Department of Education | College, Career and Technical Education

Published May 2022

HVAC

Primary Career Cluster:	Architecture & Construction
Course Contact:	CTE.Standards@tn.gov
Course Code(s):	C17H17
Prerequisite(s):	*Mechanical, Electrical, & Plumbing Systems* (C17H23)
Credit:	1
Grade Level:	11-12
Elective Focus -Graduation Requirements:	This course satisfies one of three credits required for an elective focus when taken in conjunction with other Architecture & Construction courses.
POS Concentrator:	This course satisfies one out of two required courses that meet the Perkins V concentrator definition, when taken in sequence in the approved program of study.
Programs of Study and Sequence:	This is one of the third-level course options in the *Mechanical, Electrical, & Plumbing (MEP) Systems* program of study.
Aligned Student Organization(s):	SkillsUSA: https://www.skillsusatn.org/
Coordinating Work-Based Learning:	Teachers are encouraged to use embedded WBL activities such as informational interviewing, job shadowing, and career mentoring. For information, visit https://www.tn.gov/content/tn/education/career-and-technical-education/work-based-learning.html.
Promoted Tennessee Student Industry Credentials:	Credentials are aligned with postsecondary and employment opportunities and with the competencies and skills that students acquire through their selected program of study. For a listing of promoted student industry credentials, visit https://www.tn.gov/education/career-and-technical-education/student-industry-certification.html
Teacher Endorsement(s):	501, 502, 523, 532, 567, 592, 598, 701, 707
Required Teacher Certifications/Training:	None
Teacher Resources:	https://www.tn.gov/education/career-and-technical-education/career-clusters/cte-cluster-architecture-construction.html Best for All Central: https://bestforall.tnedu.gov/

Course-At-A-Glance

CTE courses provide students with an opportunity to develop specific academic, technical, and 21st century skills necessary to be successful in career and in life. In pursuit of ensuring every student in Tennessee achieves this level of success, we begin with rigorous course standards which feed into intentionally designed programs of study.

Students engage in industry relevant content through general education integration and experiences such as career & technical student organizations (CTSO) and work-based learning (WBL). Through these experiences, students are immersed with industry standard content and technology, solve industry-based problems, meaningfully interact with industry professionals and use/produce industry specific, informational texts.

Using a Career and Technical Student Organization (CTSO) in Your Classroom

CTSOs are a great resource to put classroom learning into real-life experiences for your students through classroom, regional, state, and national competitions, and leadership opportunities. Below are CTSO connections for this course, note this is not an exhaustive list.

- Participate in CTSO Fall Leadership Conference to engage with peers by demonstrating logical thought processes and developing industry specific skills that involve teamwork and project management.
- Participate in contests that highlight job skill demonstration. These include Career Pathways Showcase, Job Interview, Carpentry, Electrical Wiring, Plumbing, and Masonry.

Using a Work-based Learning (WB) in Your Classroom

Sustained and coordinated activities that relate to the course content are the key to successful work-based learning. Possible activities for this course include the following. This is not an exhaustive list.

- **Standards 1.1-1.3** | Include a safety briefing in a visit to an industry partner/job site.
- **Standard 3.1-3.2 |** Visit a local company and discuss construction industry principles with those employees.
- **Standard 4.1-11.3** | Do a project that is used by a local industry or evaluated by local industry managers.
- **Standard 12.1-12.2** | Ask an industry rep to discuss troubleshooting on the job.
- **Standard 13.1-13.2** | Ask an industry rep to discuss the impact of construction drawings and specifications on the job.
- **Standard 14.1-14.5** | Ask an industry rep to discuss the importance of project management.

