Module One (03101-13) provides a broad introduction to the world of the HVAC technician. The most basic operating principles of HVAC systems are presented along with a review of technician licensing and trade-governing regulations. The final portion of the module describes potential career paths for the well-trained HVAC technician.

Objectives

Learning Objective 1

- Explain the basic principles of heating, ventilation, air conditioning, and refrigeration.
  - a. Explain the principles of heating.
  - b. Explain the principles of ventilation.
  - c. Explain the principles of air conditioning.
  - d. Explain the principles of refrigeration.

Learning Objective 2

- Describe the principles that guide HVAC/R installation and service techniques.
  - a. Identify common safety principles and organizations.
  - b. Describe the importance of LEED construction and energy management.
  - c. Describe trade licensing and certification requirements.
  - d. Identify important codes and permits.

Learning Objective 3

- Identify career paths available in the HVAC/R trade.
  - a. Identify the responsibilities and characteristics needed to be a successful HVAC/R technician.
  - b. Identify residential, commercial, and industrial career opportunities.
  - c. Describe opportunities provided by equipment manufacturers.

Performance Tasks

This is a knowledge-based module; there are no performance tasks.

Teaching Time: 7.5 hours
(Three 2.5-Hour Sessions)
Session time may be adjusted to accommodate your class size, schedule, and teaching style.

Prerequisites
Completion of NCCER Core Curriculum.

Before You Begin
As you prepare for each session, allow sufficient time to review the course objectives, content, visual aids (including the PowerPoint® presentation), and these lesson plans, and to gather the required equipment and materials. Consider time required for demonstrations, laboratories, field trips, and testing.

Using your access code, download the written examinations and performance profile sheets from www.nccerirc.com. The passing score for submission into NCCER’s Registry is 70% or above for the written examination; performance testing is graded pass or fail.
**Classroom Equipment and Materials**

- Whiteboard/chalkboard
- Markers/chalk
- Pencils and paper
- *HVAC Level One PowerPoint® Presentation Slides*
- DVD player
- LCD projector and screen
- Computer
- Copies of the Module Examination

**Additional Resources**

This module presents thorough resources for task training. The following resource material is suggested for further study.

*ABC’s of Air Conditioning.* Syracuse, NY: Carrier Corporation.


*Your Role in the Green Environment.* Alachua, FL: NCCER.

*Tools for Success.* Alachua, FL: NCCER.

There are a number of online resources available for trainees who would like more information on HVAC/R systems and their application. A search for additional information may be assigned as homework to interested trainees.

Instructors should view any videos that may be identified in the lesson plan before using them to ensure their suitability. The videos can provide teachable moments in both proper and improper work processes and behaviors. Be prepared to stop the videos at appropriate times to point out and discuss both proper and improper issues.

Instructors are also encouraged to locate additional audiovisual aids available through the internet, make personal videos, and take still pictures related to the HVAC/R trade and add them to the PowerPoint® presentations throughout the program.

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**Safety Considerations**

This is a knowledge-based module and no performance tasks are required. However, instructors may choose to expose trainees to the HVAC shop environment or an active job site. Ensure that trainees possess and use the required PPE during any exposure to these types of settings.

**Personal protective equipment (if the HVAC shop area or a job site is visited):**

- Standard eye protection
- Gloves
- Proper footwear as designated by the instructor or training facility provider
- Hearing protection as designated by the instructor or training facility provider
- Hard hats

**Equipment and Materials for Laboratories and Performance Testing**

- Hearing protection as designated by the instructor or training facility provider
- Hard hats
### Session One

Session One introduces trainees to the basic principles of HVAC/R systems and some of the guiding principles of trade safety, LEED construction, and energy management.

1. Show Session One PowerPoint® slides.
2. Use the Kickoff Activity to get trainees engaged and introduce them to the subject matter.
3. Use both lecturing and visual aids to present the topics of the session.
4. Emphasize the important role of the HVAC technician in maintaining indoor air quality and energy efficiency.

### Session Two

Session Two covers HVAC trade licensing and certification, as well as an introduction to building codes and permits. The potential career paths for the well-trained technician are also explored.

1. Show Session Two PowerPoint® slides.
2. Explain licensure requirements for technicians and contractors.
3. Present information regarding refrigerants and the environment.
4. Talk about building codes and permits.
5. Present trainees with a variety of HVAC career options and review USDOL statistics on the trade.

### Session Three

Session Three is a review and testing session. Have trainees complete the Module Review Questions and Trade Terms Quiz. (Alternatively, these may be assigned as homework at the end of Session Two.) Go over the Module Review Questions in class and answer any questions that the trainees may have.

1. Have trainees complete the written examination.
2. Record the testing results on Training Report Form 200, and submit the report to your Training Program Sponsor.
# Materials Checklist for Module 03101-13, *Introduction to HVAC*

<table>
<thead>
<tr>
<th>Equipment and Materials</th>
<th>Equipment</th>
<th>Tools</th>
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</thead>
<tbody>
<tr>
<td><strong>Personal protective equipment:</strong></td>
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<td>DVD player</td>
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<td>Computer</td>
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<tr>
<td>Copies of the Module Examination</td>
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</tbody>
</table>

To the extent possible, and as required for performance testing, provide a selection of the tools listed for each session; alternatively, photos may be used to teach tool identification.
The Trainee Guide for HVAC Level One is available as an NCCERconnect ebook. Contact your NCCER customer service representative at 1-888-622-3720 for more information.

Module Two (03102-13) reinforces and extends the math skills reviewed in the Core Curriculum. Common skills practiced include calculations for units of measurement in both the inch-pound and metric systems. Basic algebraic equations are practiced along with the identifying characteristics of various geometric figures.

Objectives

Learning Objective 1
- Convert units of measurement from the inch-pound system to the metric system, and vice-versa.
  - a. Identify units of measure in the inch-pound and metric systems.
  - b. Convert, length, area, and volume values.
  - c. Convert weight values.
  - d. Convert pressure and temperature values.

Learning Objective 2
- Solve basic algebraic equations.
  - a. Define algebraic terms.
  - b. Demonstrate an understanding of the sequence of operations.
  - c. Solve basic algebraic equations.

Learning Objective 3
- Identify and describe geometric figures.
  - a. Describe the characteristics of a circle.
  - b. Identify and describe types of angles.
  - c. Identify and describe types of polygons.
  - d. Calculate various values associated with triangles.

Performance Tasks
This is a knowledge-based module; there are no performance tasks.

Teaching Time: 10 hours
(Four 2.5-Hour Sessions)
Session time may be adjusted to accommodate your class size, schedule, and teaching style.

Prerequisites
Completion of NCCER Core Curriculum.

Before You Begin
As you prepare for each session, allow sufficient time to review the course objectives, content, visual aids (including the PowerPoint® presentation), and these lesson plans, and to gather the required equipment and materials. Consider time required for demonstrations, laboratories, field trips, and testing.

Using your access code, download the written examinations and performance profile sheets from www.nccerirc.com. The passing score for submission into NCCER’s Registry is 70% or above for the written examination; performance testing is graded pass or fail.
**Classroom Equipment and Materials**

- Whiteboard/chalkboard
- Markers/chalk
- Pencils and paper
- HVAC Level One PowerPoint®
- Presentation Slides
- DVD player
- LCD projector and screen
- Computer
- Calculators
- Pythagorean theorem worksheets (one copy for each trainee), from the following resource:
- Copies of the Module Examination

**Equipment and Materials for Laboratories and Performance Testing**

- Personal protective equipment (if the HVAC shop area or a job site is visited):
  - Standard eye protection
  - Gloves
  - Proper footwear as designated by the instructor or training facility provider
  - Hearing protection as designated by the instructor or training facility provider
  - Hard hats

**Additional Resources**

This module presents thorough resources for task training. The following resource material is suggested for further study.

- Metric-conversion.org: Metric Conversion Charts and Calculators.

These are a number of online resources available for trainees who would like more information on HVAC/R systems and how math is an essential skill for technicians. A search for additional information may be assigned as homework to interested trainees.

Instructors should view any videos that may be identified in the lesson plan before using them to ensure their suitability. The videos can provide teachable moments in both proper and improper work processes and behaviors. Be prepared to stop the videos at appropriate times to point out and discuss both proper and improper issues.

Instructors are also encouraged to locate additional audiovisual aids available on the internet, make personal videos, and take photos related to the HVAC/R trade and add them to the PowerPoint® presentations throughout the program.

**Safety Considerations**

This is a knowledge-based module and no performance tasks are required. However, instructors may choose to expose trainees to the HVAC shop environment or an active job site. Ensure that trainees possess and use the required PPE during any exposure to these types of settings.
Session One

Session One introduces the procedures for calculating area and volume while also demonstrating how units of measurement are converted between the inch-pound and metric systems. This session also introduces the basic relationship between temperature and pressure.

1. Show Session One PowerPoint® slides.
2. Use the Kickoff Activity to get trainees engaged and show that math can be entertaining.
3. Explain and demonstrate typical area and volume calculations.
4. Use the information contained in conversion tables to convert inch-pound units of measure to metric system values, and vice-versa.
5. Describe the relationship between temperature and pressure in gases and gas/liquid mixtures.

Session Two

Session Two provides an introduction to the basic principles of algebra and the important terms used to describe the components of an algebraic equation.

1. Show Session Two PowerPoint® slides.
2. Define algebra and various other terms associated with algebraic equations.
3. Explain the sequence of mathematical operations required for solving equations to reach an accurate result.
4. Demonstrate the solving of simple algebraic equations.
5. Use video resources to reinforce the lesson.

Session Three

Session Three reviews the identification of various geometric figures, angles, and triangles. Solving triangle-related problems using the Pythagorean theorem is also presented and practiced.

1. Show Session Three PowerPoint® slides.
2. Define the two primary types of geometry.
3. Explain how angles are created and show how different types of angles are identified.
4. Define and identify polygons.
5. Define and identify triangles.
6. Demonstrate how to solve triangle problems using the Pythagorean theorem.

Session Four

Session Four is a review and testing session. Have trainees complete the Module Review Questions and Trade Terms Quiz. (Alternatively, these may be assigned as homework at the end of Session Three.) Go over the Module Review Questions in class prior to the exam and answer any questions that the trainees may have.

1. Have trainees complete the written examination.
2. Record the testing results on Training Report Form 200, and submit the report to your Training Program Sponsor.
<table>
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<td>Copies of the Module Examination</td>
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To the extent possible, and as required for performance testing, provide a selection of the tools listed for each session; alternatively, photos may be used to teach tool identification.
Lesson Plans for Module 03106-13

BASIC ELECTRICITY

The Trainee Guide for HVAC Level One is available as an NCCERconnect ebook. Contact your NCCER customer service representative at 1-888-622-3720 for more information.

Module Three (03106-13) introduces the concepts of power generation and distribution, common electrical components, AC and DC circuits, and electrical safety as it relates to the HVAC field. The basic concepts of reading and interpreting wiring diagrams are also introduced.

Objectives

Learning Objective 1
• Describe the fundamentals of electricity.
  a. State how electrical power is created and distributed.
  b. State the safety practices associated with electricity.
  c. Describe the difference between alternating current and direct current.

Learning Objective 2
• Explain basic electrical theory.
  a. Define voltage, current, resistance, and power and describe how they are related.
  b. Use Ohm’s law to calculate the current, voltage, and resistance in a circuit.
  c. Use the power formula to calculate how much power is consumed by a circuit.
  d. Describe the differences between series and parallel circuits and calculate circuit loads for each type.

Learning Objective 3
• Identify the electrical measuring instruments used in HVAC/R work and describe their uses.
  a. Describe how voltage is measured.
  b. Describe how current is measured.
  c. Describe how resistance is measured.

Learning Objective 4
• Identify electrical components used in HVAC/R systems and describe their functions.
  a. Identify and describe various load devices and explain how they are represented on circuit diagrams.
  b. Identify and describe various control devices and explain how they are represented on circuit diagrams.
  c. Identify and describe the types of electrical diagrams used in HVAC/R work.

Performance Tasks

Performance Task 1 (Learning Objective 3)
• Use the proper instrument to measure voltage in an energized circuit.

Performance Task 2 (Learning Objective 3)
• Use the proper instrument to measure current in an energized circuit.

Performance Task 3 (Learning Objective 3)
• Use the proper instrument to measure resistance.

Performance Task 4 (Learning Objective 3)
• Use a multimeter to check circuit continuity.

Performance Task 5 (Learning Objectives 2 and 4)
• Assemble and test series and parallel circuits using a transformer or battery, wires, and selected load devices.

Teaching Time: 12.5 hours
(Five 2.5-Hour Sessions, 2.5 hours for Performance Testing)
Session time may be adjusted to accommodate your class size, schedule, and teaching style.

Prerequisites
Completion of NCCER Core Curriculum.

Before You Begin
As you prepare for each session, allow sufficient time to review the course objectives, content, visual aids (including the PowerPoint® presentation), and these lesson plans, and to gather the required equipment and materials. Consider time required for demonstrations, laboratories, field trips, and testing.
Using your access code, download the written examinations and performance profile sheets from www.nccerirc.com. The passing score for submission into NCCER’s Registry is 70% or above for the written examination; performance testing is graded pass or fail.

Safety Considerations
This module requires that trainees work with and in the vicinity of live electrical circuits less than 500VAC. Electrical safety must be emphasized at all times. Trainees should be carefully observed to ensure that they wear the proper PPE, follow safe practices, and give due respect to the unseen hazards of electrical systems. Any deficiencies must be corrected to ensure future trainee safety as they begin working with far more hazardous electrical circuits later in their training. All practice sessions and performance tasks must be completed under your direct supervision.

Classroom Equipment and Materials
- Whiteboard/chalkboard
- Markers/chalk
- Pencils and paper
- HVAC Level One PowerPoint® Presentation
- DVD player
- LCD projector and screen
- Computer
- Calculators
- Thermostatic switch, such as a limit switch
- Pressure switch, adjustable or non-adjustable
- Cartridge fuse
- HACR circuit breaker
- Solenoid valve coil or a complete solenoid valve assembly
- Typical HVAC/R relay
- Typical HVAC/R contactor
- Motor starter
- One or more types of overload protection devices
- Typical thermistor
- Copies of the Module Examination and Performance Profile Sheets

Equipment and Materials for Laboratories and Performance Testing
- Multimeter(s), both digital and analog if available
- Voltage tester
- Clamp-on ammeter
- Breadboards
- 120/240VAC to 24VAC transformers, or suitable batteries
- Selected load devices, such as lights or small motors that operate within the voltage and load capacity of the chosen power source
- Suitable switches for the circuit to be constructed
- Sufficient wire or preformed jumper wires to make connections

Personal protective equipment:
- Standard eye protection
- Electrical safety gloves, Class 00, with protective leather outer gloves
- Proper footwear as designated by the instructor or training facility provider
- Hearing protection as designated by the instructor or training facility provider
- Hard hats
- Fire extinguisher

Additional Resources
This module presents thorough resources for task training. The following resource material is suggested for further study.

http://www.reprise.com/host/electricity

There are a number of online resources available for trainees who would like more information on HVAC/R systems and their application. A search for additional information may be assigned as homework to interested trainees.
Instructors should view any videos that may be identified in the lesson plan before using them to ensure their suitability. The videos can provide teachable moments in both proper and improper work processes and behaviors. Be prepared to stop the videos at appropriate times to point out and discuss both proper and improper issues.

Instructors are also encouraged to locate additional audiovisual aids available on the Internet, make personal videos, and take still pictures related to the HVAC/R trade and add them to the PowerPoint® presentations throughout the program.
Session One introduces trainees to the concept of power generation and the difference between AC and DC power. Fundamental electrical safety is revisited. Trainees will also learn basic electrical theory related to voltage, current, resistance, and power, as well as the math used to calculate these values from available information.

1. Show the Session One PowerPoint® presentation.
2. Use the Kickoff Activity to get trainees engaged and give them an idea of what they will learn from this module.
3. Review the various ways that power is generated and distributed.
4. Present electrical safety guidelines.
5. Define common electrical units of measure and the related mathematical concepts.
6. Explain the differences between series and parallel circuits.

Session Three focuses on common electrical control devices encountered in simple HVAC/R systems, along with the types of electrical diagrams most often used.

1. Show the Session Three PowerPoint® presentation.
2. Define and show trainees thermostatic and pressure switches.
3. Describe circuit protective devices such as fuses and circuit breakers.
4. Explain how solenoid coils work and how they make valves and relays operate.
5. Compare and contrast relays, contactors, and motor starters.
6. Review transformer operation as a common source of control voltage.
7. Discuss thermistors and printed circuit boards.
8. Review common electrical diagrams and symbols.

Session Two focuses on electrical test instruments and how they are used to measure common electrical values. Common electrical load devices found in HVAC/R applications are also presented.

1. Show the Session Two PowerPoint® presentation.
2. Introduce multimeters and standard voltage testers.
3. Introduce ammeter and ohmmeter operation.
4. Describe the use of megohmmeters.
5. Identify typical load devices.

Session Four is a laboratory session that provides an opportunity to practice and/or complete the required module Performance Tasks.

1. Note that no PowerPoint® presentation is associated with this session.
2. Demonstrate the construction of a simple series and parallel circuit using breadboards or similar training devices.
3. Demonstrate a test of the circuits that were constructed and how to take various electrical measurements using test instruments.
4. Ensure that trainees are equipped with the proper PPE.
5. Have trainees construct series and parallel circuits and demonstrate the ability to take and record various electrical values. These activities correspond to Performance Tasks 1 through 5.

The Lesson Plan for this module is divided into five 2.5-hour sessions. This time includes 10 minutes for administrative tasks and a 10-minute break per session.
SESSION FIVE

Session Five is a review and testing session. Have trainees complete the Module Review Questions and Trade Terms Quiz. These may be assigned as homework at the end of Session Four. Go over the Module Review Questions in class prior to the exam and answer any questions that the trainees may have.

1. Have trainees complete the written examination. Any outstanding performance testing must be completed during this session as well.

2. Record the testing results on Training Report Form 200, and submit the report to your Training Program Sponsor.
### Materials Checklist for Module 03106-13, *Basic Electricity*

<table>
<thead>
<tr>
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<tr>
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<td>Voltage tester</td>
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<td>leather outer gloves</td>
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<td>Breadboards</td>
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<td>facility provider</td>
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<td>Calculators</td>
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<tr>
<td>Copies of the Module Examination and Performance Profile</td>
<td>Motor starter</td>
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<tr>
<td>Sheets</td>
<td>One or more types of overload protection devices</td>
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<tr>
<td></td>
<td>Typical thermistor</td>
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To the extent possible, and as required for performance testing, provide a selection of the tools listed for each session; alternatively, photos may be used to teach tool identification.
Lesson Plans for Module 03108-13

INTRODUCTION TO HEATING

The Trainee Guide for *HVAC Level One* is available as an NCCERconnect ebook. Contact your NCCER customer service representative at 1-888-622-3720 for more information.

**Module Four (03108-13)** provides HVAC technicians with an overview of common residential heating systems. Fundamental concepts of heating and combustion systems are described with an emphasis on gas forced-air heating systems. Hydronic heating systems and different types of electric forced-air heating systems are also described.

### Objectives

**Learning Objective 1**
- Explain the fundamental concepts of heating and combustion.
  - Describe the heat transfer process.
  - Identify gas fuels and their combustion characteristics.

**Learning Objective 2**
- Describe the role of forced-air gas furnaces in residential heating.
  - Describe the types of gas furnaces and how they operate.
  - Identify and describe the equipment and controls used in gas furnaces.
  - Describe the basic installation and maintenance requirements for gas furnaces.

**Learning Objective 3**
- Describe hydronic and electric heating systems.
  - Describe the operation of hydronic heating systems.
  - Describe the operation of electric heating equipment.

### Performance Tasks

**Performance Task 1**
- Identify components of induced-draft and condensing furnaces and describe their function.

**Performance Task 2**
- Perform common maintenance tasks on a gas furnace including air filter replacement and temperature measurements.

### Teaching Time: 15 hours

(Six 2.5-Hour Sessions, 2.5 hours for Performance Testing)

Session time may be adjusted to accommodate your class size, schedule, and teaching style.

### Prerequisites

Completion of NCCER *Core Curriculum*.

### Before You Begin

As you prepare for each session, allow sufficient time to review the course objectives, content, visual aids (including the PowerPoint® presentation), and these lesson plans, and to gather the required equipment and materials. Consider time required for demonstrations, laboratories, field trips, and testing.

Using your access code, download the written examinations and performance profile sheets from www.nccerirc.com. The passing score for submission into NCCER's Registry is 70% or above for the written examination; performance testing is graded pass or fail.
**Classroom Equipment and Materials**

- Whiteboard/chalkboard
- Markers/chalk
- Pencils and paper
- HVAC Level One PowerPoint® Presentation Slides
- DVD player
- LCD projector and screen
- Computer
- Copies of the Module Examination and Performance Profile Sheets

**Equipment and Materials for Laboratories and Performance Testing**

- Thermometers for air and surface temperature measurement
- Short lengths of metal pipe (copper and steel)
- Light plastic bags
- Electric hair dryer
- Components and controls that have been removed from gas furnaces, including but not limited to:
  - Different types of gas valves
  - Clean and dirty air filters
  - Typical heat exchanger assembly
  - ECM motor
  - Standard PSC motor
  - Burner assemblies
  - Ignition controls and devices
  - Flame rectifier
  - Thermocouple and thermopile
  - Safety controls
  - Assorted gas-fired forced air furnace configurations (at least one operating furnace)
  - Assorted boiler controls and components (removed from boiler)
  - An electric furnace and/or heat pump fan coil with supplemental electric heaters
- A small gas-fired packaged boiler
- Furnace and boiler manufacturer’s product literature
- Heat pump balance point worksheets
- Typical metal and PVC furnace venting materials
- Assorted hand tools used to disassemble and/or gain access to components
- Gauge and/or manometer with necessary connecting devices to measure furnace gas manifold pressure
- Assorted disposable furnace air filters
- Small paper tags with strings
- Small paper stickers
- Personal protective equipment:
  - Standard eye protection
  - Work gloves
  - Proper footwear as designated by the instructor or training facility provider
  - Hearing protection as designated by the instructor or training facility provider
  - Hard hats

**Additional Resources**

This module presents thorough resources for task training. The following resource material is suggested for further study.


