.0: INTRODUCTION TO HEATING, VENTILATION, AIR CONDITIONING, AND REFRIGERATION**

**PERFORMANCE STANDARD 3.1: EXPLAIN BASIC PRINCIPLES OF HEATING, VENTILATION, AIR CONDITIONING, AND REFRIGERATION**

- 3.1.1 Explain the principles of heating
- 3.1.2 Explain the principles of ventilation
- 3.1.3 Explain the principles of air conditioning
- 3.1.4 Explain the principles of refrigeration

**PERFORMANCE STANDARD 3.2: DESCRIBE THE PRINCIPLES THAT GUIDE HVACR INSTALLATION AND SERVICE TECHNIQUES**

- 3.2.1 Identify common safety principles and organizations
- 3.2.2 Describe the importance of LEED (Leadership in Energy and Environmental Design) construction and energy management
- 3.2.3 Describe trade licensing and certification requirements
- 3.2.4 Identify important codes and permits

**CONTENT STANDARD 4.0: INTRODUCTION TO ELECTRICITY**

**PERFORMANCE STANDARD 4.1: DESCRIBE THE FUNDAMENTALS OF ELECTRICITY**

- 4.1.1 Explain how electrical power is created and distributed
- 4.1.2 Describe the difference between alternating current and direct current
- 4.1.3 Identify general electrical safety practices
- 4.1.4 Describe the OSHA requirements and procedures related to electrical lockout/tagout

**PERFORMANCE STANDARD 4.2: EXPLAIN BASIC ELECTRICAL THEORY**

- 4.2.1 Define voltage, current, resistance, and power and describe how they are related
- 4.2.2 Use Ohm's law to calculate the current, voltage, and resistance in a circuit
- 4.2.3 Use the power formula to calculate how much power is consumed by a circuit
- 4.2.4 Describe the differences between series and parallel circuits and calculate circuit loads for each type

**PERFORMANCE STANDARD 4.3: DESCRIBE HOW ELECTRICAL MEASURING INSTRUMENTS ARE USED IN HVACR WORK**

- 4.3.1 Describe how voltage, current, and resistance are measured

**PERFORMANCE STANDARD 4.4: IDENTIFY ELECTRICAL COMPONENTS USED IN HVACR SYSTEMS AND DESCRIBE THEIR FUNCTIONS**

- 4.4.1 Identify and describe various load and control devices and explain how they are represented on circuit diagrams
- 4.4.2 Identify and describe various control devices and explain how they are represented on circuit diagrams

**CONTENT STANDARD 5.0: THERMODYNAMICS AND HEAT TRANSFER**

**PERFORMANCE STANDARD 5.1: EXPLORE THE SCIENCE OF REFRIGERATION AND HEATING**

- 5.1.1 Define matter and heat
- 5.1.2 Explain the direction and rate of heat flow
- 5.1.3 Describe the three methods of heat transfer
- 5.1.4 Identify the reference points of temperature
- 5.1.5 Explain the difference between heat and temperature
- 5.1.6 Explain the difference between latent and sensible heat
- 5.1.7 Explain the change of state of matter
- 5.1.8 Explain heat/cool storage
- 5.1.9 Define specific heat
- 5.1.10 Define sensible heat
- 5.1.11 Define latent heat of fusion
- 5.1.12 Define latent heat of vaporization
- 5.1.13 Define enthalpy
- 5.1.14 Define saturation temperature (dew point temperature)
- 5.1.15 Define water vapor pressure
- 5.1.16 Explain the direction and rate of moisture transfer
- 5.1.17 Calculate the BTUs required to change ice to steam

**PERFORMANCE STANDARD 5.2: EXPLORE THE SCIENCE OF FLUIDS AND PRESSURES AS THEY RELATE TO AIR  
CONDITIONING AND REFRIGERATION**

- 5.2.1 Explain the relationship of pressures and fluids at saturation temperatures
- 5.2.2 Use the P/T Chart to determine the difference between temperature and pressure
- 5.2.3 Define pressure
- 5.2.4 Explain atmospheric pressure
- 5.2.5 Explain the purpose of compound gauges
- 5.2.6 Explain the purpose of bourdon tubes
- 5.2.7 Explain barometric pressure
- 5.2.8 Explain absolute pressure
- 5.2.9 Explain gauge pressure
- 5.2.10 Explain inches of mercury absolute
- 5.2.11 Explain micron