Course Description

HVAC prepares students for careers in residential and commercial heating, ventilation, air conditioning, and refrigeration. Upon completion of this course, proficient students will be able to demonstrate knowledge and skill in performing basic operations with HVAC systems, with emphasis on safety, tools, and equipment specific to HVAC. In addition, students will be able to explain the functions and components of heating, cooling, and air distribution systems. They will demonstrate basic techniques to prepare piping and tubing for HVAC systems including performing soldering and brazing. Students will understand proper refrigerant management in preparation for EPA Section 608 Technician Certification. They will read and interpret drawings, specifications, and diagrams to determine materials needed to complete an HVAC project. Standards in this course also introduce basic troubleshooting and maintenance procedures and alternate power systems, and expand on principles of the construction industry, delving deeper into business and project management. Students will continue compiling artifacts for inclusion in their portfolios, which they will carry with them throughout the full sequence of courses in this program of study.

Course Standards

1. Safety

1.1 Safety Rules: Identify **safety hazards on a jobsite** and demonstrate practices for safe working. **Accurately read, interpret, and demonstrate adherence to safety rules**, including but not limited to rules pertaining to electrical safety, Occupational Safety and Health Administration (OSHA) guidelines, and state and national code requirements. Be able to distinguish between the rules and **explain why certain rules apply**. Recognize and employ **universal construction signs and symbols** such as colors, flags, stakes, and hand signals that apply to construction workplace situations. Explain the need for **jobsite security** to prevent liability.

1.2 Safety Practices: Continue to maintain **safety records** and **demonstrate adherence to industry-standard practices** regarding general machine safety, tool safety, equipment safety, electrical safety, and fire safety to protect all personnel and equipment. For example, when operating tools and equipment, regularly inspect and carefully employ the appropriate personal protective equipment (PPE), as recommended by Occupational, Safety & Health Administration (OSHA) regulations. Incorporate **safety procedures when operating tools and equipment**, such as hand and power tools, ladders, scaffolding, and lifting equipment. Complete safety test with 100 percent accuracy.

1.3 Materials Safety: Follow **procedures to work safely around materials.** Adhere to **responsibilities for employees in material safety** as outlined by the **Hazard Communication Standard (HazCom)**, such as locating and interpreting material safety data sheets (MSDS). For example, obtain an MSDS for a given material from a supplier in the community. Demonstrate **safe procedures to move materials** by planning the movement, properly lifting, stacking, and storing materials, and selecting proper materials-handling equipment. Describe **hazards involved with HVAC work,** including working around refrigerants, oils, and gases.

2. Tools & Equipment

2.1 Tool and Equipment: Identify and select the **proper tools and accessories,** critique the **readiness of the tools,** use the **tools to accomplish the desired tasks**, and then return the tools and accessories to their proper storage. Research a **new technology** recently developed for the HVAC industry.

3. Construction Industry Principles

3.1 HVAC Work: Locate and assess **requirements for performing HVAC work** including local, state, and national requirements. Interpret **HVAC codes**, and **determine inspection procedure**s and other **applicable portions of the law.** Visit the **Tennessee Contractor's Licensing Board's website** and analyze its **policies and requirements**. Explain **how such policies impact local construction businesses.**

3.2 Project Delivery Methods: Consult a variety of sources to **describe alternatives to traditional project delivery methods**, such as the design-build and construction management-related methods, distinguishing among the **roles and relationships of various construction personnel** in each scenario. Examine the **project delivery method** of an actual company. Develop a company profile with supporting graphics the company could share with a client, describing the services provided and explaining the project delivery method used by the company.

4. HVAC and Electricity

4.1 Electricity in HVAC: Building on knowledge of electricity from *Mechanical, Electrical, and Plumbing Systems*, **describe the functions of electrical components used in HVAC systems**. Examine an **electrical diagram of an HVAC system** and interpret **symbols to describe the system,** distinguishing between load devices and control devices. For example, annotate a basic HVAC electrical diagram to explain the purpose and function of each component in the overall system to an entry-level HVAC technician.