There are a number of online resources available for trainees who would like more information on both common and unique heating systems. A search for additional information may be assigned as homework to interested trainees.

Instructors should view any videos that may be identified in the lesson plan before using them to ensure their suitability. The videos can provide teachable moments in both proper and improper work processes and behaviors. Be prepared to stop the videos at appropriate times to point out and discuss both proper and improper issues.

Instructors are also encouraged to locate additional audiovisual aids available on the Internet, make personal videos, and take still pictures related to the HVAC/R trade and add them to the PowerPoint® presentations throughout the program.

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**Safety Considerations**

During the course of this module, trainees may be required to work on or around operational heating equipment and/or fuel gas supplies. Ensure that trainees possess and use the required PPE while performing these tasks.
The Lesson Plan for this module is divided into six 2.5-hour sessions. This time includes 10 minutes for administrative tasks and a 10-minute break per session.

**SESSION ONE**

Session One introduces trainees to the basic principles of combustion and heat transfer. This session is designed for the classroom environment only.

1. Show the Session One PowerPoint® presentation.
2. Use the Kickoff Activity to get trainees engaged and introduce them to the subject matter.
3. Use a demonstration to present the topic of heat transfer.
4. Discuss the combustion process and the concept of combustion efficiency.

**SESSION TWO**

Session Two introduces gas furnaces. The components and controls of gas furnaces are also covered. This session should be presented in the classroom and the lab.

1. Show the Session Two PowerPoint® presentation.
2. Review the various gas furnace configurations.
3. Describe the various primary and secondary components and controls used in a gas furnace and the purpose of each one.
4. Use video to further familiarize trainees with various components.

**SESSION THREE**

Session Three deals with gas furnace installation and maintenance. The need for adequate air for ventilation and combustion is discussed along with the need for adequate return air in the duct system.

1. Show the Session Three PowerPoint® presentation.
2. Explain that furnace location and the environment in which it is installed can affect furnace operation.
3. Describe combustion air and safety issues related to combustion byproducts.
4. Review the importance of proper installation and maintenance.
5. Describe how various maintenance procedures are performed.

**SESSION FOUR**

Session Four is devoted to demonstrations and Performance Tasks. Trainees will practice identifying all types of furnace components and performing specific maintenance activities.

1. Note that no PowerPoint® presentation is associated with this session.
2. Have trainees identify various furnace components in non-condensing and condensing furnaces.
3. Demonstrate how to replace an air filter, take temperature measurements, calculate temperature rise, and measure gas manifold pressures on an operational warm-air heating system.
4. Under your supervision, have trainees replace an air filter, measure supply and return air temperatures, calculate temperature rise, and measure gas manifold pressures.
## Session Outline for 03108-13

**INTRODUCTION TO HEATING**

### Session Five

Session Five introduces hydronic and electric heating systems. Similarities and differences between gas forced-air systems and these systems are discussed.

1. Show the Session Five PowerPoint® presentation.
2. Describe the advantages and disadvantages of hydronic heating systems.
3. Point out the various components of a small packaged boiler including safety controls.
4. Describe the components found in an electric forced-air furnace. Discuss similarities and differences between an electric furnace and a gas-fired furnace.
5. Describe how a heat pump operates to provide heat efficiently.
6. Present the concept of a structure’s balance point.

### Session Six

Session Six is a review and testing session. Have trainees complete the Module Review Questions and Trade Terms Quiz. These may have been assigned as homework at the end of Session Five. Go over the Module Review Questions and Trade Terms Quiz in class and answer any questions that the trainees may have.

1. Have trainees complete the written examination.
2. Complete any remaining Performance Tasks.
2. Record the testing results on Training Report Form 200, and submit the report to your Training Program Sponsor.
## Materials Checklist for Module 03108-13, Introduction to Heating

<table>
<thead>
<tr>
<th>Equipment and Materials</th>
<th>Equipment</th>
<th>Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Personal protective equipment:</strong></td>
<td>Short lengths of metal pipe (copper and steel)</td>
<td>Gauge and/or manometer with necessary connecting devices to measure furnace gas manifold pressure</td>
</tr>
<tr>
<td>Standard eye protection</td>
<td>Light plastic bags</td>
<td>Assorted disposable furnace air filters</td>
</tr>
<tr>
<td>Gloves</td>
<td>Electric hair dryer</td>
<td>Small paper tags with strings</td>
</tr>
<tr>
<td>Proper footwear as designated by the instructor or training facility provider</td>
<td>Assorted boiler controls and components (removed from boiler)</td>
<td>Small paper stickers</td>
</tr>
<tr>
<td>Hearing protection as designated by the instructor or training facility provider</td>
<td>An electric furnace and/or heat pump fan coil with supplemental electric heaters</td>
<td>Components and controls that have been removed from gas furnaces, including but not limited to:</td>
</tr>
</tbody>
</table>
| Hard hats | A small gas-fired packaged boiler | - Different types of gas valves  
- Clean and dirty air filters  
- Typical heat exchanger assembly  
- ECM motor  
- Standard PSC motor  
- Burner assemblies  
- Ignition controls and devices  
- Flame rectifier  
- Thermocouple and thermopile  
- Safety controls  
- Assorted gas-fired forced air furnace configurations (at least one operating furnace) |
| Whiteboard/chalkboard | Furnace and boiler manufacturer’s product literature | |
| Markers/chalk | Heat pump balance point worksheets | |
| Pencils and paper | Typical metal and PVC furnace venting materials | |
| **HVAC Level One PowerPoint® Presentation Slides** | Assorted hand tools used to disassemble and/or gain access to components | |
| DVD player | Thermometers for air and surface temperature measurement | |
| LCD projector and screen | | |
| Computer | | |
| Copies of the Module Examination and Performance Profile Sheets | | |

To the extent possible, and as required for performance testing, provide a selection of the tools listed for each session; alternatively, photos may be used to teach tool identification.
Lesson Plans for Module 03107-13

INTRODUCTION TO COOLING

The Trainee Guide for HVAC Level One is available as an NCCERconnect ebook. Contact your NCCER customer service representative at 1-888-622-3720 for more information.

Module Five (03107-13) introduces the fundamental concepts of the mechanical refrigeration cycle and examples of the primary components required to make it work. Some common refrigerants and their characteristics are also introduced. Upon completion, trainees will be able to identify typical pressure and temperature measuring instruments and some of the most common primary and secondary controls used to manage the refrigeration cycle.

Objectives

Learning Objective 1
- Explain the fundamental concepts of the refrigeration cycle.
  a. Describe how heat affects the state of substances.
  b. Explain how heat is transferred from one substance to another.
  c. Describe pressure-temperature relationships.
  d. Describe the basic pattern of refrigerant flow and the changes of state that occur in the refrigeration cycle.
  e. Identify common instruments used to measure pressure and temperature.

Learning Objective 2
- Identify common refrigerants and their basic characteristics.
  a. Identify fluorocarbon refrigerants.
  b. Describe the use of ammonia as a refrigerant.
  c. Identify various refrigerant containers and their safe handling requirements.

Learning Objective 3
- Identify the major components of cooling systems and how they function.
  a. Identify basic compressors and their function in the system.
  b. Identify different condensers used to transfer heat.
  c. Identify different evaporators used to transfer heat.
  d. Describe the devices used to meter refrigerant flow.
  e. Discuss basic refrigerant piping concepts.
  f. Identify various accessories used in refrigeration circuits.

Learning Objective 4
- Identify the common controls used in cooling systems and how they function.
  a. Identify common primary controls.
  b. Identify controls that are secondary to the process.

Performance Tasks

Performance Task 1 (Learning Objective 1)
- Measure temperatures in an operating cooling system.

Performance Task 2 (Learning Objective 1)
- Calibrate a set of refrigerant gauges and thermometers.

Performance Task 3 (Learning Objective 1)
- Connect a refrigerant gauge manifold and properly calculate subcooling and superheat on an operating system using a temperature probe.

Performance Task 4 (Learning Objective 2)
- Identify refrigerants using cylinder color codes.

Performance Task 5 (Learning Objectives 3 and 4)
- Identify compressors, condensers, evaporators, metering devices, controls, and accessories.

Teaching Time: 30 hours
(Twelve 2.5-Hour Sessions)
Session time may be adjusted to accommodate your class size, schedule, and teaching style.

Prerequisites
Completion of NCCER Core Curriculum.

Before You Begin
As you prepare for each session, allow sufficient time to review the course objectives, content, visual aids (including the PowerPoint® presentation), and these lesson plans, and to gather the required equipment and materials. Consider time required for demonstrations, laboratories, field trips, and testing.

Using your access code, download the written examinations and performance profile sheets from www.nccerirc.com. The passing score for submission into NCCER’s Registry is 70% or above for the written examination; performance testing is graded pass or fail.
Safety Considerations
This module requires that trainees work with and in the vicinity of functioning HVAC equipment as well as live electrical circuits at less than 500VAC. Electrical, mechanical, and refrigerant safety must be emphasized at all times. Trainees should be carefully observed to ensure that they wear the proper PPE, follow safe practices, and give due respect to the hazards of energized and operating HVAC/R systems and refrigerant circuits. Any deficiencies must be corrected to ensure future trainee safety as they begin working with even more hazardous systems later in their training and career. All practice sessions and performance tasks must be completed under your direct supervision.

Classroom Equipment and Materials
Whiteboard/chalkboard
Markers/chalk
Pencils and paper
HVAC Level One PowerPoint® Presentation
DVD player
LCD projector and screen
Computer
Calculators
Copies of the Module Examination and Performance Profile Sheets

Equipment and Materials for Laboratories and Performance Testing
Apparatus to boil water
Suitable container, preferably clear, to boil water
A material that conducts heat readily, such as a small metal box
A material that insulates against heat transfer, such as a small polystyrene block
A selection of temperature measurement instruments for examination
Temperature measurement instruments suitable for measuring the temperature of both refrigerant lines and air
Dial or digital pocket thermometers suitable to demonstrate calibration
One or more beakers to boil water and hold an ice/water mixture
A few fresh ice cubes
Crushed or shaved ice and water
Small adjustable or properly sized wrenches to adjust pocket thermometer(s)
Refrigeration gauge sets
Pocket screwdrivers
Fire extinguisher
Task sheets for trainee entries during practice/Performance Tasks with the following entries:
  Air temperature entering the condenser:
  Air temperature leaving the condenser:
  Suction line temperature at the condensing unit:
  Suction line pressure at the condensing unit:
  Calculated superheat:
  Liquid line temperature at the condensing unit:
  Liquid line pressure at the condensing unit:
  Calculated subcooling:
  Air temperature entering the evaporator:
  Air temperature leaving the evaporator:
  A selection of different compressors (optional)
  A selection of different condensers (optional)
  A selection of different evaporators (optional)
  A selection of different metering devices
  A selection of primary and secondary control devices, including various temperature and pressure controls and an oil pressure safety switch
  A selection of refrigerant circuit accessories
  A variety of disposable refrigerant cylinders with colors clearly identifiable (at least four)
  Personal protective equipment:
    Standard eye protection
    Work gloves
    Butyl-lined gloves
    Proper footwear as designated by the instructor or training facility provider
    Hearing protection as designated by the instructor or training facility provider
    Hard hats
Additional Resources
This module presents thorough resources for task training. The following resource material is suggested for further study.


There are a number of online resources available for trainees who would like more information on HVAC/R systems and their application. A search for additional information may be assigned as homework to interested trainees.

Instructors should view any videos that may be identified in the lesson plan before using them to ensure their suitability. The videos can provide teachable moments in both proper and improper work processes and behaviors. Be prepared to stop the videos at appropriate times to point out and discuss both proper and improper issues.

Instructors are also encouraged to locate additional audiovisual aids available on the Internet, make personal videos, and take still pictures related to the HVAC/R trade and add them to the PowerPoint® presentations throughout the program.
The Trainee Guide for HVAC Level One is available as an NCCERconnect ebook. Contact your NCCER customer service representative at 1-888-622-3720 for more information.

Module Six (03109-13) introduces the fundamental concepts of air movement and explains how these concepts form the basis for air distribution system design. With an understanding of these fundamentals, trainees are introduced to air measurement devices and the mechanical equipment used to initiate and maintain air movement. The module concludes with a review of air distribution system components and design strategies for different climates. Trainees will also practice using various air measurement devices and interpret charts related to air distribution system sizing.

**Objectives**

**Learning Objective 1**
- Describe the factors related to air movement and its measurement in air distribution systems.
  - a. Describe how pressure, velocity, and volume are interrelated in air flow.
  - b. Describe air distribution in a typical residential system.
  - c. Identify common air measurement instruments.

**Learning Objective 2**
- Describe the mechanical equipment and materials used to create air distribution systems.
  - a. Describe various blower styles and applications.
  - b. Describe various fan designs and applications.
  - c. Demonstrate an understanding of the Fan Laws.
  - d. Describe common duct materials and fittings.
  - e. Identify the characteristics of common grilles, registers, and dampers.

**Learning Objective 3**
- Identify the different approaches to air distribution system design and energy conservation.
  - a. Identify air system design strategies for cold climates.
  - b. Identify air system design strategies for warm climates.
  - c. Explain the importance of maximizing energy efficiency through the proper insulation, sealing, and testing of air distribution systems.

**Performance Tasks**

**Performance Task 1** (Learning Objective 1)
- Use a tachometer to measure blower motor rpm.

**Performance Task 2** (Learning Objectives 1 and 2)
- Read and interpret equivalent length charts and required air volume/duct size charts.

**Performance Task 3** (Learning Objective 1)
- Use a manometer to measure static pressure in a duct system.

**Performance Task 4** (Learning Objective 2)
- Use a velometer to measure the velocity of airflow at the output of air system supply diffusers and registers.

**Performance Task 5** (Learning Objective 1)
- Use a velometer to calculate system cfm.

**Teaching Time: 15 hours**
(Six 2.5-Hour Sessions)
Session time may be adjusted to accommodate your class size, schedule, and teaching style.

**Prerequisites**
Completion of NCCER Core Curriculum.

**Before You Begin**
As you prepare for each session, allow sufficient time to review the course objectives, content, visual aids (including the PowerPoint® presentation), and these lesson plans, and to gather the required equipment and materials. Consider time required for demonstrations, laboratories, field trips, and testing.

Using your access code, download the written examinations and performance profile sheets from www.nccerinc.com. The passing score for submission into NCCER’s Registry is 70% or above for the written examination; performance testing is graded pass or fail.
**Safety Considerations**
This module requires that trainees work with and in the vicinity of functioning HVAC equipment. Electrical and mechanical safety must be emphasized at all times. Trainees should be carefully observed to ensure that they wear the proper PPE, follow safe practices, and give due respect to the hazards of energized and operating HVAC/R systems. Any deficiencies must be corrected to ensure future trainee safety as they begin working with even more hazardous systems later in their training and career. All practice sessions and performance tasks must be completed under your direct supervision.

**Classroom Equipment and Materials**
- Whiteboard/chalkboard
- Markers/chalk
- Pencils and paper
- HVAC Level One PowerPoint® Presentations
- DVD player
- LCD projector and screen
- Computer
- Calculators
- Copies of the Module Examination and Performance Profile Sheets

**Equipment and Performance Testing**
- U-tube manometers and/or inclined-tube manometers
- Electronic manometers (optional)
- Velometers
- Rotating vane anemometers (optional)
- Hot-wire anemometers (optional)
- Contact and non-contact tachometers, or instruments that combine the two functions
- SMACNA HVAC Duct Design Calculator, or equal tool, for sizing duct

**Personal protective equipment:**
- Standard eye protection
- Work gloves
- Proper footwear as designated by the instructor or training facility provider
- Hearing protection as designated by the instructor or training facility provider
- Hard hats

**Additional Resources**
This module presents thorough resources for task training. The following resource material is suggested for further study.

- *Thermal and Moisture Protection*. Alachua FL: NCCER.
- *Insulating Pipes, Ducts, and Water Heaters*. Alachua FL: NCCER.

There are a number of online resources available for trainees who would like more information on HVAC/R systems and their application. A search for additional information may be assigned as homework to interested trainees.

Instructors should view any videos that may be identified in the lesson plan before using them to ensure their suitability. The videos can provide teachable moments in both proper and improper work processes and behaviors. Be prepared to stop the videos at appropriate times to point out and discuss both proper and improper issues.

Instructors are also encouraged to locate additional audiovisual aids available on the Internet, make personal videos, and take still pictures related to the HVAC/R trade and add them to the PowerPoint® presentations throughout the program.
The Lesson Plan for this module is divided into six 2.5-hour sessions. This time includes 10 minutes for administrative tasks and a 10-minute break per session.

**SESSION ONE**

Session One explores the relationship between airflow and pressure in air distribution systems. The instruments used to make various measurements in an air distribution system are introduced, along with information about their operation and use.

1. Show the Session One PowerPoint® presentation.
2. Assign the Kickoff Activity to get trainees engaged and provide them with a practical means of focusing their learning in this module.
3. Present the measureable pressure values in a duct system.
4. Review the movement of air through a simple, yet complete air distribution system.
5. Introduce temperature and humidity instruments.
6. Introduce pressure and velocity measurement devices.
7. Introduce measurements that measure rotational speed.

6. Demonstrate the use of velometers and/or anemometers to measure outlet and duct velocity.
7. Have trainees use a velometer to take various measurements and use the information to calculate airflow volume in a duct.

**SESSION THREE**

Session Three focuses on the equipment and materials that comprise a basic, complete air distribution system. The primary equipment, materials, and components are explored in detail individually.

1. Show the Session Three PowerPoint® presentation.
2. Identify different types of blowers and fans and their performance characteristics.
3. Present the Fan Laws and explain how they are used.
4. Introduce the basic concepts of design and related codes.
5. Review the materials and components used to construct duct.

**SESSION TWO**

Session Two is a laboratory and Performance Task session. Instructors demonstrate the use and operation of instruments such as tachometers and manometers. Trainees then practice using the same instruments and may complete Performance Tasks 1, 3, 4, and 5.

1. Note that no PowerPoint® presentation is associated with this session.
2. Demonstrate the use of tachometers.
3. Have trainees use tachometers under your supervision.
4. Demonstrate the use of one or more types of manometer to measure duct pressure.
5. Have trainees use manometers under your supervision.
**SESSION FOUR**

Session Four is a laboratory and Performance Task session. Instructors demonstrate the use of common duct-sizing aids using simple one-line layouts. Have trainees then practice sizing ducts and provide an opportunity to practice and/or complete Performance Task 2.

1. Note that no PowerPoint® presentation is associated with this session.
2. Demonstrate the use of duct-sizing aids based on a simple one-line diagram prepared prior to the session.
3. Have trainees practice sizing duct for a similar one-line layout using different air volume values.

**SESSION FIVE**

Session Five introduces trainees to the various air distribution system layouts used in residential applications. Duct sealing, insulation, and vapor barriers are also explored.

1. Show the Session Five PowerPoint® presentation.
2. Introduce various perimeter systems.
3. Introduce different extended plenum systems.
4. Compare and contrast approaches for warm and cold climates.
5. Introduce various overhead design approaches.
6. Emphasize the importance of duct sealing and insulation and discuss the process of duct leakage testing.

**SESSION SIX**

Session Six is a review and testing session. Have trainees complete the Module Review Questions and Trade Terms Quiz. Alternatively, these may be assigned as homework at the end of Session Five. Go over the Module Review Questions in class prior to the exam and answer any questions that the trainees may have.

1. Have trainees complete the written examination. Any outstanding performance testing must be completed during this session as well.
2. Record the testing results on Training Report Form 200, and submit the report to your Training Program Sponsor.
### Materials Checklist for Module 03109-13, Air Distribution Systems

<table>
<thead>
<tr>
<th>Equipment and Materials</th>
<th>Equipment</th>
<th>Tools</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Personal protective equipment:</strong></td>
<td>U-tube manometers and/or inclined-tube</td>
<td>Rotating vane anemometers (optional)</td>
</tr>
<tr>
<td>Standard eye protection</td>
<td>Electronic manometers (optional)</td>
<td>Rotating vane anemometers (optional)</td>
</tr>
<tr>
<td>Work gloves</td>
<td>Velometers</td>
<td>Rotating vane anemometers (optional)</td>
</tr>
<tr>
<td>Proper footwear as designated by the instructor or training facility provider</td>
<td>Hot-wire anemometers (optional)</td>
<td>Hot-wire anemometers (optional)</td>
</tr>
<tr>
<td>Hearing protection as designated by the instructor or training facility provider</td>
<td>Contact and non-contact tachometers, or instruments that combine the two functions</td>
<td>Contact and non-contact tachometers, or instruments that combine the two functions</td>
</tr>
<tr>
<td>Hard hats</td>
<td></td>
<td>Contact and non-contact tachometers, or instruments that combine the two functions</td>
</tr>
<tr>
<td>Copies of the Module Examination and Performance Profile Sheets</td>
<td>SMACNA HVAC Duct Design Calculator, or equal tool, for sizing duct</td>
<td>SMACNA HVAC Duct Design Calculator, or equal tool, for sizing duct</td>
</tr>
<tr>
<td><em>HVAC Level One PowerPoint® Presentation Slides, DVD player</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Whiteboard/chalkboard</td>
<td></td>
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<tr>
<td>Markers/chalk</td>
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<tr>
<td>Pencils and paper</td>
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<tr>
<td>LCD projector and screen</td>
<td></td>
<td></td>
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<tr>
<td>Computer</td>
<td></td>
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<tr>
<td>TV/VCR (optional)</td>
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<td></td>
</tr>
</tbody>
</table>

To the extent possible, and as required for performance testing, provide a selection of the tools listed for each session; alternatively, photos may be used to teach tool identification.
Lesson Plans for Module 03103-13

Basic Copper and Plastic Piping Practices

The Trainee Guide for HVAC Level One is available as an NCCERconnect ebook. Contact your NCCER customer service representative at 1-888-622-3720 for more information.