**PERFORMANCE STANDARD 5.3: UNDERSTAND THE RELATIONSHIP OF THE COMPONENTS OF THE REFRIGERATION CYCLE**

- 5.3.1 Properly use basic air conditioning and refrigeration related tools
- 5.3.2 Properly use power tools used in air conditioning and refrigeration
- 5.3.3 Identify the four major components and their types within the vapor compression refrigeration system
- 5.3.4 Describe the state and conditions of the refrigerant during a cycle
- 5.3.5 Explain the importance of superheat and subcooling
- 5.3.6 Explain the functions and types of the four major components of a refrigeration system
- 5.3.7 List the components that separate the high side from the low side of the system
- 5.3.8 Use the temperature/enthalpy (T-H) chart to determine the state of the refrigerant within the mechanical system

**CONTENT STANDARD 6.0: HEATING AND COMBUSTION**

**PERFORMANCE STANDARD 6.1: EXPLAIN FUNDAMENTAL CONCEPTS OF HEATING AND COMBUSTION**

- 6.1.1 Describe the heat transfer process
- 6.1.2 Identify gas fuels and their combustion characteristics

**PERFORMANCE STANDARD 6.2: DESCRIBE VARIOUS HEATING SYSTEMS**

- 6.2.1 Describe the types of gas furnaces and how they operate
- 6.2.2 Identify and describe the equipment and controls used in gas furnaces
- 6.2.3 Describe the basic installation and maintenance requirements for gas furnaces
- 6.2.4 Describe the operation of hydronic heating systems
- 6.2.5 Describe the operation of electrical heating equipment

**CONTENT STANDARD 7.0: REFRIGERATION SYSTEMS**

**PERFORMANCE STANDARD 7.1: EXPLAIN FUNDAMENTAL CONCEPTS OF THE REFRIGERATION CYCLE**

- 7.1.1 Describe how heat affects the state of substances
- 7.1.2 Explain how heat is transferred from one substance to another
- 7.1.3 Describe pressure-temperature relationships
- 7.1.4 Describe basic refrigerant flow and the changes of state occurring in the refrigeration cycle
- 7.1.5 Identify common instruments used to measure pressure and temperature

**PERFORMANCE STANDARD 7.2: UNDERSTAND THE RELATIONSHIP OF THE COMPONENTS OF THE REFRIGERATION CYCLE**

- 7.2.1 Identify fluorocarbon refrigerants
- 7.2.2 Describe the use of ammonia as a refrigerant
- 7.2.3 Identify various refrigerant containers and their safe handling requirements

**PERFORMANCE STANDARD 7.3: IDENTIFY MAJOR COMPONENTS OF COOLING SYSTEMS AND HOW THEY FUNCTION**

- 7.3.1 Identify various types of compressors
- 7.3.2 Identify different types of condensers
- 7.3.3 Identify different types of evaporators
- 7.3.4 Describe the devices used to meter refrigerant flow
- 7.3.5 Discuss basic refrigerant piping concepts
- 7.3.6 Identify various accessories used in refrigerant circuits

**PERFORMANCE STANDARD 7.4: IDENTIFY THE COMMON CONTROLS USED IN COOLING SYSTEMS**

- 7.4.1 Identify common primary and secondary controls

**CONTENT STANDARD 8.0: PIPING PRINCIPLES**

**PERFORMANCE STANDARD 8.1: RECOGNIZE AND IDENTIFY DIFFERENT TYPES OF COPPER TUBING AND THEIR RELATED FITTINGS**

- 8.1.1 Identify and describe copper tubing characteristics
- 8.1.2 Identify various copper fittings

**PERFORMANCE STANDARD 8.2: DESCRIBE AND DEMONSTRATE HOW TO JOIN COPPER TUBING MECHANICALLY**

- 8.2.1 Measure, cut, and bend copper tubing to prepare it for joining
- 8.2.2 Describe and demonstrate the methods and tools used to join copper tubing
- 8.2.3 Describe common hangers and supports associated with copper tubing installations