5. Heating Systems

5.1 Heat Loss: Building on knowledge of heat transfer from *Mechanical, Electrical, & Plumbing Systems*, describe the **processes by which heat loss calculations** are made for a residence. Describe a variety of ways in which heat is lost and why it is important for HVAC professionals to know how to perform heat loss calculations. For a given residence, follow procedures to **perform a basic heat loss calculation** for a residence with a given u-value and location.

5.2 Gas Furnaces: Analyze various **types of gas furnaces** and explain **how they operate**. Describe the **equipment and controls** involved, the concept of combustion, the various gas fuels, and their combustion characteristics. **Explain the proper procedures for installing**

and maintaining gas furnaces. Perform **basic maintenance tasks** on a gas furnace, including replacing air filters and measuring temperature.

5.3 Compare and Contrast Heating Systems: Compare and contrast **gas furnaces, hydronic heating systems, and electric heating systems** by analyzing the operating procedures and pros and cons of each system.

6. Cooling Systems

6.1 Cooling Systems: Describe the **relationship between temperature and pressure** and relate it to **use of refrigerant in cooling systems.** Distinguish between **absolute pressure and gauge pressure.** Summarize the **processes involved in the basic mechanical refrigeration cycle**, including the **changes of state that occur** and the **basic patterns of the refrigerant flow**. Analyze the **major components of cooling systems and how they function,** including compressors, condensers, evaporators, and controls. Draw evidence from textbooks, professional journals, and instructional websites to produce an explanation of the refrigerant cycle and the functioning processes of cooling systems.

6.2 Measuring Temperature: Utilize common measurement instruments including thermometers and gauge manifolds to **measure temperature and pressure in an operating cooling system.** Demonstrate the ability to calibrate a set of refrigerant gauges and thermometers, connect a refrigerant gauge manifold, and properly calculate subcooling and superheat on an operating system using the gauge manifold and a temperature probe.

7. Refrigerant Management

7.1 Refrigerants and the Environment: Building on knowledge from *Mechanical, Electrical, & Plumbing Systems*, describe the **impact of refrigerants on the environment and the laws and regulations that are in place to protect the environment**, such as the Montreal Protocol, the Clean Air Act, and EPA technician certification requirements. Distinguish among the **various types of refrigerant**, identifying the **properties and cylinder color codes of each type**. Read and interpret **safety precautions and regulations** impacting the recovery, containment, handling, and disposal of refrigerants, including EPA regulations, manufacturer's technical bulletins and MSDSs, and transportation requirements established by the U.S. Department of Transportation (DOT), analyzing how requirements are structured in the text. For example, evaluate the condition of a refrigerant container and determine if it meets DOT requirements, including proper labeling. Interpret unresolved or inadequately documented information.

7.2 Refrigerant Leak Testing: Describe the **strategies and equipment used to leak test refrigerant circuits**. Apply the appropriate tools, equipment, and **procedures to safely pressurize a refrigerant system** in preparation for leak testing and leak test the pressurized system.

7.3 Refrigerant Recycling and Recovery: Explain the **various procedures used to recover, recycle, and reclaim refrigerant from equipment.** Read and interpret technical documents to determine the **required recovery level of a given HVAC system**. Apply the appropriate tools, equipment, and procedures to **safely perform refrigerant-recovery techniques** while adhering to **applicable regulations**, including applying proper labeling and maintaining accurate records. Interpret and implement regulations surrounding the recycling, reclaiming, and disposing of refrigerant.

7.4 System Evacuation: Evaluate the **purpose and procedures of system evacuation of an air conditioning system**. Describe steps for selecting the appropriate tools to perform an evacuation for a given system. Compare and contrast common methods of evacuation such as deep vacuum and triple evacuation. **Apply the appropriate tools, equipment, and procedures to safely perform a system evacuation.**

7.5 Charge a Refrigerant Circuit: Explain and demonstrate **how to properly charge various types of refrigerant circuits** using different methods including by weight, by superheat, and by subcooling, safely employing the appropriate, tools, equipment, and procedures.