Module Seven (03103-13) introduces the trainees to the various types of copper tubing and plastic piping and the various fittings that are used with them in the HVAC industry. This module focuses on handling, cutting, bending, and mechanically joining copper tubing and plastic piping.

Objectives

Learning Objective 1
- Recognize and identify different types of copper tubing and their related fittings.
  a. Describe and identify copper tubing characteristics.
  b. Identify various copper fittings.

Learning Objective 2
- Describe and demonstrate how to join copper tubing mechanically.
  a. Measure, cut, and bend copper tubing to prepare it for joining.
  b. Describe and demonstrate the methods and tools used to join copper tubing.
  c. Describe common hangers and supports associated with copper tubing installations.

Learning Objective 3
- Recognize different types of plastic piping and show how it can be joined.
  a. Identify different types of plastic piping.
  b. Identify the tools and products needed and demonstrate how to join plastic piping.

Performance Tasks

Performance Task 1 (Learning Objective 2)
- Cut and bend copper tubing.

Performance Task 2 (Learning Objective 2)
- Safely join copper tubing using mechanical fittings.
  a. Flare tubing and complete a flared connection
  b. Use a compression fitting and ferrule to make a connection.
  c. Use a swaging tool to swage a piece of tubing.

Performance Task 3 (Learning Objective 3)
- Cut and join lengths of plastic pipe.

Teaching Time: 10 hours
(Four 2.5-Hour Sessions)
Session time may be adjusted to accommodate your class size, schedule, and teaching style.

Prerequisites
Completion of NCCER Core Curriculum.

Before You Begin
As you prepare for each session, allow sufficient time to review the course objectives, content, visual aids (including the PowerPoint® presentation), and these lesson plans, and to gather the required equipment and materials. Consider time required for demonstrations, laboratories, field trips, and testing.

Using your access code, download the written examinations and performance profile sheets from www.nccerirc.com. The passing score for submission into NCCER’s Registry is 70% or above for the written examination; performance testing is graded pass or fail.
**Safety Considerations**
This module requires that trainees work with sharp tools and toxic chemicals. Safety must be emphasized at all times. Trainees should be carefully observed to ensure that they wear the proper PPE, follow safe practices, and give due respect to the unseen hazards of handling toxic and flammable solvents. These solvents should not be used near open flames and should only be used in well-ventilated areas. Refer to the applicable material safety data sheet (MSDS) or safety data sheet (SDS) for the product in use and share the information with trainees. All practice sessions and Performance Tasks must be completed under your direct supervision.

**Classroom Equipment and Materials**
- Whiteboard/chalkboard
- Markers/chalk
- Pencils and paper
- HVAC Level One PowerPoint® Presentation
- DVD player
- LCD projector and screen
- Computer
- Copies of the Module Examination and Performance Profile Sheets

**Equipment and Materials for Laboratories and Performance Testing**
- Annealed (soft) copper tubing
- Tape measures
- Handheld tubing cutters
- Hacksaws
- Reaming tools
- Nylon abrasive pad and sand cloth
- Bending springs
- Handheld tubing benders
- Flare fittings
- Flaring tool sets
- Flare nut wrenches
- Various compression fittings with ferrules
- Swaging tools
- Various pipe hangers
- Various pipe straps
- Typical pipe support channel materials and compatible straps
- PVC and/or CPVC plastic pipe and fittings
- Tape measures
- Plastic pipe cutters
- PVC saws
- Pipe wraps
- PVC and/or CVPC clear pipe cleaner
- PVC and/or CVPC primer with a purple color
- PVC and/or CPVC solvent-cement
- MSDS or SDS for solvent-related products
- Personal protective equipment:
  - Standard eye protection
  - Well-fitted work gloves
  - Rubber or latex gloves
  - Proper footwear as designated by the instructor or training facility provider
  - Hearing protection as designated by the instructor or training facility provider
  - Hard hats

**Additional Resources**
This module presents thorough resources for task training. The following resource material is suggested for further study.

*Plastics Pipe Institute, Inc.* [plasticpipe.org](http://plasticpipe.org).


There are a number of online resources available for trainees who would like more information on copper and plastic piping systems and their application. A search for additional information may be assigned as homework to interested trainees.

Instructors should view any videos that may be identified in the lesson plan before using them to ensure their suitability. The videos can provide teachable moments in both proper and improper work processes and behaviors. Be prepared to stop the videos at appropriate times to point out and discuss both proper and improper issues.

Instructors are also encouraged to locate additional audiovisual aids available on the internet, make personal videos, and take still pictures related to the HVAC trade and add them to the PowerPoint® presentations throughout the program.
The Lesson Plan for this module is divided into four 2.5-hour sessions. This time includes 10 minutes for administrative tasks and a 10-minute break per session.

**SESSION ONE**

Session One introduces trainees to the various copper tubing materials used in typical HVAC/R systems. This session familiarizes trainees with the methods used to join and install copper tubing before being trained to perform the various tasks.

1. Show the Session One PowerPoint® presentation.
2. Use the Kickoff Activity to get trainees engaged and give them an idea of what they will learn from this module.
3. Review the characteristics of copper tubing.
4. Identify the types of copper tubing based on material markings and size.
5. Identify the types of copper tubing fittings and when they should be used.
6. Discuss the methods used to join copper tubing.

**SESSION TWO**

Session Two is a combination classroom/laboratory session that provides an opportunity to practice and/or complete the required module Performance Tasks related to copper tubing. Cutting and bending is demonstrated and practiced. The joining methods presented include flared and compression types, as well as how to swage copper tubing for soldering or brazing. The subjects of pressure testing and pipe supports are discussed during the classroom portion of the session.

1. Show the Session Two PowerPoint® presentation.
2. Discuss and demonstrate cutting and bending copper tubing.
3. Present and demonstrate the fabrication of a flared joint and a compression joint.
4. Talk about the pressure testing of assembled piping systems.
5. Identify and describe various pipe hangers and supports.
6. Have trainees will cut, bend, and join copper tubing. These laboratories correspond with Performance Tasks 1 and 2.

**SESSION THREE**

Session Three is a combination classroom/laboratory session that provides an opportunity to practice and/or complete the required module performance tasks related to plastic piping. The session focuses on cutting, preparing, and joining plastic piping.

1. Show the Session Three PowerPoint® presentation.
2. Identify different types of plastic piping and their applications.
3. Identify the tools and products needed and demonstrate how to join plastic piping.
4. Have trainees cut and join plastic piping. This laboratory corresponds with Performance Task 3.
Session Four is a review and testing session. Have trainees complete the Module Review Questions and Trade Terms Quiz. Alternatively, these may be assigned as homework at the end of Session Three. Go over the Module Review Questions and Trade Terms Quiz in class prior to the exam and answer any questions that the trainees may have.

1. Have trainees complete the written examination. Any outstanding performance testing must be completed during this session as well.

2. Record the testing results on Training Report Form 200, and submit the report to your Training Program Sponsor.
<table>
<thead>
<tr>
<th>Equipment and Materials</th>
<th>Equipment</th>
<th>Tools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal protective equipment:</td>
<td>Annealed (soft) copper tubing</td>
<td>Handheld tubing cutters</td>
</tr>
<tr>
<td>Standard eye protection</td>
<td>Tape measures</td>
<td>Hacksaws</td>
</tr>
<tr>
<td>Well-fitted work gloves</td>
<td>Nylon abrasive pad and sand cloth</td>
<td>Reaming tools</td>
</tr>
<tr>
<td>Rubber or latex gloves</td>
<td>Bending springs</td>
<td>Handheld tubing benders</td>
</tr>
<tr>
<td>Proper footwear as designated by the instructor or training facility provider</td>
<td>Flare fittings</td>
<td>Flare nut wrenches</td>
</tr>
<tr>
<td>Hearing protection as designated by the instructor or training facility provider</td>
<td>Various compression fittings with ferrules</td>
<td>Flaring tool sets</td>
</tr>
<tr>
<td>Hard hats</td>
<td>Various pipe hangers</td>
<td>Swaging tools</td>
</tr>
<tr>
<td>Whiteboard/chalkboard</td>
<td>Various pipe straps</td>
<td>Plastic pipe cutters</td>
</tr>
<tr>
<td>Markers/chalk</td>
<td>Typical pipe support channel materials and compatible straps</td>
<td></td>
</tr>
<tr>
<td>Pencils and paper</td>
<td>PVC and/or CPVC plastic pipe and fittings</td>
<td></td>
</tr>
<tr>
<td>HVAC Level One PowerPoint® Presentation</td>
<td>PVC saws</td>
<td></td>
</tr>
<tr>
<td>DVD player</td>
<td>Pipe wraps</td>
<td></td>
</tr>
<tr>
<td>LCD projector and screen</td>
<td>PVC and/or CVPC clear pipe cleaner</td>
<td></td>
</tr>
<tr>
<td>Computer</td>
<td>PVC and/or CVPC primer with a purple color</td>
<td></td>
</tr>
<tr>
<td>Copies of the Module Examination and Performance Profile Sheets</td>
<td>PVC and/or CPVC solvent-cement</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MSDS or SDS for solvent-related products</td>
<td></td>
</tr>
</tbody>
</table>

To the extent possible, and as required for performance testing, provide a selection of the tools listed for each session; alternatively, photos may be used to teach tool identification.
Module Eight (03104-13) explains soldering and brazing as the two methods used for joining copper tubing and fittings. It describes the safety equipment, tools, and materials needed for soldering and brazing copper tubing in various applications. It also explains the preparations required and the processes involved in soldering and brazing copper tubing.

**Objectives**

**Learning Objective 1**
- Describe and demonstrate the safe process of soldering copper tubing.
  - a. Describe and demonstrate the use of the PPE, tools, and materials needed to solder copper tubing.
  - b. Describe and demonstrate the preparation required for soldering.
  - c. Describe and demonstrate the soldering process.

**Learning Objective 2**
- Describe and demonstrate the safe process of brazing copper tubing.
  - a. Describe and demonstrate the use of the PPE, tools, and materials needed to braze copper tubing.
  - b. Describe and demonstrate the preparation used for brazing.
  - c. Describe and demonstrate the brazing process.
  - d. Describe and demonstrate the process of brazing copper tubing to dissimilar metals.

**Performance Tasks**

**Performance Task 1** (Learning Objective 2)
- Properly set up and shut down oxyacetylene equipment.

**Performance Task 2** (Learning Objective 1)
- Properly set up and shut down an acetylene single tank.

**Performance Task 3** (Learning Objective 1)
- Properly prep and safely solder copper tubing in various planes, using various fittings.

**Performance Task 4** (Learning Objective 2)
- Properly prep and safely braze copper tubing using various fittings.

**Teaching Time: 10 hours**

(Four 2.5-Hour Sessions)

Session time may be adjusted to accommodate your class size, schedule, and teaching style.

**Prerequisites**

Completion of NCCER Core Curriculum.

**Before You Begin**

As you prepare for each session, allow sufficient time to review the course objectives, content, visual aids (including the PowerPoint® presentation), and these lesson plans, and to gather the required equipment and materials. Consider time required for demonstrations, laboratories, field trips, and testing.

Using your access code, download the written examinations and performance profile sheets from www.nccerirc.com. The passing score for submission into NCCER’s Registry is 70% or above for the written examination; performance testing is graded pass or fail.
Safety Considerations
This module requires that trainees work with and in the vicinity of open flames, sparks, combustible and explosive gases, toxic fumes, and hot objects and surfaces. Safety must be emphasized at all times. Trainees should be carefully observed to ensure that they wear the proper PPE, follow safe practices, and give due respect to unseen hazards related to soldering and brazing. Any deficiencies must be corrected to ensure future trainee safety. All practice sessions and Performance Tasks must be completed under your direct supervision.

Classroom Equipment and Materials
- Whiteboard/chalkboard
- Markers/chalk
- Pencils and paper
- HVAC Level One PowerPoint® Presentation
- DVD player
- LCD projector and screen
- Computer
- Copies of the Module Examination and Performance Profile Sheets

Equipment and Materials for Laboratories and Performance Testing
- Air/acetylene torch set with appropriate tip
- Oxyacetylene equipment with appropriate brazing tips
- Cup-type striker
- Solder and brazing filler metals; phosphorous-bearing filler metal is suggested for brazing
- Solder and brazing fluxes
- Wet cloth
- Copper tubing and fittings (⅛" OD tubing is suggested for soldering; ¼" or ½" OD tubing is suggested for oxyacetylene brazing)
- Nitrogen cylinder with regulator
- Accessories for nitrogen purging
- Propane, MAP-Pro, and/or small acetylene cylinders
- Self-igniting soldering torch head
- Air/acetylene torch kit, complete
- Various solders
- Various soldering fluxes
- Heat-absorbing paste
- Complete oxyacetylene outfit with regulators, operating tools, tip cleaners, and various torch handles and tip styles
- Various types of filler metal rods
- Brazing flux
- Personal protective equipment: Non-flammable clothing made of fabric such as cotton
- Long-sleeve shirt and cuff-less pants
- Eye and face protection
- Flame-resistant gloves and high-top work boots
- Hearing protection as designated by the instructor or training facility provider
- Hard hat as designated by the instructor or training facility provider
- Fire extinguisher
- Fire blanket or other flame/heat blocking material if soldering or blazing is done near other flammable material

Additional Resources
This module presents thorough resources for task training. The following resource material is suggested for further study.


There are a number of online resources available for trainees who would like more information on soldering and brazing. A search for additional information may be assigned as homework to interested trainees.

Instructors should view any videos that may be identified in the lesson plan before using them to ensure their suitability. The videos can provide teachable moments in both proper and improper work processes and behaviors. Be prepared to stop the videos at appropriate times to point out and discuss both proper and improper issues.

Instructors are also encouraged to locate additional audiovisual aids available on the internet, make personal videos, and take still pictures related to the HVAC/R trade and add them to the PowerPoint® presentations throughout the program.
The Lesson Plan for this module is divided into four 2.5-hour sessions. This time includes 10 minutes for administrative tasks and a 10-minute break per session.

**Session One**

Session One introduces trainees to the PPE, tools, and materials needed to safely solder copper tubing and fittings. The preparations required prior to soldering and the soldering procedures used for various applications are covered.

1. Show the Session One PowerPoint® presentation.
2. Use the Kickoff Activity to get trainees engaged and give them an idea of what they will learn from this module.
3. Review the appropriate PPE that is needed and the correct safety procedures that should be followed when soldering copper tubing and fittings.
4. Identify and describe the tools and materials needed for soldering copper tubing and fittings.
5. Review how to measure, cut, ream, and clean the copper tubing and fittings to prepare them for soldering.
6. Review the steps involved in soldering copper tubing and fittings.

**Session Two**

Session Two focuses on the PPE, equipment, preparations, and procedures involved in safely brazing copper tubing and fittings.

1. Show the Session Two PowerPoint® presentation.
2. Review the appropriate PPE that is needed and the correct safety procedures that should be followed when brazing copper tubing and fittings.
3. Identify and describe the equipment needed for brazing copper tubing and fittings.
4. Review how to prepare copper tubing and fittings for brazing.
5. Review how to prepare oxyacetylene and air/acetylene torch equipment for brazing.
6. Describe how to purge refrigerant lines using nitrogen.
7. Describe the brazing process for copper tubing and fittings, as well as brazing copper to dissimilar metals.

**Session Three**

Session Three is a laboratory session that provides an opportunity to practice and/or complete all of the required Performance Tasks.

1. Note that no PowerPoint® presentation is associated with this session.
2. Demonstrate how to set up an acetylene single tank, prepare and solder copper tubing and fittings, and shut down the equipment when finished.
3. Demonstrate how to set up oxyacetylene equipment, prepare and braze copper tubing and fittings, and shut down the equipment when finished.
4. Ensure that trainees are equipped with the proper PPE.
5. Have trainees demonstrate the ability to safely prepare for and complete the steps required for soldering and brazing copper tubing and various fittings. This laboratory corresponds with Performance Tasks 1 through 4.
Session Four is a review and testing session. Have trainees complete the Module Review Questions and Trade Terms Quiz. Alternatively, these may be assigned as homework at the end of Session Three. Go over the Module Review Questions in class prior to the exam and answer any questions that the trainees may have.

1. Have trainees complete the written examination. Any outstanding performance testing must be completed during this session as well.

2. Record the testing results on Training Report Form 200, and submit the report to your Training Program Sponsor.
## Materials Checklist for Module 03104-13, Soldering and Brazing

<table>
<thead>
<tr>
<th>Equipment and Materials</th>
<th>Equipment</th>
<th>Tools</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Safety and Personal protective equipment:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-flammable clothing made of fabric such as cotton</td>
<td>Air/acetylene torch set with appropriate tip</td>
<td>Cup-type striker</td>
</tr>
<tr>
<td>Long-sleeve shirt and cuff-less pants</td>
<td>Oxyacetylene equipment with appropriate brazing tips</td>
<td>Wet cloth</td>
</tr>
<tr>
<td>Eye and face protection</td>
<td>Solder and brazing filler metals; phosphorous-bearing filler metal is suggested for brazing</td>
<td></td>
</tr>
<tr>
<td>Hearing protection as designated by the instructor or training facility provider</td>
<td>Solder and brazing fluxes</td>
<td></td>
</tr>
<tr>
<td>Hard hats</td>
<td>Copper tubing and fittings (1/4&quot; OD tubing is suggested for soldering; 3/8&quot; or 1/2&quot; OD tubing is suggested for oxyacetylene brazing)</td>
<td></td>
</tr>
<tr>
<td>Flame-resistant gloves and high-top work boots</td>
<td>Nitrogen cylinder with regulator</td>
<td></td>
</tr>
<tr>
<td>Hearing protection as designated by the instructor or training facility provider</td>
<td>Accessories for nitrogen purging</td>
<td></td>
</tr>
<tr>
<td>Hard hat as designated by the instructor or training facility provider</td>
<td>Propane, MAP-Pro, and/or small acetylene cylinders</td>
<td></td>
</tr>
<tr>
<td>Fire extinguisher</td>
<td>Self-igniting soldering torch head</td>
<td></td>
</tr>
<tr>
<td>Fire blanket or other flame/heat blocking material if soldering or blazing is done near other flammable material</td>
<td>Air/acetylene torch kit, complete</td>
<td></td>
</tr>
<tr>
<td>Copies of the Module Examination and Performance Profile Sheets</td>
<td>Various solders</td>
<td></td>
</tr>
<tr>
<td>HVAC Level One PowerPoint® Presentation Slides, DVD player</td>
<td>Various soldering fluxes</td>
<td></td>
</tr>
<tr>
<td>Whiteboard/chalkboard</td>
<td>Heat-absorbing paste</td>
<td></td>
</tr>
<tr>
<td>Markers/chalk</td>
<td>Complete oxyacetylene outfit with regulators, operating tools, tip cleaners, and various torch handles and tip styles</td>
<td></td>
</tr>
<tr>
<td>Pencils and paper</td>
<td>Various types of filler metal rods</td>
<td></td>
</tr>
<tr>
<td>LCD projector and screen</td>
<td>Brazing flux</td>
<td></td>
</tr>
<tr>
<td>Computer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TV/VCR (optional)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

To the extent possible, and as required for performance testing, provide a selection of the tools listed for each session; alternatively, photos may be used to teach tool identification.
Lesson Plans for Module 03105-13

BASIC CARBON STEEL PIPING PRACTICES

The Trainee Guide for HVAC Level One is available as an NCCERconnect ebook. Contact your NCCER customer service representative at 1-888-622-3720 for more information.

Module Nine (03105-13) provides the basic knowledge and skills needed to thread and install carbon steel piping systems. In addition, the concepts of assembling and installing grooved piping systems are also presented. The module provides coverage of basic piping system installation considerations and coverage of piping system hangers and supports.

Objectives

Learning Objective 1
- Describe and identify the various types of steel pipe and fittings.
  a. Identify the characteristics and uses of steel pipe.
  b. Describe how pipe threads are classified and measured.
  c. Identify the various types of fittings used on steel pipe and describe how they are used.
  d. Describe how to properly measure lengths of steel pipe.

Learning Objective 2
- Describe the tools and methods used to cut and thread steel pipe.
  a. Identify pipe cutting and reaming tools and describe how they are used.
  b. Identify threading tools and describe how they are used.

Learning Objective 3
- Explain and demonstrate the methods of installing and mechanically joining steel pipe.
  a. Explain and demonstrate the methods and use of the tools to connect threaded pipe.
  b. Explain and demonstrate an understanding of pipe grooving methods.
  c. Describe how to assemble flanged steel pipe.
  d. Describe how to correctly install steel pipe.

Performance Tasks

Performance Task 1 (Learning Objective 1)
- Cut, ream, and thread steel pipe.

Performance Task 2 (Learning Objectives 1 and 2)
- Join lengths of threaded pipe using selected fittings.

Teaching Time: 10 hours
(Four 2.5-Hour Sessions)

Session time may be adjusted to accommodate your class size, schedule, and teaching style.

Prerequisites

Completion of NCCER Core Curriculum.

Before You Begin

As you prepare for each session, allow sufficient time to review the course objectives, content, visual aids (including the PowerPoint® presentation), and these lesson plans, and to gather the required equipment and materials. Consider time required for demonstrations, laboratories, field trips, and testing.

Using your access code, download the written examinations and performance profile sheets from www.nccerirc.com. The passing score for submission into NCCER’s Registry is 70% or above for the written examination; performance testing is graded pass or fail.
**Safety Considerations**

This module requires that trainees work with steel piping materials, common hand tools, and powerful rotating machinery and power tools. Personal safety must be emphasized at all times. Trainees should be carefully observed to ensure that they wear the proper PPE, follow safe practices, and give due respect to the hazards of operating power tools and handling metal parts. Any deficiencies must be corrected to ensure future trainee safety as they begin working with even more hazardous systems later in their training and career. All practice sessions and Performance Tasks must be completed under your direct supervision.