**PERFORMANCE STANDARD 8.3: RECOGNIZE DIFFERENT TYPES OF PLASTIC PIPING AND SHOW HOW IT CAN BE JOINED**

- 8.3.1 Identify different types of plastic piping
- 8.3.2 Identify the tools and products needed and demonstrate how to join plastic piping

**PERFORMANCE STANDARD 8.4: DESCRIBE AND DEMONSTRATE THE SAFE PROCESS OF SOLDERING COPPER TUBING**

- 8.4.1 Describe and demonstrate the use of the PPE, tools, and materials needed to solder copper tubing
- 8.4.2 Describe and demonstrate the preparation required for soldering
- 8.4.3 Describe and demonstrate the soldering process

**PERFORMANCE STANDARD 8.5: DESCRIBE AND DEMONSTRATE THE SAFE PROCESS OF BRAZING COPPER TUBING**

- 8.5.1 Describe and demonstrate the use of the PPE, tools, and materials needed to braze copper tubing
- 8.5.2 Describe and demonstrate the preparation used for brazing
- 8.5.3 Describe and demonstrate the brazing process
- 8.5.4 Describe and demonstrate the process of brazing copper tubing to dissimilar metals

**PERFORMANCE STANDARD 8.6: DESCRIBE AND IDENTIFY THE VARIOUS TYPES OF STEEL PIPE AND FITTING**

- 8.6.1 Identify the characteristics and uses of steel pipe
- 8.6.2 Describe how pipe threads are classified and measured
- 8.6.3 Identify the various types of fittings used on steel pipe and describe how they are used
- 8.6.4 Describe how to properly measure lengths of steel pipe

**PERFORMANCE STANDARD 8.7: DESCRIBE THE TOOLS AND METHODS USED TO CUT AND THREAD STEEL PIPE**

- 8.7.1 Identify pipe cutting and reaming tools and describe how they are used
- 8.7.2 Identify threading tools and describe how they are used

**PERFORMANCE STANDARD 8.8: EXPLAIN AND DEMONSTRATE THE METHODS OF INSTALLING AND MECHANICALLY JOINING STEEL PIPE**

- 8.8.1 Explain and demonstrate the methods and use of the tools to connect threaded pipe
- 8.8.2 Explain and demonstrate an understanding of pipe grooving methods
- 8.8.3 Describe how to assemble flanged steel pipe
- 8.8.4 Describe how to correctly install steel pipe



**CONTENT STANDARD 9.0: COMPRESSORS**

**PERFORMANCE STANDARD 9.1: IDENTIFY AND DESCRIBE VARIOUS APPROACHES TO COMPRESSOR CAPACITY CONTROL**

- 9.1.1 Identify and describe capacity control methods for reciprocating and scroll compressors
- 9.1.2 Identify and describe capacity control methods for screw and centrifugal compressors

**PERFORMANCE STANDARD 9.2: DESCRIBE THE COMMON CAUSES OF COMPRESSOR FAILURES**

- 9.2.1 Describe compressor failures related to the refrigerant circuit
- 9.2.2 Describe compressor failures related to electrical issues

**PERFORMANCE STANDARD 9.3: IDENTIFY AND EXPLAIN THE OPERATION OF VARIOUS COMPRESSOR PROTECTION DEVICES**

- 9.3.1 Identify and explain the operation of various overload devices
- 9.3.2 Identify and explain the operation of other compressor protection devices

**PERFORMANCE STANDARD 9.4: EXPLAIN HOW TO ANALYZE THE OPERATION OF A HERMETIC COMPRESSOR**

- 9.4.1 Explain how to evaluate the mechanical operation of an operable compressor
- 9.4.2 Explain how to evaluate the electrical operation of an operable compressor

**CONTENT STANDARD 10.0: ASPECTS OF REFRIGERANTS**

**PERFORMANCE STANDARD 10.1: DESCRIBE THE DESIRABLE CHARACTERISTICS OF REFRIGERANTS AND THE VARIOUS APPLICATIONS THAT REQUIRE THESE CHARACTERISTICS**

- 10.1.1 Describe the desirable characteristics of refrigerants
- 10.1.2 Identify various applications that require specific refrigerant characteristics