8. Air Distribution Systems

8.1 Air Distribution Systems: Describe the **physical principles involved in air distribution systems**, including pressure, velocity, and volume. Recognize the various types and properties of mechanical equipment that make up an air distribution system, including various blowers, fans, duct materials, grilles, registers, and dampers. **Analyze the design of a simple air distribution system (i.e., as found in a typical residence) and explain how the system functions**, noting where physical principles can be observed. Create a visual display with supporting text to explain the functions of the system.

8.2 Ventilation: **Explain the purpose and importance of ventilation in modern HVAC systems.** Recommend how an HVAC technician could share with a client to illustrate the impact of proper ventilation on indoor air quality including services provided by the technician and steps the client can take to ensure high indoor air quality.

8.3 Energy Efficiency: Illustrate **how the design and proper installation of an air distribution system impacts the energy efficiency** of the system**.** Drawing on observations, supporting technical manuals, and resources such as those from the U.S. Green Building Council and EPA Energy Star, outline strategies to increase energy efficiency for the HVAC system in a given building, such as properly sealing the ducts, dampers, and vent locations.

8.4 Test Equipment: Utilize test equipment including tachometers, manometers, and velometers to **analyze the performance of an air distribution system.** For example, collect measurements with a velometer, apply the information to calculate the airflow volume in a duct, and report the findings using appropriate units. Read and interpret equivalent length charts and required air volume and duct size charts.

9. Basic Copper & Plastic Piping

9.1 Plastic Piping: Distinguish among **different types of plastic pipe, fittings, and valves** for use in HVAC, and **select the correct support and spacing for HVAC plastic piping**. Compare and contrast the tools, hazards, and procedures for cutting and joining various types of plastic pipe. Employ tools and procedures to **safely measure, cut, and join plastic piping and fittings** for HVAC**.**

9.2 Copper Tubing: Describe the **properties of various types of copper tubing** used for HVAC. Describe common fittings, hangers, and supports used in copper tubing. Demonstrate **how to measure, cut, and bend copper tubing** for HVAC systems while preparing the tubing to be joined. Demonstrate **techniques for mechanically joining copper tubing**, including flared connections and compression connections. Prepare tubing for soldering and brazing by **swaging, deburring, and cleaning a tube**. Inspect completed joints by **safely performing leak testing procedures**.

10. Soldering & Brazing

10.1 Compare and Contrast Soldering and Brazing: Explain the **purpose and process of soldering and brazing for an HVAC professional,** outlining **how the techniques work**. Compare and contrast **soldering and brazing, noting the uses, procedures, and equipment for each.** Distinguish among the **purposes, types, and uses of a variety of filler alloys and fluxes** used in soldering and brazing.

10.2 Tools and Equipment for Soldering and Brazing: Describe the **tools, equipment, and PPE used for soldering and brazing.** Explain the **safe operation of soldering and brazing equipment** including assembling, testing, lighting, and shutting down acetylene and oxyacetylene equipment. Safely set up and shut down an acetylene single tank and oxyacetylene equipment. Describe and demonstrate **procedures to safely prepare, solder, and braze copper tubing using various fittings.**

10.3 Conduct Soldering and Brazing: Implement safe **procedures to complete copper, brass, and steel tubing assemblies for a given layout.** Steps include measuring, cutting, and fitting assemblies; choosing the proper filler alloys and fluxes for the assigned job; demonstrating proper use of acetylene and oxyacetylene equipment; and pressure testing assemblies to determine the proper completion of assemblies.

11. Carbon Steel Piping

11.1 Steel Piping: Describe the **characteristics and uses of steel pipe**, making note of the similarities and differences in steel piping, plastic piping, and copper tubing. Draw on evidence from textbooks and physical observations to support claims.