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**Classroom Equipment and Materials**

- Whiteboard/chalkboard
- Markers/chalk
- Pencils and paper
- HVAC Level One PowerPoint® Presentations
- DVD player
- LCD projector and screen
- Computer
- Copies of the Module Examination and Performance Profile Sheets

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**Equipment and Materials for Laboratories and Performance Testing**

- ½" steel pipe for threading demonstration and practice (other sizes may be used)
- Hand threader stock and appropriate dies for threading
- Assortment of fittings of the same pipe size
- Power threader
- Chain or yoke tripods
- Single- and/or four-wheel pipe cutters
- Pipe reamers
- Measuring tapes
- Thread cutting oil and pump basin
- Pipe wrenches
- Pipe joint compound
- PTFE tape
- Rags
- Various threaded pipe fittings, including:
  - Tees
  - Crosses
  - Elbows of various angles
  - Ground-joint unions
  - Flange union
  - Couplings, including reducing couplings

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**Additional Resources**

This module presents thorough resources for task training. The following resource material is suggested for further study.


Instructors should view any videos that may be identified in the lesson plan before using them to ensure their suitability. The videos can provide teachable moments in both proper and improper work processes and behaviors. Be prepared to stop the videos at appropriate times to point out and discuss both proper and improper issues.

Instructors are also encouraged to locate additional audiovisual aids available on the internet, make personal videos, and take still pictures related to the HVAC/R trade and add them to the PowerPoint® presentations throughout the program.
SESSION ONE

Session One introduces trainees to carbon steel piping materials and fittings typically used in the HVAC/R environment. The processes of cutting, reaming, and threading pipe are reviewed in the classroom.

1. Show the Session One PowerPoint® presentation.
2. Use the video(s) identified in the Kickoff Activity to get trainees engaged and give them an idea of what they will learn in this module.
3. Describe the various piping materials used in steel piping systems.
4. Familiarize trainees with tapered pipe threads.
5. Identify the common fittings used to assemble threaded piping systems.
6. Describe and discuss the processes of cutting and reaming steel pipe.
7. Describe and discuss the process of threading pipe using both manual and powered equipment.

SESSION THREE

Session Three is a laboratory and Performance Task session. Instructors demonstrate how to cut, ream, and thread steel pipe. The assembly of threaded joints is also demonstrated. Trainees then practice those tasks and may complete Performance Tasks 1 and 2.

1. Note that no PowerPoint® presentation is associated with this session.
2. Demonstrate measuring, cutting, and reaming steel pipe.
3. Demonstrate how to thread pipe using both a hand threader and a power threader.
4. Have trainees cut, ream, and thread pipe using both a hand threader and a power threader.
5. Demonstrate how to properly assemble threaded pipe and fittings.
6. Have trainees assemble threaded pipe and fittings.

SESSION FOUR

Session Four is a review and testing session. Have trainees complete the Module Review Questions and Trade Terms Quiz. These may have been assigned as homework at the end of Session Three. Go over the Module Review Questions in class prior to the exam and answer any questions that the trainees may have.

1. Have trainees complete the written examination. Any outstanding performance testing must be completed during this session as well.
2. Record the testing results on Training Report Form 200, and submit the report to your Training Program Sponsor.
### Materials Checklist for Module 03105-13, Basic Carbon Steel Piping Practices

<table>
<thead>
<tr>
<th>Equipment and Materials</th>
<th>Equipment</th>
<th>Tools</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Personal protective equipment:</strong></td>
<td>Power threader</td>
<td>Chain or yoke tripods</td>
</tr>
<tr>
<td>Non-flammable clothing made of fabric such as cotton</td>
<td>½” steel pipe for threading demonstration and practice (other sizes may be used)</td>
<td>Pipe reamers</td>
</tr>
<tr>
<td>Long-sleeve shirt and cuffless pants</td>
<td>Hand threader stock and appropriate dies for threading</td>
<td>Measuring tapes</td>
</tr>
<tr>
<td>Eye and face protection</td>
<td>Assortment of fittings of the same pipe size</td>
<td>Pipe wrenches</td>
</tr>
<tr>
<td>Hearing protection as designated by the instructor or training facility provider</td>
<td>Thread cutting oil and pump basin</td>
<td>Chain and/or yoke vises</td>
</tr>
<tr>
<td>Hard hats</td>
<td>Pipe joint compound</td>
<td>Hand threader stock with various dies</td>
</tr>
<tr>
<td>Flame-resistant gloves and high-top work boots</td>
<td>PTFE tape</td>
<td>Various types and sizes of pipe wrenches</td>
</tr>
<tr>
<td>Hearing protection as designated by the instructor or training facility provider</td>
<td>Fire blanket or other flame/heat blocking material if soldering or blazing is done near other flammable material</td>
<td>Rags</td>
</tr>
<tr>
<td>Hard hat as designated by the instructor or training facility provider</td>
<td>Various threaded pipe fittings, including: Tees Crosses Elbows of various angles Ground-joint unions Flange union Couplings, including reducing couplings Nipples Plugs Caps Bushings</td>
<td>Single- and/or four-wheel pipe cutters</td>
</tr>
<tr>
<td>Copies of the Module Examination and Performance Profile Sheets</td>
<td>Fire extinguisher</td>
<td></td>
</tr>
<tr>
<td>HVAC Level One PowerPoint® Presentation Slides, DVD player</td>
<td>White and yellow PTFE thread tape</td>
<td></td>
</tr>
<tr>
<td>Whiteboard/chalkboard</td>
<td>One or more types of grooved joint couplings with gaskets</td>
<td></td>
</tr>
<tr>
<td>Markers/chalk</td>
<td>Raised-face pipe flange</td>
<td></td>
</tr>
<tr>
<td>Pencils and paper</td>
<td>Full-face pipe flange</td>
<td></td>
</tr>
<tr>
<td>LCD projector and screen</td>
<td></td>
<td></td>
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<tr>
<td>Computer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TV/VCR/DVD player (optional)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

To the extent possible, and as required for performance testing, provide a selection of the tools listed for each session; alternatively, photos may be used to teach tool identification.
Lesson Plans for Module 03206-13

**ALTERNATING CURRENT**

The Trainee Guide for *HVAC Level Two* is available as an NCCERconnect e-book. Contact your NCCER customer service representative at 1-888-622-3720 for more information.

**Module One (03206-13)** presents the basic concepts of alternating current generation and use. It also discusses how single- and three-phase alternating current is used to power resistive and inductive circuits in HVAC/R equipment. Various types of transformers used in HVAC systems are identified. The basic operation of single- and three-phase motors is explained. In addition, the process of safely testing AC-powered devices is covered.

### Objectives

#### Learning Objective 1
- Explain how AC power is generated and how it is used.
  - a. Explain the basic concepts of power generation.
  - b. Describe a sine wave and how it is created.
  - c. Explain the concept of AC power frequency.
  - d. Explain how single- and three-phase power is provided for practical use.
  - e. Identify resistive and inductive circuits.

#### Learning Objective 2
- Explain how transformers operate and identify various types of transformers used in HVAC systems.
  - a. Explain how transformers operate.
  - b. Identify various forms of single-phase and three-phase transformers.

#### Learning Objective 3
- Explain the various types of induction motors and explain how they operate.
  - a. Explain how single-phase motors operate.
  - b. Describe single-phase motor starting circuits.
  - c. Identify the physical and operating characteristics of three-phase motors.

#### Learning Objective 4
- Explain how to safely test various AC-powered devices.
  - a. Identify electrical test instruments and methods used to test motors.
  - b. Explain how to use a capacitor tester.
  - c. Identify basic electrical safety rules and guidelines for safely testing AC components.

### Performance Tasks

**Performance Task 1** (Learning Objective 1)
- Point out the components used in a functional AC power supply circuit and explain their functions.

**Performance Task 2** (Learning Objective 4)
- Following applicable safety practices, test AC components, including transformers, capacitors, and motor windings.

### Teaching Time: 10 hours

(Four 2.5-Hour Classroom Sessions)

Session time may be adjusted to accommodate your class size, schedule, and teaching style.

### Prerequisites

*Core Curriculum* and *HVAC Level One*.

### Before You Begin

As you prepare for each session, allow sufficient time to review the course objectives, content, visual aids (including the PowerPoint® presentation), and these lesson plans, and to gather the required equipment and materials. Consider time required for demonstrations, laboratories, field trips, and testing.

Using your access code, download the written examinations and performance profile sheets from www.nccerirc.com. The passing score for submission into NCCER’s Registry is 70% or above for the written examination; performance testing is graded pass or fail.
Safety Considerations
This module requires that trainees work with and in the vicinity of functioning HVAC equipment as well as live electrical circuits at less than 500VAC. Electrical and mechanical safety must be emphasized at all times. Trainees should be carefully observed to ensure that they wear the proper PPE, follow safe practices, and give due respect to the hazards of energized and operating HVAC systems and components. Any deficiencies must be corrected to ensure future safety as trainees begin working with even more hazardous systems later in their training and career. All practice sessions and Performance Tasks must be completed under your direct supervision.

Classroom Equipment and Materials
Whiteboard/chalkboard
Markers/chalk
Pencils and paper
HVAC Level Two PowerPoint® Presentation Slides
DVD player
LCD projector and screen
Computer
Calculators
Various control transformers
Various single-phase motors
Three-phase motor
Capacitor tester
Megohmmeter
Copies of the Module Examination and Performance Profile Sheets

Equipment and Materials for Laboratories and Performance Testing
Standard eye protection
Work gloves
Proper footwear as designated by the instructor or training facility
Hearing protection as designated by the instructor or training facility
One or more powered HVAC systems
Multimeters
Capacitor testers
Various motors, both functional and electrically damaged
Control transformers, both functional and electrically damaged
Various start and run capacitors

Additional Resources
This module presents thorough resources for task training. The following resource material is suggested for further study.


There are a number of online resources available for trainees who would like more information on alternating current. A search for additional information may be assigned as homework to interested trainees.

Instructors should view any videos that may be identified in the lesson plan before using them to ensure their suitability. The videos can provide teachable moments in both proper and improper work processes and behaviors. Be prepared to stop the videos at appropriate times to point out and discuss both proper and improper conduct and techniques.

Instructors are also encouraged to locate additional audiovisual aids available on the internet, make personal videos, and take photos related to the HVAC/R trade and add them to the PowerPoint® presentations throughout the program.
The Lesson Plan for this module is divided into four 2.5-hour sessions. This time includes 10 minutes for administrative tasks and a 10-minute break per session.

### Session One
Session One reviews AC and DC power generation. Essential information about AC power concepts is presented, along with the function and operation of transformers.
1. Use the Kickoff Activity to get trainees engaged and provide some historical information about Nikola Tesla.
2. Show the Session One PowerPoint® presentation.
3. Explain the basic concepts of AC power generation and distribution.
4. Discuss resistive and inductive circuits.
5. Discuss the operation of different transformers and their role in HVAC systems.

### Session Two
Session Two focuses on the operation of both single- and three-phase motors and how they are electrically tested.
1. Show the Session Two PowerPoint® presentation.
2. Explain how various single-phase motors operate.
3. Present starting strategies for single-phase motors.
4. Describe the construction and operation of three-phase motors.
5. Discuss electrical testing procedures and the required safety guidelines for testing AC components.

### Session Three
Session Three is devoted to laboratories and Performance Tasks 1 and 2.
1. Note that no PowerPoint® presentation is associated with this session.
2. Trainees must demonstrate their individual knowledge of the power supply components serving an HVAC system.
3. Demonstrate testing procedures for a transformers, motors, and capacitors.
4. Trainees practice or complete the tasks associated with Performance Tasks 1 and 2.

### Session Four
Session Four is a review and testing session. Have trainees complete the Module Review Questions. Alternatively, these may be assigned as homework at the end of Session Two. Go over the Module Review Questions in class prior to the exam and answer any questions that the trainees may have.
1. Have trainees complete the written examination. Any outstanding performance testing must be completed during this session as well.
2. Record the testing results on Training Report Form 200, and submit the report to your Training Program Sponsor.
Module Two (03302-13) presents refrigerant compressors. Since the compressor is considered the heart of any HVAC system, its good health and well-being are crucial to overall system performance and reliability. Compressors can take many forms, but they all perform the same basic function. They create the pressure differential in the system that allows refrigerant to move through the metering device and through the condenser and evaporator coils where heat is exchanged. Because the compressor is the most expensive component in most HVAC systems, it is important that technicians be able to correctly diagnose and correct problems that can affect compressor operation to avoid a costly compressor replacement.

Objectives

Learning Objective 1
- Identify and describe the operation of various compressor types.
  a. Identify and describe the operation of various hermetic and semi-hermetic compressors.
  b. Identify and describe the operation of reciprocating compressors.
  c. Identify and describe the operation of rotary compressors.
  d. Identify and describe the operation of scroll compressors.
  e. Identify and describe the operation of screw compressors.
  f. Identify and describe the operation of centrifugal compressors.

Learning Objective 2
- Identify and describe various approaches to compressor capacity control.
  a. Identify and describe capacity control methods for reciprocating and scroll compressors.
  b. Identify and describe capacity control methods for screw and centrifugal compressors.

Learning Objective 3
- Describe common causes of compressor failures.
  a. Describe compressor failures related to the refrigerant circuit.
  b. Describe compressor failures related to electrical issues.

Learning Objective 4
- Identify and explain the operation of various compressor protection devices.
  a. Identify and explain the operation of various overload devices.
  b. Identify and explain the operation of other compressor protection devices.

Learning Objective 5
- Explain how to analyze the operation of a hermetic compressor.
  a. Explain how to evaluate the mechanical operation of an operable compressor.
  b. Explain how to evaluate the electrical operation of an operable compressor.

Performance Tasks

Performance Task 1 (Learning Objective 5)
- Measure and record the electrical and mechanical operating parameters of an operational compressor.

Performance Task 2 (Learning Objective 3)
- Use a sealed tube acid/moisture test kit to test a refrigerant circuit.

Teaching Time: 12.5 hours
(Five 2.5-Hour Classroom Sessions)
Session time may be adjusted to accommodate your class size, schedule, and teaching style.

Prerequisites
Core Curriculum and HVAC Level One.
Before You Begin
As you prepare for each session, allow sufficient time to review the course objectives, content, visual aids (including the PowerPoint® presentation), and these lesson plans, and to gather the required equipment and materials. Consider time required for demonstrations, laboratories, field trips, and testing.

Using your access code, download the written examinations and performance profile sheets from www.nccerirc.com. The passing score for submission into NCCER’s Registry is 70% or above for the written examination; performance testing is graded pass or fail.

Safety Considerations
This module requires that trainees work on functioning HVAC equipment. In those instances, trainees should be carefully observed to ensure that they wear the proper PPE, follow safe practices, and give due respect to the hazards of energized and operating HVAC systems. Any work on functioning HVAC equipment must be done under the direct supervision of the instructor.

Classroom Equipment and Materials
Whiteboard/chalkboard
Markers/chalk
Pencils and paper
HVAC Level Two PowerPoint®
Presentation Slides
DVD player
LCD projector and screen
Computer
Calculators
Copies of the Module Examination and Performance Profile Sheets
Fixed and orbiting scrolls from a scroll compressor
An electronic compressor overload control module
Various types of pressure switches used for compressor and system protection
Anti-short-cycle timers, both delay-on-break and delay-on-make styles

Equipment and Materials for Laboratories and Performance Testing
Standard eye protection
Work gloves
Proper footwear as designated by the instructor or training facility
Hearing protection as designated by the instructor or training facility
Common hand tools to remove equipment access panels
Manufacturer’s installation and startup instructions for the equipment in use

Additional Resources
This module presents thorough resources for task training. The following resource material is suggested for further study.


There are a number of on-line resources available for trainees who would like more information on compressors. A search for additional information may be assigned as homework to interested trainees.

Instructors should view any videos that may be identified in the lesson plan before using them to ensure their suitability. The videos can provide teachable moments in both proper and improper work processes and behaviors. Be prepared to stop the videos at appropriate times to point out and discuss both proper and improper conduct and techniques.

Instructors are also encouraged to locate additional audiovisual aids available on the internet, make personal videos, and take photos related to compressors and add them to the PowerPoint® presentations throughout the program. Resources available on the internet include how-to videos that show various service techniques. Some valuable video resources relevant to the module are provided by Emerson Climate Technologies® and can be found at:

http://www.emersonclimate.com/en-us/Resources/Emerson_Climate_Videos/Pages/Emerson_Climate_Videos.aspx
The Lesson Plan for this module is divided into five 2.5-hour sessions. This time includes 10 minutes for administrative tasks and a 10-minute break per session.

**SESSION ONE**

Session One reviews the construction and operating characteristics of various compressor types.

1. Show the Session One PowerPoint® presentation.
2. Use the Kickoff Activity to get trainees engaged in the subject matter.
3. Discuss the characteristics of hermetic and semi-hermetic compressors.
4. Explain the differences between reciprocating, rotary, scroll, screw, and centrifugal compressors.

**SESSION THREE**

Session Three explores devices used to protect the compressor from conditions that can cause compressor failure or other system damage. A discussion of compressor performance analysis completes the session.

1. Show the Session Three PowerPoint® presentation.
2. Describe electrical protection devices that are used with compressors.
3. Discuss other protective devices, such as pressure switches.
4. Explain how both the mechanical and electrical operation of a compressor is analyzed.

**SESSION TWO**

Session Two presents the various approaches to compressor and system capacity control. In addition, the common causes and types of compressor failures are explored.

1. Show the Session Two PowerPoint® presentation.
2. Explain how capacity control can be achieved with various types of compressors.
3. Emphasize the importance of oil management when multiple compressors operate on a single refrigerant circuit.
4. Explain how problems in the refrigerant circuit can lead to compressor failure.
5. Describe various types of compressor electrical failure and their potential causes.

**SESSION FOUR**

Session Four is devoted to laboratories and Performance Tasks 1 and 2.

1. Note that there is no PowerPoint® presentation associated with this session.
2. Demonstrate how to use a sealed-tube acid/moisture test kit.
3. Demonstrate how to measure and record essential information from an operating compressor.
4. Trainees practice and/or complete Performance Tasks 1 and 2.

**SESSION FIVE**

Session Five is a review and testing session. Have trainees complete the module Review Questions. Go over the module Review Questions in class prior to the exam and answer any questions that the trainees may have.

1. Have trainees complete the written examination. Any outstanding performance testing must be completed during this session as well.
2. Record the testing results on Training Report Form 200, and submit the report to your Training Program Sponsor.
Module Three (03301-13) discusses the refrigerants and oils used in modern refrigeration and air conditioning systems. Today, new technologies and stringent environmental laws are driving changes in the HVAC industry. Older refrigerants that damage the environment are being phased out and replaced with more environmentally-friendly refrigerants. These new refrigerants often require new compressor lubricating oils. These modern refrigerants and oils also have new handling and service requirements with which technicians must be familiar.

### Objectives

**Learning Objective 1**
- Define *refrigerants* and their desirable characteristics and identify the various applications that require specific refrigerant characteristics.
  - Define *refrigerants* and identify desirable characteristics.
  - Identify the various applications that require specific refrigerant characteristics.

**Learning Objective 2**
- Identify various refrigerant classifications and describe their environmental impact.
  - Identify the primary chemical classifications of common characteristics.
  - Describe the environmental concerns associated with refrigerants.
  - Identify and describe compounded and blended azeotropic, near-azeotropic, and zeotropic refrigerants.
  - Identify the safety classifications of refrigerants.

**Learning Objective 3**
- Explain how to use pressure-temperature (P-T) charts to calculate superheat and subcooling.
  - Explain how to use P-T charts for compound, azeotropic, and near-azeotropic refrigerants to calculate superheat and subcooling.
  - Explain how to use P-T charts for zeotropic refrigerants to calculate superheat and subcooling.

**Learning Objective 4**
- Describe the important issues related to the function of lubricating oils in the refrigerant circuit.
  - Identify the important characteristics of refrigerant oils.
  - Identify mineral-based and synthetic oils.
  - Describe issues related to the movement of oil through the refrigerant circuit.
  - Describe the various types and sources of oil contamination.
  - Describe common practices associated with handling, charging, and removing oils.

**Learning Objective 5**
- Explain the considerations related to various refrigerant conversion processes.
  - Identify issues of concern for all refrigerant conversions.
  - Describe common practices related to popular refrigerant conversions.

### Performance Tasks

**Performance Task 1 (Learning Objective 3)**
- Install refrigerant gauges on a functional system and calculate superheat and subcooling using the appropriate P-T chart.

### Teaching Time: 12.5 hours

(Five 2.5-Hour Classroom Sessions)

Session time may be adjusted to accommodate your class size, schedule, and teaching style.

### Prerequisites

*Core Curriculum* and *HVAC Level One*. 
Before You Begin
As you prepare for each session, allow sufficient time to review the course objectives, content, visual aids (including the PowerPoint® presentation), and these lesson plans, and to gather the required equipment and materials. Consider time required for demonstrations, laboratories, field trips, and testing.

Using your access code, download the written examinations and performance profile sheets from www.nccerirc.com. The passing score for submission into NCCER's Registry is 70% or above for the written examination; performance testing is graded pass or fail.

Safety Considerations
This module does require that trainees work on functioning HVAC equipment. In those instances, trainees should be carefully observed to ensure that they wear the proper PPE, follow safe practices, and give due respect to the hazards of energized and operating HVAC systems. Any work on functioning HVAC equipment must be done under the direct supervision of the instructor.

Classroom Equipment and Materials
- Whiteboard/chalkboard
- Markers/chalk
- Pencils and paper
- HVAC Level Two PowerPoint® Presentation Slides
- DVD player
- LCD projector and screen
- Computer
- Refrigerant P-T charts
- Copies of the Module Examination and Performance Profile Sheets
- Acid/moisture test kit
- Oil test kit

Equipment and Materials for Laboratories and Performance Testing
- Standard eye protection
- Gloves
- Proper footwear as designated by the instructor or training facility provider
- Hearing protection as designated by the instructor or training facility provider
- Refrigerant P-T charts for the refrigerants in use
- Gauge manifold sets (compatible with all refrigerants being used)
- Thermometers appropriate to measure refrigerant line temperatures
- Operating HVAC or refrigeration equipment; ideally, at least one system using an azeotropic or near-azeotropic refrigerant and at least one that uses azeotropic refrigerant is needed.
- Hand tools needed to access equipment (screwdrivers, nut drivers, etc.)