**PERFORMANCE STANDARD 10.2: IDENTIFY VARIOUS REFRIGERANT CLASSIFICATIONS AND DESCRIBE THEIR ENVIRONMENTAL IMPACT**

- 10.2.1 Identify the primary chemical classifications of common characteristics
- 10.2.2 Describe the environmental concerns associated with refrigerants
- 10.2.3 Identify and describe compounded and blended azeotropic, near-azeotropic, and zeotropic refrigerants
- 10.2.4 Identify various refrigerant classifications and cylinder colors

**PERFORMANCE STANDARD 10.3: EXPLAIN HOW TO USE PRESSURE-TEMPERATURE (PT) CHARTS TO CALCULATE SUPERHEAT AND SUBCOOLING**

- 10.3.1 Explain how to use PT charts for compound, azeotropic, and near-azeotropic refrigerants
- 10.3.2 Explain how to use PT charts for zeotropic refrigerants

**PERFORMANCE STANDARD 10.4: IDENTIFY AND DESCRIBE LUBRICATING OILS AND ISSUES RELATED TO THEIR FUNCTION**

- 10.4.1 Identify the important characteristics of refrigerant oils
- 10.4.2 Compare mineral-based and synthetic oils
- 10.4.3 Describe the movement of oil through the refrigerant circuit
- 10.4.4 Describe oil contamination and its sources
- 10.4.5 Describe common practices associated with handling, charging, and removing oils

**PERFORMANCE STANDARD 10.5: DESCRIBE CONSIDERATIONS RELATED TO REFRIGERANT CONVERSIONS**

- 10.5.1 Identify issues of concern in all refrigerant conversions
- 10.5.2 Describe common practices related to refrigerant conversions

**PERFORMANCE STANDARD 10.6: DESCRIBE THE EQUIPMENT AND APPROACHES USED TO LEAK TEST REFRIGERANT CIRCUITS**

- 10.6.1 Describe the various methods used to detect refrigerant leaks
- 10.6.2 Describe how leak detection is approached based on the current refrigerant charge in the system

**PERFORMANCE STANDARD 10.7: DESCRIBE REFRIGERANT CONTAINMENT AND MANAGEMENT REQUIREMENTS AND THE EQUIPMENT USED TO RECOVER REFRIGERANTS**

- 10.7.1 Identify the basic refrigerant containment requirements of Section 608 of the Clean Air Act
- 10.7.2 Identify and explain how to operate refrigerant recovery and recycling equipment

**PERFORMANCE STANDARD 10.8: EXPLAIN THE RELATED PRINCIPLES AND IDENTIFY THE EQUIPMENT USED TO EVACUATE REFRIGERANT CIRCUITS**

- 10.8.1 Explain the basic principles of refrigerant circuit evacuation
- 10.8.2 Identify and explain how to operate vacuum pumps to evacuate a system

**PERFORMANCE STANDARD 10.9: DESCRIBE THE PROCEDURES FOR CHARGING REFRIGERANT CIRCUITS**

- 10.9.1 Identify and describe the equipment and components related to refrigerant charging
- 10.9.2 Explain how to properly charge various types of refrigerants using the appropriate method

**CONTENT STANDARD 11.0: METERING DEVICES**

**PERFORMANCE STANDARD 11.1: EXPLAIN THE FUNCTION OF REFRIGERANT METERING DEVICES AND THEIR EFFECT ON REFRIGERANTS**

- 11.1.1 Explain the function of metering devices
- 11.1.2 Describe how refrigerants react as they pass through a metering device
- 11.1.3 Identify distributors and explain their relationship to metering device performance and operation

**PERFORMANCE STANDARD 11.2: IDENTIFY FIXED METERING DEVICES AND EXPLAIN HOW THEY FUNCTION**

- 11.2.1 Identify and explain how fixed orifice metering devices function
- 11.2.2 Identify and explain how capillary tubes function
- 11.2.3 Describe common problems associated with fixed metering devices

**PERFORMANCE STANDARD 11.3: IDENTIFY TYPES OF EXPANSION VALVES AND EXPLAIN HOW THEY OPERATE**

- 11.3.1 Identify and explain the operation of manual expansion valves
- 11.3.2 Identify and explain the operation of automatic expansion valves
- 11.3.3 Identify and explain the operation of thermal expansion valves
- 11.3.4 Identify and explain the operation of electric and electronically controlled expansion valves
- 11.3.5 Describe common problems associated with all types of expansion valves