11.2 Steel Pipe Threads: Analyze the **classification and measurement of pipe threads**. Describe the **uses of different types of fittings used on steel pipe**. Employ **tools and procedures to safely measure, cut, thread, and ream steel pipe.**

11.3 Join Steel Piping: Explain and demonstrate the **methods of installing, connecting, and mechanically joining steel pipe**, including joining threaded pipe using fittings, pipe grooving methods, and assembling flanged steel pipe.

12. Basic Maintenance & Repair Process

12.1 HVAC Troubleshooting: Identify and demonstrate **basic troubleshooting strategies appropriate for evaluating HVAC systems, appliances, and devices**. For example, develop and implement a troubleshooting strategy to test and remedy an undercharged system.

12.2 HVAC Maintenance: Identify **routine maintenance procedures that should be performed on HVAC systems for a given building.** Describe a timeline of recommended maintenance procedures for a client, justifying why each procedure is necessary by highlighting its preventive or cost-efficient characteristics. For example, create a schedule of items to inspect, clean, and replace in order to keep an HVAC system running efficiently.

13. Construction Drawings & Specifications

13.1 Drawings and Specifications: Explain the **relationship between construction drawings and specifications**. Describe **how both the construction drawings and specifications provide information about the HVAC system for a building.** For example, examine construction drawings and specifications to determine the requirements for hangers and supports in a given HVAC piping system.

13.2 Request for Information: Describe **processes by which construction professionals obtain clarification from architects** regarding construction documents, such as by the use of **requests for information (RFI's).** Write a request for information (RFI), as would a construction professional to an architect to request clarification for a detail of the construction documents, such as the selection of a product.

14. Business & Project Management

14.1 Contracts: Describe **the components and purpose of a basic contract document for a residential project**, determining the meaning of key terms and other industry-specific words. Recognize **the relationship and responsibilities of various parties to a contract.** Write a basic contract for a job, such as a HVAC service agreement for work done for a residential client.

14.2 Project Management: Establish and implement **specific goals to manage project assignments in a timely manner**, including organizing teams to effectively manage assignments, monitoring and reporting on project progress, and evaluating a completed project according to client requirements. For example, inspect and critique a team member's work, providing constructive feedback for improvement. Similarly, respond to constructive feedback from a team member to improve project outcomes and meet project goals.

14.3 Project Completion: Interpret **construction drawings and diagrams** to determine the **correct materials, tools, and equipment needed to complete an HVAC project.** Plan and implement **the steps needed to complete the project**, adhering to inspection procedures and employing safe practices throughout. Draw from print and electronic examples to create a material list, cost estimation, schedule, and inspection checklist for a project, applying the components of the documents to the given project.

14.4 Communication: Produce and **describe clear and coherent writing for communication in the HVAC industry.** Create a service order for a given HVAC project. Explain the service order to a peer, as would a service technician to a client.

14.5 Reports: Utilize technology to write and share **periodical reports** (weekly, monthly, etc.) to provide others with information about progress during HVAC projects as would a project manager to a supervisor. Summarize activities in a **narrative form including overall progress in relationship to a previously planned schedule.**

15. Portfolio

15.1 Portfolio: Update materials from coursework to add to the portfolio started in *Fundamentals of Construction* and *Mechanical, Electrical, & Plumbing Systems*. Continually reflect on coursework experiences and revise and refine the career plan generated in prior courses. Include photographs or illustrations and written descriptions of sequential progress in construction projects.

Standards Alignment Notes

*References to other standards include:

- NCCER Curriculum: National Center for Construction Education and Research

    - Note: NCCER accreditation is required to offer NCCER credentials to students. Instructors trained through the NCCER Instructor Certification Training Program (ICTP) may use the NCCER curricula to teach the listed standards. By doing so, their students will receive a certificate of completion for NCCER HVAC Level One and be placed in NCCER's National Registry Database.
- P21: Partnership for 21st Century Skills Framework for 21st Century Learning
    - Note: While not all standards are specifically aligned, teachers will find the framework helpful for setting expectations for student behavior in their classroom and practicing specific career readiness skills.