Additional Resources
This module presents thorough resources for task training. The following resource material is suggested for further study.


There are a number of online resources available for trainees who would like more information on refrigerants and oils. A search for additional information may be assigned as homework to interested trainees.

Instructors should view any videos that may be identified in the lesson plan before using them to ensure their suitability. The videos can provide teachable moments in both proper and improper work processes and behaviors. Be prepared to stop the videos at appropriate times to point out and discuss both proper and improper conduct and techniques.

Instructors are also encouraged to locate additional audiovisual aids available on the internet, make personal videos, and take photos related to refrigerants and oils and add them to the PowerPoint® presentations throughout the program.
The Lesson Plan for this module is divided into five 2.5-hour sessions. This time includes 10 minutes for administrative tasks and a 10-minute break per session.

**Session One**

Session One defines refrigerants and reviews the characteristics of various refrigerants commonly found in today's systems.

1. Show the Session One PowerPoint® presentation.
2. Use the Kickoff Activity to get trainees engaged.
3. Define refrigerants and the various applications that require specific refrigerant characteristics.
4. Identify the primary chemical classifications of common refrigerants.
5. Identify and describe compounded and blended azeotropic, near-azeotropic, and zeotropic refrigerants.
6. Identify the safety classifications of refrigerants.

**Session Two**

Session Two reviews the use of P-T charts to determine superheat and subcooling values for various refrigerant types. In addition, the subject of lubricating oils is introduced.

1. Show the Session Two PowerPoint® presentation.
2. Review superheat and subcooling and the procedures for their calculation for azeotropic and near-azeotropic refrigerants.
3. Explain how superheat and subcooling calculations are made on zeotropic refrigerants.
4. Identify important and desirable characteristics of refrigerant oils.

**Session Three**

Session Three is devoted to laboratories and Performance Task 1.

1. Explain and demonstrate how to connect to an operating refrigerant circuit and use P-T charts to calculate superheat and subcooling.
2. Have trainees practice acquiring pressures and temperatures from operating systems and determining the superheat and subcooling values. These activities correspond to Performance Task 1.
3. Identify important and desirable characteristics of refrigerant oils.

**Session Four**

Session Four covers the function and movement of refrigeration oil through an operating system and on version of a refrigerant circuit to an alternative refrigerant.

1. Show the Session Four PowerPoint® presentation.
2. Discuss issues related to the movement of oil through the refrigerant circuit.
3. Describe the various types and sources of oil contamination.
4. Describe common practices associated with handling, charging, and removing oils.
5. Identify issues of concern and common practices for refrigerant conversions.

**Session Five**

Session Five is a review and testing session. Have trainees complete the Module Review Questions. Answer any questions that the trainees may have.

1. Have trainees complete the written examination. Any outstanding performance testing must be completed during this session as well.
2. Record the testing results on Training Report Form 200, and submit the report to your Training Program Sponsor.
Lesson Plans for Module 03205-13

LEAK DETECTION, EVACUATION, RECOVERY, AND CHARGING

The Trainee Guide for HVAC Level Two is available as an NCCERconnect e-book. Contact your NCCER customer service representative at 1-888-622-3720 for more information.

Module Four (03205-13) provides trainees with guidance related to servicing the refrigerant circuit of HVAC systems. The four essential service tasks—leak detection, evacuation, recovery, and charging—are covered in detail. In addition, information related to the US EPA’s requirements for providing these services in an environmentally sound manner are also provided. Developing the necessary skills to provide these services are vital to the future success of trainees in the HVAC/R trade. To that end, a significant amount of this module is devoted to hands-on practice and the successful completion of its required performance tasks.

### Objectives

**Learning Objective 1**
- Describe the equipment and approaches used to leak test refrigerant circuits.
  a. Describe the various devices used to detect refrigerant leaks.
  b. Describe how leak detection is approached based on the current refrigerant charge in the system.

**Learning Objective 2**
- Describe refrigerant containment and management requirements and the equipment used to recover refrigerants.
  a. Identify the basic refrigerant containment requirements of Section 608 of the Clean Air Act.
  b. Identify and explain how to operate refrigerant recovery and recycling equipment.

**Learning Objective 3**
- Explain the related principles and identify the equipment used to evacuate refrigerant circuits.
  a. Explain the basic principles of refrigerant circuit evacuation.
  b. Identify and explain how to operate the equipment used to evacuate refrigerant circuits.

**Learning Objective 4**
- Describe the procedures for charging refrigerant circuits.
  a. Identify and describe the equipment and components related to refrigerant charging.
  b. Explain how to properly charge various types of refrigerants using different methods.

### Performance Tasks

**Performance Task 1 (Learning Objective 1)**
- Use a mixture of nitrogen with traces of HCFC-22 refrigerant to pressurize a refrigerant system in preparation for leak testing.

**Performance Task 2 (Learning Objective 1)**
- Using at least two of the following methods, leak test a pressurized refrigerant circuit:
  - Electronic leak detector
  - Ultrasonic leak detector
  - Liquids
  - Ultraviolet/fluorescent systems

**Performance Task 3 (Learning Objective 2)**
- Use a recovery unit to recover the refrigerant from a system.

**Performance Task 4 (Learning Objective 3)**
- Evacuate a system using the deep vacuum method and perform a vacuum leak test.

**Performance Task 5 (Learning Objective 3)**
- Evacuate a system using the triple evacuation method.

**Performance Task 6 (Learning Objective 4)**
- Demonstrate how to properly charge a refrigerant circuit by the following methods:
  - By weight
  - By superheat (fixed orifice metering device)
  - By subcooling (thermostatic expansion valve metering device)

### Teaching Time: 30 hours
(Twelve 2.5-Hour Classroom Sessions)
Session time may be adjusted to accommodate your class size, schedule, and teaching style.

### Prerequisites

*Core Curriculum* and *HVAC Level One.*
**Before You Begin**

As you prepare for each session, allow sufficient time to review the course objectives, content, visual aids (including the PowerPoint® presentation), and these lesson plans, and to gather the required equipment and materials. Consider time required for demonstrations, laboratories, field trips, and testing.

Using your access code, download the written examinations and performance profile sheets from www.nccerirc.com. The passing score for submission into NCCER’s Registry is 70% or above for the written examination; performance testing is graded pass or fail.

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**Safety Considerations**

This module requires that trainees work with refrigerants and other pressurized gases in addition to functioning HVAC equipment. In those instances, trainees should be carefully observed to ensure that they wear the proper PPE, follow safe practices, and give due respect to the hazards of operating HVAC systems and handling refrigerants. Any work performed on functioning HVAC equipment must be done under the direct supervision of the instructor.

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**Classroom Equipment and Materials**

- Whiteboard/chalkboard
- Markers/chalk
- Pencils and paper
- HVAC Level Two PowerPoint® Presentation Slides
- DVD player
- LCD projector and screen
- Computer
- Calculators
- One or more electronic leak detectors
- One or more ultrasonic leak detectors
- Fluorescent dye capsule and ultraviolet light assembly
- One or more types of refrigerant recovery units
- One or more vacuum pumps
- One or more vacuum gauges or analyzers
- A cylinder of any zeotropic refrigerant
- One or more types of refrigerant charging scale
- Refrigerant charging cylinder
- Copies of the Module Examination and Performance Profile Sheets

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**Equipment and Materials for Laboratories and Performance Testing**

- Standard eye protection
- Butyl and work gloves
- Proper footwear as designated by the instructor or training facility provider
- Hearing protection as designated by the instructor or training facility provider
- Pressure-regulator assembly for nitrogen cylinders
- Pressure-relief valve for nitrogen-to-equipment connection
- Refrigerant gauge manifolds
- At least two of the following types of leak detectors:
  - Electronic leak detector
  - Ultrasonic leak detector
  - Liquid leak detection solution
- Fluorescent leak detection dyes with required lamps
- Refrigerant recovery unit(s)
- Refrigerant recovery cylinder(s)
- Additional charging hoses required for recovery and evacuation activities
- Small filter-driers for recovery units
- Vacuum pump(s)
- Vacuum gauge(s) or analyzer(s)
- Refrigerant scale(s)
- Digital thermometers, appropriate for suction and liquid line measurement
- Flashlights
- Two or more operational refrigeration, comfort cooling, or heat pump systems; split or packaged. Note that at least one system must be equipped with a fixed metering device, and another must be equipped with a TXV metering device.
- Cylinders of dry nitrogen
- HCFC-22 refrigerant
- Any additional refrigerants that may be required for the cooling and/or heat pump systems used in the laboratory session
Additional Resources
This module presents thorough resources for task training. The following resource material is suggested for further study.


There are a number of online resources available for trainees who would like more information on refrigerant leak detection, evacuation, recovery, and charging. A search for additional information may be assigned as homework to interested trainees.

Instructors should view any videos that may be identified in the lesson plan before using them to ensure their suitability. The videos can provide teachable moments in both proper and improper work processes and behaviors. Be prepared to stop the videos at appropriate times to point out and discuss both proper and improper conduct and techniques.

The instructor resources for this module include a number of relevant videos provided through the courtesy of Ritchie Engineering Company Inc., YELLOW JACKET Products Division. These videos are available on the Instructor Resource Center or DVD along with the PowerPoint® presentation. The video files can be accessed directly from the DVD, or via links placed in the suggested locations for viewing in the PowerPoint® presentation.

Instructors are also encouraged to locate additional audiovisual aids available on the internet, make personal videos, and take photos related to the subject matter and add them to the PowerPoint® presentations throughout the program.
Lesson Plans for Module 03303-13  
METERING DEVICES

The Trainee Guide for HVAC Level Two is available as an NCCERconnect e-book. Contact your NCCER customer service representative at 1-888-622-3720 for more information.

Module Five (03303-13) introduces metering devices used in the mechanical refrigeration cycle. The primary function of metering devices is presented, along with related components such as the distributor. The operation of capillary tube, fixed-orifice, and expansion-type metering devices is explored in detail. In addition, the process of selecting and installing thermal expansion valves specifically is covered.

Objectives

Learning Objective 1
- Explain the function of refrigerant metering devices and their effect on refrigerants.
  a. Explain the function of metering devices.
  b. Describe how refrigerants react as they pass through a metering device.
  c. Identify distributors and explain their relationship to metering device performance and operation.

Learning Objective 2
- Identify fixed metering devices and explain how they function.
  a. Identify and explain how fixed-orifice metering devices function.
  b. Identify and explain how capillary tubes function.
  c. Describe common problems associated with fixed metering devices.

Learning Objective 3
- Identify types of expansion valves and explain how they operate.
  a. Identify and explain the operation of manual expansion valves.
  b. Identify and explain the operation of automatic expansion valves.
  c. Identify and explain the operation of thermal expansion valves.
  d. Identify and explain the operation of electric and electronically controlled expansion valves.
  e. Describe common problems associated with all types of expansion valves.

Learning Objective 4
- Explain how thermal expansion valves are selected and installed.
  a. Explain how thermal expansion valves are selected for a given application.
  b. Describe the installation practices and considerations related to thermal expansion valves.

Performance Tasks

Performance Task 1 (Learning Objective 2)
- Replace the orifice piston in a piston-type metering device.

Performance Task 2 (Learning Objective 4)
- Install an externally equalized expansion valve, correctly placing the sensing bulb and equalizer tube.

Performance Task 3 (Learning Objective 4)
- Calculate superheat and adjust an expansion valve to obtain the correct superheat.

Teaching Time: 12.5 hours  
(Five 2.5-Hour Classroom Sessions)

Session time may be adjusted to accommodate your class size, schedule, and teaching style.

Prerequisites

Core Curriculum and HVAC Level One.

Before You Begin

As you prepare for each session, allow sufficient time to review the course objectives, content, visual aids (including the PowerPoint® presentation), and these lesson plans, and to gather the required equipment and materials. Consider time required for demonstrations, laboratories, field trips, and testing.

Using your access code, download the written examinations and performance profile sheets from www.nccerirc.com. The passing score for submission into NCCER’s Registry is 70% or above for the written examination; performance testing is graded pass or fail.
Safety Considerations

This module requires that trainees work with and in the vicinity of functioning HVAC equipment as well as live electrical circuits at less than 500VAC. In addition, soldering and brazing activities may be required. Electrical, mechanical, and refrigerant safety must be emphasized at all times. Trainees should be carefully observed to ensure that they wear the proper PPE, follow safe practices, and give due respect to the hazards of energized and operating HVAC/R systems and refrigerant circuits. Any deficiencies must be corrected to ensure future trainee safety as they begin working with even more hazardous systems later in their training and career. All practice sessions and Performance Tasks must be completed under your direct supervision.

Classroom Equipment and Materials

- Whiteboard/chalkboard
- Markers/chalk
- Pencils and paper
- HVAC Level Two PowerPoint® Presentation Slides
- DVD player
- LCD projector and screen
- Computer
- Calculators
- Capillary tubing
- A complete fixed-orifice metering device assembly
- An adjustable TXV that can be disassembled; a Sporlan S-Series valve or similar is best
- AN EEV that can be disassembled
- A modular expansion valve with several different mating components.
- An expansion valve (or modular valve component) equipped with Chatleff connections
- Copies of the Module Examination and Performance Profile Sheets

Equipment and Materials for Laboratories and Performance Testing

- Standard eye protection
- Work gloves
- Proper footwear as designated by the instructor or training facility
- Hearing protection as designated by the instructor or training facility
- Several expansion valves with mechanical fittings (such as Chatleff, Aeroquip, or flare)
- Several fixed-orifice pistons and housings
- Gauge manifolds
- Thermometers appropriate to measure refrigerant line temperatures
- Wrenches needed to install/adjust TXVs and fixed-orifice pistons
- Screwdrivers to install TXV sensing bulb straps
- One or more functional comfort cooling or refrigeration systems using a TXV as a metering device
- One or more comfort cooling or refrigeration systems that have no refrigerant charge

Additional Resources

This module presents thorough resources for task training. The following resource material is suggested for further study.

- TEV & AEV Theory and Application. Catalog E-1A. Sporlan Division of Parker Hannifin Corporation.

There are a number of online resources available for trainees who would like more information on metering devices. A search for additional information may be assigned as homework to interested trainees.

Instructors should view any videos that may be identified in the lesson plan before using them to ensure their suitability. The videos can provide teachable moments in both proper and improper work processes and behaviors. Be prepared to stop the videos at appropriate times to point out and discuss both proper and improper conduct and techniques.

Instructors are also encouraged to locate additional audiovisual aids available on the internet, make personal videos, and take photos related to the HVAC/R trade and add them to the PowerPoint® presentations throughout the program.
Session Outline for 03303-13

METERING DEVICES

The Lesson Plan for this module is divided into five 2.5-hour sessions. This time includes 10 minutes for administrative tasks and a 10-minute break per session.

**SESSION ONE**

Session One begins with a review of metering device functions and what changes take place in refrigerants as a result. The function of distributors is discussed. Fixed metering devices are presented in detail, along with common problems associated with them.

1. Show the Session One PowerPoint® presentation.
2. Use the Kickoff Activity to refresh the trainees’ memories on the subjects of superheat and subcooling.
3. Discuss the changes refrigerants undergo as they pass through the metering device and the evaporator.
4. Talk about the advantages and disadvantages of fixed metering devices.
5. Discuss fixed metering device performance issues in detail.

**SESSION TWO**

Session Two focuses on the construction and operation of various types of expansion valves.

1. Show the Session Two PowerPoint® presentation.
2. Present the use of manual expansion valves.
3. Discuss automatic expansion valves and their operation.
4. Discuss thermostatic expansion valves and their operation.
5. Discuss electric and electronic expansion valves and their operation.

**SESSION THREE**

Session Three reviews common problems associated with expansion valves. The session continues with coverage of expansion valve selection and installation procedures.

1. Show the Session Three PowerPoint® presentation.
2. Discuss common expansion valve problems, with an in-depth review of hunting.
3. Present the factors to consider when selecting TXVs.
4. Review the installation considerations of TXVs.
5. Explain how TXVs are adjusted.

**SESSION FOUR**

Session Four is devoted to laboratories and Performance Tasks 1, 2, and 3.

1. Demonstrate how to install fixed-orifice pistons; how to install a TXV; and how to adjust the superheat setting of a TXV.
2. Trainees practice and/or complete the tasks associated with Performance Tasks 1, 2, and 3.

**SESSION FIVE**

Session Five is a review and testing session. Have trainees complete the module Review Questions and go over the module Review Questions in class prior to the exam and answer any questions that the trainees may have.

1. Have trainees complete the written examination. Any outstanding performance testing must be completed during this session as well.
2. Record the testing results on Training Report Form 200, and submit the report to your Training Program Sponsor.
Lesson Plans for Module 03211-13

HEAT PUMPS

The Trainee Guide for HVAC Level Two is available as an NCCERconnect e-book. Contact your NCCER customer service representative at 1-888-622-3720 for more information.

Module Six (03211-13) introduces heat pumps, a very efficient form of electric heat. Compared to straight electric heat, heat pumps can consistently operate at higher energy efficiency. This module presents the operation of heat pump systems in detail with additional emphasis on the most common form of supplemental heat, electric resistance heating elements. The installation considerations of both split and packaged heat pumps systems are also reviewed.

Objectives

Learning Objective 1
• Explain heat pump operating principles and their related performance ratings.
  a. Explain how heat pumps can extract heat from air and water.
  b. Describe the Coefficient of Performance (COP) and how it is determined.
  c. Describe the Heating Seasonal Performance Factor (HSPF) and how it is determined.
  d. Describe the Seasonal Energy Efficiency Ratio (SEER) and how it is determined.

Learning Objective 2
• Describe the operation of heat pump systems.
  a. Describe the refrigeration cycle of heat pumps.
  b. Identify the various types of heat pump systems.
  c. Describe the basic control strategies for heat pumps and defrost cycles.
  d. Identify unit components that are important to heat pump operation.
  e. Describe sources of supplemental and/or emergency heat used in heat pumps.

Learning Objective 3
• Identify common installation practices associated with heat pumps.
  a. Identify installation practices associated with split systems.
  b. Identify installation practices associated with packaged systems.

Learning Objective 4
• Describe the operation of electric heating equipment used with heat pumps.
  a. Explain how electric heating equipment operates.
  b. Identify the major components of an electric heater.

Performance Tasks

Performance Task 1
• Install a heat pump and complete a proper startup.

Teaching Time: 20.0 hours
(Eight 2.5-Hour Classroom Sessions)
Session time may be adjusted to accommodate your class size, schedule, and teaching style.

Prerequisites
Core Curriculum and HVAC Level One.

Before You Begin
As you prepare for each session, allow sufficient time to review the course objectives, content, visual aids (including the PowerPoint® presentation), and these lesson plans, and to gather the required equipment and materials. Consider time required for demonstrations, laboratories, field trips, and testing.

Using your access code, download the written examinations and performance profile sheets from www.nccerirc.com. The passing score for submission into NCCER’s Registry is 70% or above for the written examination; performance testing is graded pass or fail.
**Safety Considerations**

This module does require that trainees work on functioning HVAC equipment. In those instances, trainees should be carefully observed to ensure that they wear the proper PPE, follow safe practices, and give due respect to the hazards of energized and operating HVAC systems. Any work on functioning HVAC equipment must be done under the direct supervision of the instructor.

**Classroom Equipment and Materials**

- Whiteboard/chalkboard
- Markers/chalk
- Pencils and paper
- HVAC Level Two PowerPoint® Presentation Slides
- DVD player
- LCD projector and screen
- Computer
- Calculators
- Copies of the Module Examination and Performance Profile Sheets

**Equipment and Materials for Laboratory and Performance Testing**

- Reversing valve
- An accessory electric heater package(s)
- Automatic reset limit switch
- Manual reset limit switch
- Fusible link
- Air/acetylene or oxyacetylene torch set with appropriate tips
- Cup-type striker
- Solder and/or brazing filler metals; phosphorous-bearing filler metal is suggested for brazing
- Solder and/or brazing fluxes (if required for filler metal in use)
- Nitrogen cylinder with regulator
- Accessories for nitrogen purging
- Common HVAC hand and power tools
- Flaring and/or swaging tools
- Gauge manifold set
- VOM and clamp-on ammeter
- Electronic thermometers
- Vacuum pump
- Vacuum analyzer
- Split-system heat pump equipment with accessory electric heater package, wall thermostat, and outdoor thermostat accessory kit
- Heat pump manufacturer’s installation and startup instructions (multiple copies)
- Pre-insulated interconnecting line set or the tubing, fittings, and insulation to create a line set
- Bi-flow filter-drier (optional)
- Fusible disconnect switches for indoor and outdoor units
- Power wiring materials, including wire, flexible conduit, conduit fittings, and wire nuts
- Thermostat wire
- Assorted hardware
- Refrigerant appropriate for the equipment
- PPE and safety equipment, including:
  - Eye and face protection
  - Work gloves
  - Flame-resistant gloves and high-top work boots
  - Hearing protection as designated by the instructor or training facility
  - Hard hats as designated by the instructor or training facility
  - Non-flammable clothing made of fabric such as cotton
  - Long-sleeve shirt and cuff-less pants
  - Fire extinguisher
  - Fire blanket or other flame/heat blocking material if soldering or blazing is done near other flammable material

**Additional Resources**

This module presents thorough resources for task training.

There are a number of online resources available for trainees who would like more information on heat pumps. A search for additional information may be assigned as homework to interested trainees.

Instructors should view any videos that may be identified in the lesson plan before using them to ensure their suitability. The videos can provide teachable moments in both proper and improper work processes and behaviors. Be prepared to stop the videos at appropriate times to point out and discuss both proper and improper conduct and techniques.

Instructors are also encouraged to locate additional audiovisual aids available on the internet, make personal videos, and take photos related to heat pumps and add them to the PowerPoint® presentations throughout the program.
The Lesson Plan for this module is divided into eight 2.5-hour sessions. This time includes 10 minutes for administrative tasks and a 10-minute break per session.

### Session Outline for 03211-13

**Heat Pumps**

**Session One**

Session One explains how heat pumps extract heat from air and water, defines the various heat pump performance ratings, and presents the heat pump refrigeration cycle.

1. Show the Session One PowerPoint® presentation.
2. Use the Kickoff Activity to get trainees engaged and refresh their memories of the refrigeration cycle.
3. Explain how heat pumps extract heat from air and water.
4. Define COP, HSPF, and SEER and describe how each is determined.
5. Review the heat pump refrigeration cycle and related components.

**Session Two**

Session Two identifies the various types of heat pumps and presents the related controls and control strategies.

1. Show the Session Two PowerPoint® presentation.
2. Review the various types of heat pump systems.
3. Review the wiring diagrams, controls, and typical sequence of operation in detail.

**Session Three**

Session Three describes the unique components found in heat pumps and supplemental heat sources. The installation considerations of split systems are also presented.

1. Show the Session Three PowerPoint® presentation.
2. Identify unit components that are important to heat pump operation.
3. Define the balance point and show how it is determined.
4. Describe sources of supplemental and/or emergency heat used in heat pump systems.
5. Present the installation considerations for split system heat pumps.

**Session Four**

Session Four describes how packaged heat pump systems are installed and reviews the details of supplemental electric heat accessories.

1. Show the Session Four PowerPoint® presentation.
2. Identify installation practices associated with packaged systems.
3. Discuss the components and power requirements for electric heat accessories.
4. Review the operation and safety controls related to electric heat.
5. Review plans for the upcoming laboratory sessions.
**SESSIONS FIVE - SEVEN**

Laboratory Sessions Five through Seven provide trainees an opportunity to practice the installation of a heat pump system, including the startup and performance testing of the equipment.

1. Note that there is no PowerPoint® presentation associated with this session.

2. Under your direct supervision, trainees install a heat pump system and complete the startup tasks per the manufacturer’s installation instructions.

3. Demonstrate the performance of any specific tasks that trainees have not yet practiced.

4. Trainees practice and/or complete the tasks associated with Performance Task 1 during this session.

**SESSION EIGHT**

Session Eight is a review and testing session. Have trainees complete the Module Review Questions. Go over the Module Review Questions in class prior to the exam and answer any questions that the trainees may have.

1. Have trainees complete the written examination. Any outstanding performance testing must be completed during this session as well.

2. Record the testing results on Training Report Form 200, and submit the report to your Training Program Sponsor.
Lesson Plans for Module 03215-13

BASIC MAINTENANCE

The Trainee Guide for HVAC Level Two is available as an NCCERconnect e-book. Contact your NCCER customer service representative at 1-888-622-3720 for more information.

Module Seven (03215-13) introduces trainees to the common tasks associated with basic maintenance activities. Specific tasks, such as lubrication and belt installation, are reviewed in detail. In addition, the module provides detailed coverage of the tasks required to complete thorough maintenance inspections of gas furnaces and common cooling/heat pump systems.

Objectives

Learning Objective 1
- Identify and describe common gaskets, packing materials, seals, and bearings.
  a. Identify and describe common gasket and packing materials.
  b. Identify and describe common types of seals.
  c. Identify and describe common types of bearings.

Learning Objective 2
- Describe the properties of common lubricants and how they are applied.
  a. Describe the properties of commonly used lubricants.
  b. Explain the importance of selecting the proper lubricants and how to apply them.

Learning Objective 3
- Identify different types of drive belts and describe how they are installed and adjusted.
  a. Identify various types of drive belts.
  b. Explain how to install and adjust drive belts.

Learning Objective 4
- Describe the inspection and/or maintenance requirements for selected equipment.
  a. Identify common health hazards associated with HVAC maintenance activities.
  b. Describe the common inspection and maintenance procedures for gas heating equipment.
  c. Describe the common inspection and maintenance procedures for DX cooling and heat pump systems.
  d. Describe the common inspection and maintenance procedures for various system accessories.
  e. Describe how to properly complete common HVAC service reports.

Performance Tasks

Performance Task 1 (Learning Objective 3)
- Properly install, align, and adjust a drive belt.

Performance Task 2 (Learning Objective 2)
- Lubricate a bearing using a grease gun.

Performance Task 3 (Learning Objective 4)
- Perform an inspection and periodic maintenance on a gas furnace and document the inspection results on a checklist.

Performance Task 4 (Learning Objective 4)
- Perform an inspection and periodic maintenance on a cooling or heat pump system and document the inspection results on a checklist.

Teaching Time: 20 hours
(Eight 2.5-Hour Classroom Sessions)
Session time may be adjusted to accommodate your class size, schedule, and teaching style.

Prerequisites

Core Curriculum and HVAC Level One.

Before You Begin

As you prepare for each session, allow sufficient time to review the course objectives, content, visual aids (including the PowerPoint® presentation), and these lesson plans, and to gather the required equipment and materials. Consider time required for demonstrations, laboratories, field trips, and testing.

Using your access code, download the written examinations and performance profile sheets from www.nccerirc.com. The passing score for submission into NCCER’s Registry is 70% or above for the written examination; performance testing is graded pass or fail.
**Safety Considerations**

This module requires that trainees work with and in the vicinity of functioning heating and cooling equipment as well as live electrical circuits at less than 500VAC. Electrical, mechanical, combustible gas, and refrigerant safety must be emphasized at all times. Trainees should be carefully observed to ensure that they wear the proper PPE, follow safe practices, and give due respect to the hazards of energized and operating HVAC/R systems and refrigerant circuits. Any deficiencies must be corrected to ensure future trainee safety as they begin working with even more hazardous systems later in their training and career. All practice sessions and Performance Tasks must be completed under your direct supervision.

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**Classroom Equipment and Materials**

- Whiteboard/chalkboard
- Markers/chalk
- Pencils and paper
- HVAC Level Two PowerPoint® Presentation Slides
- DVD player
- LCD projector and screen
- Computer
- Various types of gasket and packing material
- Bearings, including damaged bearings
- Gasket scraper
- Packing puller
- Mechanical and non-mechanical seals
- O-rings

**Equipment and Materials for Laboratories and Performance Testing**

- Standard eye protection
- Work gloves
- Proper footwear as designated by the instructor or training facility provider
- Hearing protection as designated by the instructor or training facility
- Respiratory protection as designated by the instructor or training facility
- A selection of oil and grease lubricants
- Lever-type grease gun
- Rags
- Roller bearings
- Straightedge
- Allen wrenches
- Refrigerant P-T charts or cards
- Refrigerant gauge manifolds
- AC/DC Ammeter (standard and microamp ranges)
- Multimeter
- Stack thermometers or electronic temperature probes with a sufficient range for flue measurements
- Draft gauges
- Selection of V-belts
- V-belt tension gauge
- Sling psychrometers
- U-tube and inclined tube manometers
- Carpenter’s level
- Lubricating oil
- Soap and water solution
- Vacuum cleaners
- Drill with spring cable and wire brush attachment
- Feeler gauges
- RTV-type sealant
- Coil cleaner
- Sprayer for coil cleaner solution
- Buckets
- Flashlights
- Inspection mirrors
- Utility knives
- Stiff brushes
- Insulated jumper wire (if needed for defrost bypass)
- Magnet

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**Additional Resources**

This module presents thorough resources for task training. The following resource material is suggested for further study.


There are a number of online resources, including video, available for trainees who would like more information on HVAC/R system maintenance. A search for additional information may be assigned as homework to interested trainees.

Instructors should view any videos before using them to ensure their suitability. The videos can provide teachable moments in both proper and improper work processes and behaviors. Be prepared to stop the videos at appropriate times to point out and discuss both proper and improper conduct and techniques.

Instructors are also encouraged to locate additional audiovisual aids available on the internet, make personal videos, and take still pictures related to the HVAC/R trade and add them to the PowerPoint® presentations throughout the program.
The Lesson Plan for this module is divided into eight 2.5-hour sessions. This time includes 10 minutes for administrative tasks and a 10-minute break per session.

**Session One**

Session One begins with coverage of the various types of gasket and packing materials and how they are used. It continues with coverage of mechanical and non-mechanical seals and concludes with a discussion of bearing types and their uses.

1. Show the Session One PowerPoint® presentation.
2. Use the Kickoff Activity to get trainees engaged and give them an idea of what they will learn in this module.
3. Describe gasket and packing materials and how they are used.
4. Describe non-mechanical and mechanical seals.
5. Discuss the types of bearings and identify sources of bearing failure.

**Session Three**

Session Three covers the drive belts used to drive blower fans in some commercial packaged units and air handlers. It includes a brief laboratory and the opportunity to complete Performance Task 1.

1. Show the Session Three PowerPoint® presentation.
2. Discuss the various types of drive belts.
3. Demonstrate how to install and adjust drive belts.
4. Have the trainees practice installing, adjusting, and aligning drive belts to satisfy Performance Task 1.

**Session Two**

Session Two covers types of lubricants as well as lubricant selection and application. It includes a brief laboratory and the opportunity to complete Performance Task 2.

1. Show the Session Two PowerPoint® presentation.
2. Discuss the properties of lubricants.
3. Describe how to select and apply lubricants.
4. Demonstrate how to properly lubricate a bearing.
5. Have the trainees practice lubricating a bearing to satisfy Performance Task 2.

**Session Four**

Session Four deals with basic maintenance procedures, starting with coverage of the health hazards related to rat, bird, and bat droppings. This session also includes instructions for periodic servicing of gas furnaces, cooling units, and heat pumps.

1. Show the Session Four PowerPoint® presentation.
2. Describe the hazards of animal droppings and explain how to avoid these hazards.
3. Discuss the tools, equipment, and procedures for inspecting and servicing gas furnaces.
4. Discuss the tools, equipment, and procedures for inspecting and servicing cooling units and heat pumps.
### Session Five

Session Five covers maintenance of system accessories such as humidifiers, electronic air cleaners, and filters. This session also provides information and instructions for the variety of forms and reports associated with maintenance activities.

1. Show the Session Five PowerPoint® presentation.
2. Explain how to service humidifiers and electronic air cleaners.
3. Explain how to inspect and clean air filters and condensate pumps.
4. Describe the various types of forms and reports associated with periodic maintenance activities.

### Session Eight

Session Eight is a review and testing session. Have trainees complete the module Review Questions. Alternatively, these may be assigned as homework at the end of Session Seven. Go over the module Review Questions in class prior to the exam and answer any questions that the trainees may have.

1. Have trainees complete the written examination. Any outstanding performance testing must be completed during this session as well.
2. Record the testing results on Training Report Form 200, and submit the report to your Training Program Sponsor.

### Sessions Six and Seven

Sessions Six and Seven are devoted to laboratories and Performance Tasks 3 and 4.

1. Note that there is no PowerPoint® presentation associated with these sessions.
2. Trainees practice the inspection of gas furnaces and cooling/heat pump systems.
3. Trainees practice and/or complete the tasks associated with Performance Tasks 3 and 4 in these two hands-on sessions.
Chimneys, Vents, and Flues

Module Eight (03202-13) covers the chimneys, vents, and flues that are used with fuel-burning furnaces and boilers. All fuel-burning appliances must have adequate air for complete combustion and must have a means to safely remove the products of combustion. Different types of fuel-fired furnaces and boilers have different and unique requirements for venting the products of combustion.

Objectives

Learning Objective 1
- Describe the principles of combustion.
  a. Describe the requirements for combustion and flame characteristics.
  b. Distinguish between complete and incomplete combustion.
  c. Describe the contents of flue gases and related concerns.

Learning Objective 2
- Identify the basic requirements and components of a furnace venting system.
  a. Explain the basic principles of combustion and ventilation.
  b. Identify vented appliance categories.
  c. Describe the construction of various venting systems.

Learning Objective 3
- Describe the basic venting considerations for various gas-fired heating units.
  a. Describe the venting considerations for natural-draft furnaces.
  b. Describe the venting considerations for induced-draft furnaces.
  c. Describe the venting considerations for condensing furnaces.

Performance Tasks
- This is a knowledge-based module; there are no performance tasks.

Teaching Time: 5 hours
(Two 2.5-Hour Classroom Sessions)
Session time may be adjusted to accommodate your class size, schedule, and teaching style.

Prerequisites
Core Curriculum and HVAC Level One.

Before You Begin
As you prepare for each session, allow sufficient time to review the course objectives, content, visual aids (including the PowerPoint® presentation), and these lesson plans, and to gather the required equipment and materials. Consider time required for demonstrations, laboratories, field trips, and testing.

Using your access code, download the written examinations and performance profile sheets from www.nccerirc.com. The passing score for submission into NCCER’s Registry is 70% or above for the written examination; performance testing is graded pass or fail.
Safety Considerations
This module does not require that trainees work on functioning HVAC equipment. However, trainees may observe operating furnaces and/or boilers. In those instances, trainees should be carefully observed to ensure that they wear the proper PPE, follow safe practices, and give due respect to the hazards of energized and operating HVAC/R systems. Any observations of operating heating equipment must be done under the direct supervision of the instructor.

Classroom Equipment and Materials
Whiteboard/chalkboard
Markers/chalk
Pencils and paper
HVAC Level Two PowerPoint® Presentation Slides
DVD player
LCD projector and screen
Computer
Calculators
Copies of the Module Examination
Carbon monoxide detector
National Fuel Gas Code (multiple copies)
Short length of Type B vent pipe
Short length of PVC pipe
Short length of flexible chimney liner
Condensing furnace installation instructions (multiple copies)

Additional Resources
This module presents thorough resources for task training. The following resource material is suggested for further study.


There are a number of online resources available for trainees who would like more information on furnace vent installation. A search for additional information may be assigned as homework to interested trainees.

Instructors should view any videos that may be identified in the lesson plan before using them to ensure their suitability. The videos can provide teachable moments in both proper and improper work processes and behaviors. Be prepared to stop the videos at appropriate times to point out and discuss both proper and improper conduct and techniques.

Instructors are also encouraged to locate additional audiovisual aids available on the Internet, make personal videos, and take photos related to furnace venting and add them to the PowerPoint presentations throughout the program. Resources available on the Internet include how-to videos that show how to install furnaces and venting systems.
The Lesson Plan for this module is divided into two 2.5-hour sessions. This time includes 10 minutes for administrative tasks and a 10-minute break per session.

### Session One

Session One discusses the principles of combustion, identifies requirements and components of a furnace venting system, and describes basic venting considerations for different gas furnace types.

1. Show the Session One PowerPoint® presentation.
2. Discuss the requirements for proper combustion and describe flame characteristics.
3. Describe the contents of flue gas and discuss why flue gas must be safely removed from a structure.
4. Explain the principles of combustion ventilation and identify vented appliance categories. Describe the construction of various types of vent systems.
5. Describe the venting considerations for natural-draft, induced-draft, and condensing gas furnaces.

### Session Two

Session Two is a review and testing session. Have trainees complete the Module Review Questions. Go over the Module Review Questions in class prior to the exam and answer any questions that the trainees may have.

1. Have trainees complete the written examination.
2. Record the testing results on Training Report Form 200, and submit the report to your Training Program Sponsor.
Module Nine (03213-13) covers sheet metal duct systems. While other materials can be used to fabricate air ducts, sheet metal has been and continues to be one of the most popular materials for this purpose. Major advantages of sheet metal ducts systems include low resistance to airflow, strength, and durability. In addition to using time-tested assembly methods, modern sheet metal duct systems need to be sealed to prevent leakage of conditioned air, and insulated to prevent heat loss or heat gain through the walls of the duct.

Objectives

Learning Objective 1
- Identify and describe common types of sheet metal.
  a. Identify various types of steel sheet metals.
  b. Identify various types of alloy sheet metals.

Learning Objective 2
- Identify various methods of joining sheet metal.
  a. Identify various types of duct seams.
  b. Identify various methods of duct component connection.

Learning Objective 3
- Describe the methods used to suspend and support sheet metal duct.
  a. Describe methods used to suspend sheet metal duct.
  b. Describe methods used to support sheet metal duct.

Learning Objective 4
- Describe methods used to insulate and attenuate sheet metal duct.
  a. Describe the selection and installation of duct lining products.
  b. Describe the selection and installation of external duct wraps.

Learning Objective 5
- Identify various sheet metal duct accessories and describe their installation.
  a. Identify and describe the installation of various types of dampers.
  b. Identify and describe the installation of duct takeoffs and access doors.

Learning Objective 6
- Identify different types of flexible duct and explain how it is installed.
  a. Identify different types of flexible duct.
  b. Explain how flexible duct is connected and supported.

Performance Tasks
This is a knowledge-based module; there are no performance tasks.

Teaching Time: 10.0 hours
(Four 2.5-Hour Classroom Sessions)
Session time may be adjusted to accommodate your class size, schedule, and teaching style.

Prerequisites
Core Curriculum and HVAC Level One.

Before You Begin
As you prepare for each session, allow sufficient time to review the course objectives, content, visual aids (including the PowerPoint presentation), and these lesson plans, and to gather the required equipment and materials. Consider time required for demonstrations, laboratories, field trips, and testing.

Using your access code, download the written examinations and performance profile sheets from www.nccerirc.com. The passing score for submission into NCCER's Registry is 70% or above for the written examination; performance testing is graded pass or fail.
**Safety Considerations**

This module does not require trainees to work on functioning HVAC equipment. However, trainees may observe operating equipment that is attached to a sheet metal duct system. In those instances, trainees should be carefully observed to ensure that they wear the proper PPE, follow safe practices, and give due respect to the hazards of energized and operating HVAC systems. Any observations of operating equipment must be done under the direct supervision of the instructor.

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**Classroom Equipment and Materials**

<table>
<thead>
<tr>
<th>Whiteboard/chalkboard</th>
<th>Sheet metal gauge</th>
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<tbody>
<tr>
<td>Markers/chalk</td>
<td>Short strips of sheet metal (different gauges)</td>
</tr>
<tr>
<td>Pencils and paper</td>
<td>Short sections of S-slip and drive connectors</td>
</tr>
<tr>
<td>HVAC Level Two PowerPoint® Presentation slides</td>
<td>Outward stitch staple gun</td>
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<tr>
<td>DVD player or a computer with a DVD drive</td>
<td>Mechanical fasteners for duct insulation</td>
</tr>
<tr>
<td>LCD projector and screen</td>
<td>Short sections of insulated flexible duct</td>
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<tr>
<td>Computer with internet access</td>
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<td>Calculators</td>
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<tr>
<td>Copies of the Module Examination</td>
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**Additional Resources**

This module presents thorough resources for task training. The following resource material is suggested for further study.


There are a number of online resources available for trainees who would like more information on sheet metal duct systems. A search for additional information may be assigned as homework to interested trainees.

Instructors should view any videos that may be identified in the lesson plan before using them to ensure their suitability. The videos can provide teachable moments in both proper and improper work processes and behaviors. Be prepared to stop the videos at appropriate times to point out and discuss both proper and improper conduct and techniques.

Instructors are also encouraged to locate additional audiovisual aids available on the Internet, make personal videos, and take photos related to sheet metal duct systems and add them to the PowerPoint® presentations throughout the program. Resources available on the internet include how-to videos that show sheet metal duct fabrication and installation procedures.
The Lesson Plan for this module is divided into four 2.5-hour sessions. This time includes 10 minutes for administrative tasks and a 10-minute break per session.

**SESSION ONE**

Session One identifies and describes common types of sheet metal and identifies various methods of joining sheet metal.

1. Show the Session One PowerPoint® presentation.
2. Use the Kickoff Activity to get trainees engaged.
3. Identify various types of steel sheet metal and alloy sheet metal.
4. Identify various types of duct seams and the various methods used to connect duct components.

**SESSION TWO**

Session Two describes the methods used to suspend and support sheet metal duct and describes methods used to insulate and attenuate sheet metal duct.

1. Show the Session Two PowerPoint® presentation.
2. Describe methods used to suspend and support sheet metal duct.
3. Describe the methods used to insulate and attenuate sheet metal duct.

**SESSION THREE**

Session Three identifies various sheet metal duct accessories and how they are installed. Different types of flexible duct are identified along with how they are connected and supported.

1. Show the Session Three PowerPoint® presentation.
2. Identify and describe the installation of duct dampers, duct takeoffs, and duct access doors.
3. Identify different types of flexible duct and describe how it is connected and supported.

**SESSION FOUR**

Session Four is a review and testing session. Have trainees complete the Module Review Questions. Go over the Module Review Questions in class prior to the exam and answer any questions that the trainees may have.

1. Have trainees complete the written examination.
2. Record the testing results on Training Report Form 200, and submit the report to your Training Program Sponsor.
Lesson Plans for Module 03214-13

FIBERGLASS AND FABRIC DUCT SYSTEMS

The Trainee Guide for HVAC Level Two is available as an NCCERconnect e-book. Contact your NCCER customer service representative at 1-888-622-3720 for more information.

Module Ten (03214-13) reviews the application and methods of fabricating fiberglass duct systems. In addition, the installation guidelines for installing a fiberglass system are presented, along with the methods to repair damaged components. The module concludes with coverage of fabric-based duct systems, which have become increasingly popular in a variety of applications.

Objectives

Learning Objective 1
- Describe the standards and application considerations related to fiberglass duct.
  a. Identify the standards related to fiberglass duct.
  b. Identify application considerations related to fiberglass duct.

Learning Objective 2
- Describe the methods used to fabricate and repair fiberglass duct.
  a. Describe how to close and join fiberglass duct using various methods.
  b. Describe how to repair both minor and major fiberglass duct damage.

Learning Objective 3
- Describe the methods used to suspend and support fiberglass duct systems.
  a. Describe methods used to suspend and support fiberglass duct.
  b. Describe methods used to suspend and support fiberglass duct fittings and risers.

Learning Objective 4
- Describe fabric-based air distribution products and their installation methods.
  a. Identify various types and designs of fabric-based air distribution products.
  b. Describe the various methods of installing and suspending fabric-based air distribution products.

Performance Tasks
- This is a knowledge-based module; there are no performance tasks.

Teaching Time: 7.5 hours
(Three 2.5-Hour Classroom Sessions)
Session time may be adjusted to accommodate your class size, schedule, and teaching style.

Prerequisites
Core Curriculum and HVAC Level One.

Before You Begin
As you prepare for each session, allow sufficient time to review the course objectives, content, visual aids (including the PowerPoint® presentation), and these lesson plans, and to gather the required equipment and materials. Consider time required for demonstrations, laboratories, field trips, and testing.

Using your access code, download the written examinations and performance profile sheets from www.nccerirc.com. The passing score for submission into NCCER’s Registry is 70% or above for the written examination; performance testing is graded pass or fail.
Safety Considerations
This is a knowledge-based module and no performance tasks are required. However, instructors may choose to expose trainees to the HVAC shop environment or an active job site. Ensure that trainees possess and use the required PPE during any exposure to these types of settings.

Classroom Equipment and Materials
Whiteboard/chalkboard
Markers/chalk
Pencils and paper
HVAC Level Two PowerPoint® Presentation Slides
DVD player
LCD projector and screen
Computer
Copies of the Module Examination
One or more pieces of fiberglass duct board material
Foil tapes used for fiberglass duct fabrication
Glass fabric tape and mastic
Samples of fabric duct and fittings with zipper attachments
Samples of fabric duct suspension components

Equipment and Materials for Laboratories and Performance Testing
Standard eye protection
Work gloves
Proper footwear as designated by the instructor or training facility
Hearing protection as designated by the instructor or training facility

Additional Resources
This module presents thorough resources for task training. The following resource material is suggested for further study.


There are a number of online resources available for trainees who would like more information on fiberglass and fabric-based air distribution systems and their application. A search for additional information may be assigned as homework to interested trainees.

Instructors should view any videos that may be identified in the lesson plan before using them to ensure their suitability. The videos can provide teachable moments in both proper and improper work processes and behaviors. Be prepared to stop the videos at appropriate times to point out and discuss both proper and improper conduct and techniques.

Instructors are also encouraged to locate additional audiovisual aids available on the internet, make personal videos, and take photos related to the HVAC/R trade and add them to the PowerPoint® presentations throughout the program.
The Lesson Plan for this module is divided into three 2.5-hour sessions. This time includes 10 minutes for administrative tasks and a 10-minute break per session.

**SESSION ONE**

Session One begins with an introduction to fiberglass duct materials and application considerations. The methods used to fabricate and assemble fiberglass duct components are also presented.

1. Show the Session One PowerPoint® presentation.
2. Use the Kickoff Activity to give trainees an idea of what they will learn in this module.
3. Discuss the fiberglass duct material characteristics and the standards they must meet.
4. Review the fabrication and assembly of fiberglass duct modules.

**SESSION TWO**

Session Two provides a review of fiberglass duct repair procedures and the requirements for installing and supporting fiberglass duct systems. The session concludes with the introduction and review of fabric-based air distribution systems.

1. Show the Session Two PowerPoint® presentation.
2. Review the methods used to repair damaged fiberglass duct board.
3. Explain how hanger materials and spacing are determined.
5. Describe the materials used and installation procedures for fabric-based duct.

**SESSION THREE**

Session Three is a review and testing session. Have trainees complete the Module Review Questions. Alternatively, these may be assigned as homework at the end of Session Two. Go over the Module Review Questions in class prior to the exam and answer any questions that the trainees may have.

1. Have trainees complete the written examination.
2. Record the testing results on Training Report Form 200, and submit the report to your Training Program Sponsor.
Lesson Plans for Module 03201-13

COMMERCIAL AIRSIDE SYSTEMS

The Trainee Guide for HVAC Level Two is available as an NCCERconnect e-book. Contact your NCCER customer service representative at 1-888-622-3720 for more information.

Module Eleven (03201-13) introduces the air distribution systems used in commercial structures such as schools and office buildings that are divided into comfort heating and cooling zones. The module covers the various types of systems, as well as the air terminals and air source equipment used in these systems. Accessories commonly used with commercial systems are also covered.

Objectives

Learning Objective 1
- Describe basic commercial airside systems and their operating characteristics.
  a. Describe the typical operating characteristics of a commercial airside system.
  b. Describe the purpose and function of ventilation and exhaust systems.

Learning Objective 2
- Describe various approaches used in commercial air distribution design.
  a. Describe single-zone constant volume system operation.
  b. Describe multi-zone constant volume system operation.
  c. Describe variable volume, variable temperature (VVT) system operation.
  d. Describe variable air volume (VAV) system operation.

Learning Objective 3
- Describe common air terminal operation and related air delivery devices.
  a. Explain the basic operation of VVT and single-duct VAV terminal devices.
  b. Explain the basic operation of fan-powered VAV terminals.
  c. Identify various styles of commercial grilles and registers.

Learning Objective 4
- Identify the characteristics and components of various airflow sources.
  a. Describe the various forms and components of packaged systems.
  b. Describe the various forms and components of air handling units.
  c. Describe the purpose and function of economizers.
  d. Describe common accessories used with commercial airside systems.

Performance Tasks
This is a knowledge-based module; there are no performance tasks.

Teaching Time: 12.5 hours
(Five 2.5-Hour Classroom Sessions)
Session time may be adjusted to accommodate your class size, schedule, and teaching style.

Prerequisites
Core Curriculum and HVAC Level Two.

Before You Begin
As you prepare for each session, allow sufficient time to review the course objectives, content, visual aids (including the PowerPoint® presentation), and these lesson plans, and to gather the required equipment and materials. Consider time required for demonstrations, laboratories, field trips, and testing.

Using your access code, download the written examinations and performance profile sheets from www.nccerirc.com. The passing score for submission into NCCER’s Registry is 70% or above for the written examination; performance testing is graded pass or fail.
**Safety Considerations**

This is a knowledge-based module and no Performance Tasks are required. However, instructors may choose to expose trainees to the HVAC shop environment or an active job site. Ensure that trainees possess and use the required PPE during any exposure to these types of settings.

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**Classroom Equipment and Materials**

- Whiteboard/chalkboard
- Markers/chalk
- Pencils and paper
- *HVAC Level Two* PowerPoint® Presentation Slides
- DVD player
- LCD projector and screen
- Computer
- Copies of the Module Examination

**Equipment and Materials for Laboratories and Performance Testing**

- Examples of manufacturer literature for packaged equipment
- Examples of manufacturer literature for air terminals
- Examples of air filters used in commercial all-air systems
- Examples of air supply grilles and air terminals

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**Additional Resources**

This module presents thorough resources for task training. The following resource material is suggested for further study.

- *Central Station Air Handlers (TDP-611)*. Syracuse, NY: Carrier Corporation

There are a number of online resources available for trainees who would like more information on HVAC commercial air distribution systems and their applications. A search for additional information may be assigned as homework to interested trainees.

There may be suitable videos available online. However, instructors should view them in advance to ensure their suitability. Appropriate videos can provide teachable moments in both proper and improper work processes and behaviors. Be prepared to stop the videos at appropriate times to point out and discuss both proper and improper conduct and techniques.

Instructors are also encouraged to locate additional audiovisual aids available on the internet, make personal videos, and take photos related to the HVAC/R trade and add them to the PowerPoint® presentations throughout the program.
The Lesson Plan for this module is divided into five 2.5-hour sessions. This time includes 10 minutes for administrative tasks and a 10-minute break per session.

**SESSION ONE**

Session One begins with an overview of commercial air distribution systems and their characteristics. It provides descriptions of the types of commercial all-air systems, including single- and multi-zone types.

1. Show the Session One PowerPoint® presentation.
2. Use the Kickoff Activity to get trainees engaged and give them an idea of what they will learn in this module.
3. Discuss the characteristics of commercial all-air systems.
4. Describe the types of single-zone and multi-zone constant-volume systems.
5. Describe the types of single-zone and multi-zone variable-volume systems.

**SESSION TWO**

Session Two covers types of air terminals and supply air outlets used with commercial all-air systems. It covers VVT and VAV air terminals, including passive and fan-powered terminals. It also covers grilles and diffusers used with these systems.

1. Show the Session Two PowerPoint® presentation.
2. Discuss standard VVT and VAV air terminals.
3. Describe the fan-powered terminals used in VVT and VAV systems.
4. Cover the variety of supply air grilles and diffusers used with VVT and VAV systems.

**SESSION THREE**

Session Three provides a review of air-source equipment and accessories. It includes coverage of packaged cooling, heating, and heat pump systems; air handlers; economizers; and the accessories available for use with this equipment.

1. Show the Session Three PowerPoint® presentation.
2. Describe the differences in packaged cooling-only units, year-round air conditioners, vertical packaged units, and packaged heat pumps.
3. Describe the different types of air handlers used in commercial VVT and VAV systems.

**SESSION FOUR**

Session Four covers the kinds of accessories used with commercial all-air systems and the equipment used in these systems. It includes coverage of economizers, head pressure controls, crankcase heaters, and other accessories.

1. Explain the purpose of an economizer and discuss the different types.
2. Describe the accessories that are available for use with packaged units.

**SESSION FIVE**

Session Five is a review and testing session. Have trainees complete the Module Review Questions. Alternatively, these may be assigned as homework at the end of Session Four. Go over the Module Review Questions in class prior to the exam and answer any questions that the trainees may have.

1. Have trainees complete the written examination.
2. Record the testing results on Training Report Form 200, and submit the report to your Training Program Sponsor.
Module Twelve (03204-13) introduces the factors related to indoor air quality and human comfort. Since humidity is a common comfort factor for all types of buildings, the equipment used to control humidity is presented in detail. The module also covers the air filtration materials and the introduction of outside air into the indoor environment.

**Objectives**

**Learning Objective 1**
• Explain the importance of indoor air quality and the factors to be controlled.
  a. Identify the factors related to the quality of indoor air.
  b. Describe the elements of human comfort and their relationship to air properties.

**Learning Objective 2**
• Describe the processes and equipment used to control humidity levels.
  a. Explain the relationship between air and moisture content.
  b. Describe the processes and equipment used to humidify and dehumidify air.

**Learning Objective 3**
• Describe the equipment and devices used to control air cleanliness.
  a. Identify the various types of media-based air filters.
  b. Describe the operation of non-media based air filtration and purification equipment.

**Learning Objective 4**
• Identify the equipment used to provide and control the introduction of fresh air into buildings.
  a. Explain how dampers and economizers are used to control the introduction of fresh air.
  b. Describe the function and operation of energy and heat recovery ventilation systems.

**Performance Tasks**
• This is a knowledge-based module; there are no performance tasks.

**Teaching Time: 5 hours**
(Two 2.5-Hour Sessions)
Session time may be adjusted to accommodate your class size, schedule, and teaching style.

**Prerequisites**
*Core Curriculum* and *HVAC Level One*.

**Before You Begin**
As you prepare for each session, allow sufficient time to review the course objectives, content, visual aids (including the PowerPoint® presentation), and these lesson plans, and to gather the required equipment and materials. Consider time required for demonstrations, laboratories, field trips, and testing.

Using your access code, download the written examinations and performance profile sheets from [www.nccerirc.com](http://www.nccerirc.com). The passing score for submission into NCCER’s Registry is 70% or above for the written examination; performance testing is graded pass or fail.
Safety Considerations
This module does not require that trainees work directly with functioning HVAC equipment. However, trainees may observe operating HVAC/R equipment or systems. In those instances, they should be carefully observed to ensure that they wear the proper PPE, follow safe practices, and give due respect to the hazards of energized and operating HVAC/R systems. Any observations of operating equipment must be done under the direct supervision of the instructor.

Classroom Equipment and Materials

<table>
<thead>
<tr>
<th>Whiteboard/chalkboard</th>
<th>Calculators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Markers/chalk</td>
<td>Copies of the Module Examination</td>
</tr>
<tr>
<td>Pencils and paper</td>
<td>Sufficient psychrometric charts, paper or laminated, for all trainees</td>
</tr>
<tr>
<td>HVAC Level Two PowerPoint®</td>
<td>Various types of mechanical filters</td>
</tr>
<tr>
<td>Presentation Slides</td>
<td>An electronic air cleaner assembly</td>
</tr>
<tr>
<td>DVD player</td>
<td>A UV light assembly</td>
</tr>
<tr>
<td>LCD projector and screen</td>
<td>An ERV and/or an HRV</td>
</tr>
</tbody>
</table>

Additional Resources
This module presents thorough resources for task training. The following resource material is suggested for further study.

- [www.epa.gov/iaq/ia-intro.html](http://www.epa.gov/iaq/ia-intro.html) – An Introduction to Indoor Air Quality (IAQ). US Environmental Protection Agency
- [www.epa.gov/iaq/pubs/residair.html](http://www.epa.gov/iaq/pubs/residair.html) – Review of residential air purification systems

There are a number of online resources available for trainees who would like more information on HVAC/R equipment, indoor air quality issues, and the equipment used to control and improve indoor air quality. A search for additional information may be assigned as homework to interested trainees.

Instructors should view any videos that may be identified in the lesson plan before using them to ensure their suitability. The videos can provide teachable moments in both proper and improper work processes and behaviors. Be prepared to stop the videos at appropriate times to point out and discuss both proper and improper conduct and techniques.

Instructors are also encouraged to locate additional audiovisual aids available on the internet, make personal videos, and take photos related to the HVAC/R trade and add them to the PowerPoint® presentations throughout the program.
The Lesson Plan for this module is divided into two 2.5-hour sessions. This time includes 10 minutes for administrative tasks and a 10-minute break per session.

### Session One

Session One begins with a review of indoor air quality factors and their importance to health and to the performance of an HVAC system. Humidity and the equipment used to control moisture levels in the environment are explored in detail. This session also covers the subjects of air filtration and ventilation equipment and components.

1. Show the Session One PowerPoint® presentation.
2. Use the Kickoff Activity to help trainees to understand the physical relationship between moisture and air.
3. Discuss human comfort and how it is related to the properties of air.
4. Present the subjects of humidification and dehumidification and the equipment used to control airborne moisture.
5. Explain the difference in various air filtration materials and how they are applied.
6. Discuss the need for ventilation air from outdoors and the equipment used to provide and control ventilation air.

### Session Two

Session Two is a review and testing session. Have trainees complete the module Review Questions. Alternatively, these may be assigned as homework at the end of Session Three. Go over the module Review Questions in class prior to the exam and answer any questions that the trainees may have.

1. Have trainees complete the written examination.
2. Record the testing results on Training Report Form 200, and submit the report to your Training Program Sponsor.
Lesson Plans for Module 03203-13

Introduction to Hydronic Systems

The Trainee Guide for HVAC Level Two is available as an NCCERconnect e-book. Contact your NCCER customer service representative at 1-888-622-3720 for more information.

Module Thirteen (03203-13) introduces hydronic heating systems. In hydronic heating systems, fluids (typically water) are used to transfer heat. Fuels such as gas or oil are used to heat the water in a boiler. Pumps then circulate that heated water throughout the structure where terminal devices such as radiators release the heat into different areas.

Objectives

Learning Objective 1
- Describe hydronic systems and the principles of closed-system water flow.
  a. Describe the basic properties of water and the significance of its contents.
  b. Describe the relationship between water flow and system pressures.

Learning Objective 2
- Describe the primary types of hot-water heating systems and their components.
  a. Identify gravity and forced hydronic systems.
  b. Describe the different types of boilers used.
  c. Identify primary boiler components.
  d. Identify common components related to air and pressure control.
  e. Identify common components related to water level and flow control.

Learning Objective 3
- Identify various hot-water heating piping systems and the various terminal devices used.
  a. Describe the characteristics of one- and two-pipe systems.
  b. Describe the function of hot-water zoning systems.
  c. Identify various hot-water heating system terminal devices.

Learning Objective 4
- Describe the methods and devices used to select pumps and balance water flow in hydronic systems.
  a. Identify the devices used to measure and control water flow in hydronic systems.
  b. Describe how circulating pumps are selected based on required flow rates.
  c. Explain how to measure pump pressures and system flow rates in an operating system.

Performance Tasks
- This is a knowledge-based module; there are no performance tasks.

Teaching Time: 12.5 hours
(Five 2.5-Hour Classroom Sessions)
Session time may be adjusted to accommodate your class size, schedule, and teaching style.

Prerequisites
Core Curriculum and HVAC Level One.

Before You Begin
As you prepare for each session, allow sufficient time to review the course objectives, content, visual aids (including the PowerPoint® presentation), and these lesson plans, and to gather the required equipment and materials. Consider time required for demonstrations, laboratories, field trips, and testing.

Using your access code, download the written examinations and performance profile sheets from www.nccerirc.com. The passing score for submission into NCCER’s Registry is 70% or above for the written examination; performance testing is graded pass or fail.
### Safety Considerations

This module does not require that trainees work directly with functioning HVAC equipment. However, trainees may observe operating boilers and/or hydronic heating systems. In those instances, trainees should be carefully observed to ensure that they wear the proper PPE, follow safe practices, and give due respect to the hazards of energized and operating HVAC/R systems. Any observations of operating hydronic heating equipment must be done under the direct supervision of the instructor.

### Classroom Equipment and Materials

<table>
<thead>
<tr>
<th>Item</th>
<th>Item</th>
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<tbody>
<tr>
<td>Whiteboard/chalkboard</td>
<td>Pressure-reducing valve(s)</td>
</tr>
<tr>
<td>Markers/chalk</td>
<td>Pressure-relief valve(s)</td>
</tr>
<tr>
<td>Pencils and paper</td>
<td>Backflow preventer(s)</td>
</tr>
<tr>
<td>HVAC Level Two PowerPoint®</td>
<td>Check valve(s)</td>
</tr>
<tr>
<td>Presentation Slides</td>
<td>Three-way mixing and/or diverting valve(s)</td>
</tr>
<tr>
<td>DVD player</td>
<td>Samples of PEX tubing</td>
</tr>
<tr>
<td>LCD projector and screen</td>
<td>Samples of finned-tube from a baseboard terminal</td>
</tr>
<tr>
<td>Computer</td>
<td>Orifice plate flow measurement device</td>
</tr>
<tr>
<td>Calculators</td>
<td>Venturi tube flow measurement device</td>
</tr>
<tr>
<td>Copies of the Module Examination</td>
<td>Zone valve(s)</td>
</tr>
<tr>
<td>Small packaged boiler</td>
<td></td>
</tr>
<tr>
<td>Aquastat(s)</td>
<td></td>
</tr>
<tr>
<td>Circulating pump</td>
<td></td>
</tr>
<tr>
<td>Air elimination device(s)</td>
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</tbody>
</table>

### Additional Resources

This module presents thorough resources for task training. The following resource material is suggested for further study.


There are a number of online resources available for trainees who would like more information on hydronic systems and applications. A search for additional information may be assigned as homework to interested trainees.

Instructors should view any videos that may be identified in the lesson plan before using them to ensure their suitability. The videos can provide teachable moments in both proper and improper work processes and behaviors. Be prepared to stop the videos at appropriate times to point out and discuss both proper and improper conduct and techniques.

Instructors are also encouraged to locate additional audiovisual aids available on the internet, make personal videos, and take photos related to hydronics and add them to the PowerPoint® presentations throughout the program. Resources available on the internet include:


The Lesson Plan for this module is divided into five 2.5-hour sessions. This time includes 10 minutes for administrative tasks and a 10-minute break per session.

<table>
<thead>
<tr>
<th>SESSION ONE</th>
<th>SESSION THREE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Session One discusses the properties of water and the relationship between pressure and water flow in the system. The characteristics of gravity and forced hydronic heating systems are covered. Different boiler types are also discussed.</td>
<td>Session Three covers the advantages and disadvantages of the different types of hydronic heating system piping schemes. Terminal devices and their uses are also covered.</td>
</tr>
<tr>
<td>1. Show the Session One PowerPoint® presentation.</td>
<td>1. Show the Session Three PowerPoint® presentation.</td>
</tr>
<tr>
<td>2. Describe some of the advantages and benefits of hydronic heating systems over forced-air heating systems.</td>
<td>2. Explain that different applications require different hydronic piping schemes.</td>
</tr>
<tr>
<td>3. Discuss the properties of water and the relationship between water pressure and water flow rates.</td>
<td>3. Discuss the benefits of zoning in a hydronic heating system.</td>
</tr>
<tr>
<td>4. Explain how gravity and forced hydronic heating systems operate.</td>
<td>4. Describe and discuss the uses of various hydronic system terminals.</td>
</tr>
<tr>
<td>5. Discuss the different types of boilers typically found in modern hydronic heating systems.</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>SESSION TWO</th>
<th>SESSION FOUR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Session Two focuses on boiler components and auxiliary devices used to control air, pressure, water level, and water flow control.</td>
<td>Session Four covers the importance of hydronic system pump sizing and discusses how water flow in a system is measured and balanced.</td>
</tr>
<tr>
<td>1. Show the Session Two PowerPoint® presentation.</td>
<td>1. Show the Session Four PowerPoint® presentation.</td>
</tr>
<tr>
<td>2. Describe primary boiler components.</td>
<td>2. Identify the devices used to measure and control water flow in a hydronic heating system.</td>
</tr>
<tr>
<td>3. Discuss the various components used to control air and pressure in the system.</td>
<td>3. Demonstrate how to select a circulating pump for a hydronic heating system.</td>
</tr>
<tr>
<td>4. Discuss the various components used to control water level and water flow in the system.</td>
<td>4. Discuss how to measure pump pressure and how to determine system flow rates.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SESSION FIVE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Session Five is a review and testing session. Have trainees complete the Module Review Questions. Go over the Module Review Questions in class prior to the exam and answer any questions that the trainees may have.</td>
</tr>
<tr>
<td>1. Have trainees complete the written examination.</td>
</tr>
<tr>
<td>2. Record the testing results on Training Report Form 200, and submit the report to your Training Program Sponsor.</td>
</tr>
</tbody>
</table>
Module One (03313-13) provides trainees with guidance related to working with a variety of fasteners, hardware, and wiring terminations used in HVAC systems. Additionally, direction will be given to the installation of these components in accordance with accepted practices.

Objectives

Learning Objective 1
- Identify the types, uses, and installation methods of fasteners.
  a. Identify various types and the uses of threaded fasteners.
  b. Identify and explain how to use taps, dies, and screw extractors.
  c. Explain how to install and torque fasteners to a specific value.
  d. Identify and explain how to install various types of toggle and anchor bolts.
  e. Identify various types of non-threaded fasteners.

Learning Objective 2
- Identify and describe the installation of various types of vibration isolators.
  a. Identify and describe vibration isolators used to support and suspend equipment and piping.
  b. Identify and describe methods used to restrain equipment during seismic events.
  c. Explain how to select and install various vibration isolators.

Learning Objective 3
- Identify common low- and line-voltage electrical termination hardware and explain how to properly terminate wiring connections.
  a. Identify common low- and line-voltage electrical terminating hardware.
  b. Explain how to properly terminate low- and line-voltage wiring connections.

Performance Tasks

Performance Task 1 (Learning Objective 1)
- Torque threaded hardware to a specific torque value.

Performance Task 2 (Learning Objective 1)
- Select the appropriate drill bit and install an anchor in brick or concrete block.

Performance Task 3 (Learning Objective 3)
- Terminate line- and low-voltage wiring on a compressor contactor.

Teaching Time: 10 hours
(Four 2.5-Hour Classroom Sessions)
Session time may be adjusted to accommodate your class size, schedule, and teaching style.

Prerequisites
Core Curriculum; HVAC Level One and HVAC Level Two.

Before You Begin
As you prepare for each session, allow sufficient time to review the course objectives, content, visual aids (including the PowerPoint® presentation), and these lesson plans, and to gather the required equipment and materials. Consider time required for demonstrations, laboratories, field trips, and testing.

Using your access code, download the written examinations and performance profile sheets from www.nccerirc.com. The passing score for submission into NCCER’s Registry is 70% or above for the written examination; performance testing is graded pass or fail.
Classroom Equipment and Materials

- Whiteboard/chalkboard
- Markers/chalk
- Pencils and paper
- HVAC Level Three PowerPoint® Presentations
- DVD player
- LCD projector and screen
- Computer
- Internet access during class (optional)
- Assortment of retaining and lock rings
- Assortment of pin fasteners
- Various types of keys
- Lock ring pliers
- Bottoming, plug, and taper taps
- Various types of dies
- One or more sizes of screw extractors
- Vibration isolation pads; 1 square inch pieces
- Copies of the Module Examination and Performance Profile Sheets

Equipment and Materials for Laboratories and Performance Testing

- Standard eye protection
- Proper footwear as designated by the instructor or training facility provider
- Hearing protection as designated by the instructor or training facility provider
- Work gloves
- Dust masks
- Various types of threaded fasteners, including nuts and bolts that can be torqued
- Torque wrenches with sockets appropriate for the hardware in use
- Hammer drills
- Masonry drill bits
- Various types of anchor bolts or anchors
- Epoxy for anchors
- Bricks and/or concrete blocks
- One or more compressor contactors
- An assortment of wire terminals, appropriate for the wire size in use
- Scrap stranded wire, typical of sizes used in compressor contactor control and power connections
- Wire stripping tools
- Wire terminal crimping tools

Additional Resources

This module presents thorough resources for task training. The following resource material is suggested for further study.


There are a number of online resources available for trainees who would like more information on fasteners, hardware, and wiring terminations. A search for additional information may be assigned as homework to interested trainees.

Instructors should view any videos that may be identified in the lesson plan before using them to ensure their suitability. The videos can provide teachable moments in both proper and improper work processes and behaviors. Be prepared to stop the videos at appropriate times to point out and discuss both proper and improper conduct and techniques. In addition to any videos that may have been incorporated into the training sessions, other sources of relevant video include:

- [www.nutsandbolts.com](http://www.nutsandbolts.com) – This website has a number of short educational videos related to identifying different fasteners that may be of interest.
- [www.boltscience.com](http://www.boltscience.com) – An interesting video is provided on this website showing how threaded fasteners self-loosen.
- [www.rennsteig.us](http://www.rennsteig.us) – This manufacturer provides video for the use of their line of screw extraction tools and wire crimping tools. Look under “General Info” for Instructional Videos.

Instructors are also encouraged to locate additional audiovisual aids available on the internet, make personal videos, and take photos related to the subject matter and add them to the PowerPoint® presentations throughout the program.
The Lesson Plan for this module is divided into four 2.5-hour sessions. This time includes 10 minutes for administrative tasks and a 10-minute break per session.

### Session One
Session One introduces trainees to the variety of fasteners and extractors, and how to torque threaded fasteners.

1. Show the Session One PowerPoint® presentation.
2. Use the Kickoff activity to emphasize the importance of using the correct components for the specific applications.
3. Introduce various types of threaded fasteners.
4. Describe the use of taps and dies.
5. Describe tools used for extraction and torquing.
6. Discuss torque values and tightening sequences.
7. Trainees practice and/or complete the tasks associated with Performance Task 1.

### Session Two
Session Two introduces trainees to the variety of bolts, fasteners, and vibration isolators.

1. Show the Session Two PowerPoint® presentation.
2. Introduce the various types of toggle bolts and anchors.
3. Explain how anchors and anchor bolts are installed.
4. Introduce the various non-threaded fasteners.
5. Introduce and discuss the use of vibration isolators.
6. Trainees practice and/or complete the tasks associated with Performance Task 2.

### Session Three
Session Three introduces trainees to seismic restraints and wiring terminations.

1. Show the Session Three PowerPoint® presentation.
2. Introduce and explain the purpose of seismic restraints.
3. Discuss the selection of vibration isolators.
4. Discuss various types of wire terminations and how they are installed.
5. Trainees practice and/or complete the tasks associated with Performance Task 3.

### Session Four
Session Four is a review and testing session. Have trainees complete the module Review Questions. Go over the module Review Questions in class prior to the exam and answer any questions that the trainees may have.

1. Have trainees complete the written examination. Any outstanding performance testing must be completed during this session as well.
2. Record the testing results on Training Report Form 200, and submit the report to your Training Program Sponsor.
Module Two (03314-13) provides trainees with information and skills needed to troubleshoot control circuits and electric motors found in heating and cooling equipment. Developing troubleshooting skills for control circuits and electric motors is vital to the future success of trainees in the HVAC/R trade. To that end, a portion of this module is devoted to hands-on practice and the successful completion of its required performance tasks.

Objectives

Learning Objective 1
- Identify and describe the operation of common HVAC control circuit devices.
  a. Identify and describe the operation of relays, contactors, and motor starters.
  b. Identify and describe the operation of other common safety and control circuit devices.

Learning Objective 2
- Describe the operation, installation, and testing of various thermostats and temperature controls.
  a. Describe the operation of various thermostats and temperature controls.
  b. Identify and describe how to troubleshoot thermostats.
  c. Explain how to install and wire thermostats.
  d. Explain how to troubleshoot the functions of a thermostat.

Learning Objective 3
- Describe the sequence of operation for basic HVAC systems.
  a. Describe the sequence of operation of a basic cooling-only system.
  b. Describe the sequence of operation for a common heating and cooling system.
  c. Describe the operation of basic pneumatic control systems.

Learning Objective 4
- Explain how to troubleshoot common control circuits and load components.
  a. Identify basic safety practices related to troubleshooting HVAC power and control circuits.
  b. Explain how to approach HVAC-related problems and prepare for troubleshooting.
  c. Explain how to test high-voltage power sources.
  d. Explain how to troubleshoot control circuits and low-voltage power sources.
  e. Explain how to troubleshoot both resistive and inductive loads, including motors and their related devices.
  f. Explain how to troubleshoot various hydronic control system components.

Learning Objective 5
- Describe the operation of variable frequency drives (VFD) and their selection considerations.
  a. Describe the operation of a VFD.
  b. Identify VFD parameters that can be programmed.
  c. Describe the important considerations for the selection of a VFD.
  d. Explain dynamic motor braking processes.

Learning Objective 6
- Identify and describe how to service electronically commutated motors (ECMs).
  a. Identify and describe the operation of ECMs.
  b. Describe how to install and set up an ECM.
  c. Describe how to troubleshoot an ECM.

Performance Tasks

Performance Task 1 (Learning Objective 2)
- Wire, check the operation of, and adjust the heat anticipator/cycle rate of a thermostat.

Performance Task 2 (Learning Objectives 1, 3, and 4)
- Interpret control circuit diagrams.

Performance Task 3 (Learning Objectives 1, 3, 4, and 6)
- Perform electrical tests and/or troubleshooting procedures on the following:
  - Single- and three-phase power sources
  - Fuses and circuit breakers
  - Resistive loads
  - Relays and/or contactors
  - Motor windings
  - Start and run capacitors
  - Start relays and thermistors
Teaching Time: 30 hours
(Twelve 2.5-Hour Classroom Sessions)
Session time may be adjusted to accommodate your class size, schedule, and teaching style.

Prerequisites
Core Curriculum; HVAC Level One; HVAC Level Two.

Before You Begin
As you prepare for each session, allow sufficient time to review the course objectives, content, visual aids (including the PowerPoint® presentation), and these lesson plans, and to gather the required equipment and materials. Consider time required for demonstrations, laboratories, field trips, and testing.

Using your access code, download the written examinations and performance profile sheets from www.nccerirc.com. The passing score for submission into NCCER’s Registry is 70% or above for the written examination; performance testing is graded pass or fail.

Safety Considerations
This module requires that trainees work with different types of operating HVAC equipment. In those instances, trainees should be carefully observed to ensure that they wear the proper PPE, follow safe practices, and give due respect to the hazards of operating systems. Any work performed on functioning equipment must be done under the direct supervision of the instructor.

Classroom Equipment and Materials
- Whiteboard/chalkboard
- Markers/chalk
- Pencils and paper
- HVAC Level Three PowerPoint® Presentations
- DVD player
- LCD projector and screen
- Computer
- Internet access during class (optional)
- Calculators
- Assorted control relays
- Various time-delay relays
- One or more typical motor starters
- Assorted thermistors
- Typical boiler reset controller
- Low water cutoff controls, both electronic and float-operated if available
- Typical VFD (powered, if possible)
- Functional fractional-horsepower ECM
- Failed ECM
- Manufacturer’s documentation for the ECMS in use
- ECM tester (optional)
- Copies of the Module Examination and Performance Profile Sheets

Equipment and Materials for Laboratories and Performance Testing
- Standard eye protection
- Work gloves
- Proper footwear as designated by the instructor or training facility provider
- Hearing protection as designated by the instructor or training facility provider
- Various types of room thermostats
- Thermostat installation instructions for the thermostats in use
- Multi-conductor thermostat wire
- Common hand tools
- Wire strippers
- Small levels
- Multimeters
- Ammeters or ammeter accessories for multimeters
- Digital or pocket thermometers
- Wiring diagrams and other documentation for the specific equipment being used in the laboratory
- Assorted fuses and circuit breakers
- Resistive loads such as crankcase heaters and electric heating elements (installed or available for bench testing)
- Inductive loads such as motors (installed or available for bench testing)
- Various control devices, including relays, contactors, transformers, and thermistors (installed or available for bench testing)
- Start and run capacitors (installed or available for bench testing)
- PTC thermistors
- Capacitor testers
- Flashlights
- Various single-phase and three-phase operational HVAC systems and equipment that contain the listed components for troubleshooting
**Additional Resources**

This module presents thorough resources for task training. The following resource material is suggested for further study.


There are a number of online resources available for trainees who would like more information on troubleshooting control circuits and electric motors. A search for additional information may be assigned as homework to interested trainees.

Instructors should view any videos that may be identified in the lesson plan before using them to ensure their suitability. The videos can provide teachable moments in both proper and improper work processes and behaviors. Be prepared to stop the videos at appropriate times to point out and discuss both proper and improper conduct and techniques.

Instructors are encouraged to locate additional audiovisual aids available on the Internet, make personal videos, and take photos related to the subject matter and add them to the PowerPoint® presentations throughout the program.
SESSION ONE

Session One describes how HVAC control circuit devices interact to ensure proper and safe equipment operation.

1. Show the Session One PowerPoint® presentation.
2. Use the Kickoff Activity to encourage trainee thought about the troubleshooting process in general.
3. Describe how control circuit devices such as relays, contactors, motor starters, switches, and safety devices function to enable proper and safe equipment operation.

SESSION TWO

Session Two discusses how thermostats operate to maintain temperature in the conditioned space. Various types of thermostats are introduced. Thermostat installation techniques are also reviewed.

1. Show the Session Two PowerPoint® presentation.
2. Describe how the different types of room thermostats function to control system operation.
3. Describe how to correctly install and adjust room thermostats.

SESSION THREE

Session Three is a laboratory devoted to Performance Task 1 in which trainees will install, adjust, and check the operation of room thermostats.

1. Note that there is no PowerPoint® presentation associated with this session.
2. Trainees practice and/or complete the tasks associated with Performance Task 1 in this hands-on session.

SESSION FOUR

Session Four describes the electrical operating sequences of HVAC systems in various operating modes and describes how pneumatic controls are applied to HVAC systems.

1. Show the Session Four PowerPoint® presentation.
2. Describe the operating sequences of heating and cooling equipment.
3. Describe basic pneumatic control components and how they function together in a pneumatic system.

SESSION FIVE

Session Five describes how to troubleshoot control circuits and various load components.

1. Show the Session Five PowerPoint® presentation.
2. Discuss the safety aspects of electrical troubleshooting.
3. Discuss why an organized approach is necessary when troubleshooting.
4. Describe how to test high-voltage power sources.

SESSION SIX

Session Six continues to focus on troubleshooting control circuits and various load components.

1. Show the Session Six PowerPoint® presentation.
2. Describe how to isolate problems to a faulty circuit or component.
3. Explain how to test resistive and inductive loads.
4. Describe how various hydronic heating system components interact in a hydronic heating system.
5. Describe the operating sequence of a hydronic heating system.
SESSION SEVEN

Session Seven introduces the use of variable frequency drives (VFDs) in HVAC applications.

1. Show the Session Seven PowerPoint® presentation.
2. Discuss basic VFD operation including programmable parameters and selection considerations.
3. Discuss how motor braking is accomplished with VFDs.

SESSION EIGHT

Session Eight discusses electronically commutated motors (ECMs) used in HVAC applications.

1. Show the Session Eight PowerPoint® presentation.
2. Discuss ECM characteristics and describe how they operate.
3. Describe how to install and set up ECMs.
4. Explain how to troubleshoot ECMs.

SESSIONS NINE - ELEVEN

Sessions Nine through Eleven are devoted to laboratories and Performance Tasks 2 and 3. A total of three sessions provide the necessary time for instructors to demonstrate various troubleshooting techniques, and for trainees to practice these essential skills.

1. Note that there is no PowerPoint® presentation associated with this session.
2. Demonstrate how to use control circuit wiring diagrams to isolate electrical faults.
3. Demonstrate how test and/or troubleshoot the required components.
4. Trainees practice and/or complete the tasks associated with Performance Tasks 2 and 3 in a series of hands-on sessions.

SESSION TWELVE

Session Twelve is a review and testing session. Have trainees complete the module Review Questions. Go over the module Review Questions in class prior to the exam and answer any questions that the trainees may have.

1. Have trainees complete the written examination. Any outstanding performance testing must be completed during this session as well.
2. Record the testing results on Training Report Form 200, and submit the report to your Training Program Sponsor.
Module Three (03210-13) provides guidance related to troubleshooting cooling systems. Developing the necessary skills to provide troubleshooting services are vital to the future success of trainees in the HVAC/R trade.

### Objectives

**Learning Objective 1**
- Describe the operation of the refrigeration cycle and identify problems that can occur.
  - a. Identify the primary components of the refrigeration cycle and explain their individual function.
  - b. Describe the operation of a typical refrigeration cycle.
  - c. Explain the steps to analyzing refrigeration circuit operating conditions.
  - d. Describe possible causes for specific abnormal pressures and temperatures.
  - e. Explain how condenser and evaporator airflow problems affect the refrigeration cycle.
  - f. Identify and describe problems related to fixed metering devices.
  - g. Identify and describe problems related to TXVs and distributors.
  - h. Identify and describe other problems related to the refrigerant circuit.

**Learning Objective 2**
- Explain how to troubleshoot and replace a cooling system compressor.
  - a. Identify common problems that can result in compressor failure.
  - b. Explain how to troubleshoot compressor mechanical problems.
  - c. Explain how to replace a hermetic compressor following a failure.
  - d. Describe the additional steps that may be required to replace a compressor following an electrical failure.

### Performance Task

**Performance Task 1** (Learning Objectives 1 and 2)
- Demonstrate the ability to isolate and determine the solution for at least four of the following types of malfunctions:
  - Compressor failures
  - System-related compressor problems
  - Refrigerant undercharge or overcharge
  - Evaporator and condenser problems
  - Metering device problems
  - Refrigerant lines and accessories
  - Noncondensables and refrigerant circuit contamination

### Teaching Time: 17.5 hours
(Seven 2.5-Hour Classroom Sessions)
Session time may be adjusted to accommodate your class size, schedule, and teaching style.

### Prerequisites
*Core Curriculum; HVAC Level One; HVAC Level Two.*

### Before You Begin
As you prepare for each session, allow sufficient time to review the course objectives, content, visual aids (including the PowerPoint® presentation), and these lesson plans, and to gather the required equipment and materials. Consider time required for demonstrations, laboratories, field trips, and testing.

Using your access code, download the written examinations and performance profile sheets from [www.nccerirc.com](http://www.nccerirc.com). The passing score for submission into NCCER's Registry is 70% or above for the written examination; performance testing is graded pass or fail.
**Safety Considerations**

This module requires that trainees work with refrigerants and other pressurized gases in addition to functioning HVAC equipment. In those instances, trainees should be carefully observed to ensure that they wear the proper PPE, follow safe practices, and give due respect to the hazards of operating HVAC systems and handling refrigerants. Any work performed on functioning HVAC equipment must be done under the direct supervision of the instructor.

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**Classroom Equipment and Materials**

- Whiteboard/chalkboard
- Markers/chalk
- Pencils and paper
- *HVAC Level Three* PowerPoint® Presentations
- DVD player
- LCD projector and screen
- Computer
- Internet access during class (optional)
- Copies of the Module Examination and Performance Profile Sheets

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**Equipment and Materials for Laboratories and Performance Testing**

- Standard eye protection
- Work gloves
- Proper footwear as designated by the instructor or training facility provider
- Hearing protection as designated by the instructor or training facility provider
- Refrigerant gauge manifolds
- Flashlights
- Multimeters
- Ammeters or ammeter accessories for multimeters
- Digital thermometers, appropriate for tubing and air temperature measurements
- Common hand tools
- Refrigerant recovery unit(s) (optional, depending upon chosen procedure)
- Refrigerant recovery cylinder(s) (optional, depending upon chosen procedure)
- Additional charging hoses for recovery/evacuation tasks (optional, depending upon chosen procedure)
- Small filter-driers for recovery units (optional, depending upon chosen procedure)
- Vacuum pump(s) (optional, depending upon chosen procedure)
- Vacuum gauge(s) or analyzer(s) (optional, depending upon chosen procedure)
- Two or more operational refrigeration or comfort cooling systems; split or packaged. Note that at least one system should be equipped with a fixed metering device, and another with a TXV metering device.
- Any refrigerants that may be required for the troubleshooting of cooling systems used in this laboratory session.

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**Additional Resources**

This module presents thorough resources for task training. The following resource material is suggested for further study.


There are a number of online resources available for trainees who would like more information on troubleshooting cooling systems. A search for additional information may be assigned as homework to interested trainees.

Instructors should view any videos that may be identified in the lesson plan before using them to ensure their suitability. The videos can provide teachable moments in both proper and improper work processes and behaviors. Be prepared to stop the videos at appropriate times to point out and discuss both proper and improper conduct and techniques.

Instructors are also encouraged to locate additional audiovisual aids available on the internet, make personal videos, and take photos related to the subject matter and add them to the PowerPoint® presentations throughout the program.
The Lesson Plan for this module is divided into seven 2.5-hour sessions. This time includes 10 minutes for administrative tasks and a 10-minute break per session.

**SESSION ONE**

Session One reviews the refrigeration cycle operation and discusses how to identify the systems to detect problems.

1. Show the Session One PowerPoint® presentation.
2. Use the Kickoff Activity to refresh memories and prepare trainees for the content of this module.
3. Review the components that are related to the refrigeration cycle.
4. Review the operation of the refrigeration cycle.
5. Present the steps in analyzing system operating conditions.
6. Describe how to identify the symptoms of various refrigeration cycle problems.

**SESSION TWO**

Session Two discusses component and accessory problems and system contamination.

1. Show the Session Two PowerPoint® presentation.
2. Describe problems related to fixed metering devices.
3. Discuss TXV and distributor problems.
4. Describe other unique problems associated with refrigerant circuits.
5. Review compressor-related refrigerant circuit problems.
6. Describe system problems that can lead to compressor failure.

**SESSION THREE**

Session Three reviews compressor mechanical problems and when replacement is required.

1. Show the Session Three PowerPoint® presentation.
2. Describe how to troubleshoot mechanical compressor malfunctions.
3. Review the replacement process for a failed compressor.
4. Explain the unique steps to be taken to replace a compressor following an electrical failure.

**SESSIONS FOUR - SIX**

Sessions Four through Six are devoted to laboratories and Performance Task 1. A total of three contiguous sessions is devoted to demonstrating and practicing these essential skills due to their complex nature.

1. Note that there is no PowerPoint® presentation associated with this session.
2. Demonstrate how to isolate and determine the solution for at least four of the types of malfunctions listed in the Performance Task section.
3. Trainees practice and/or complete the tasks associated with Performance Task 1 in a series of hands-on sessions.

**SESSION SEVEN**

Session Seven is a review and testing session. Have trainees complete the Module Review Questions. Go over the Module Review Questions in class prior to the exam and answer any questions that the trainees may have.

1. Have trainees complete the written examination. Any outstanding performance testing must be completed during this session as well.
2. Record the testing results on Training Report Form 200, and submit the report to your Training Program Sponsor.
Lesson Plans for Module 03311-13

TROUBLESHOOTING HEAT PUMPS

Module Four (03311-13) provides trainees with guidance related to troubleshooting heat pump systems. Developing the necessary skills to provide these services are vital to the future success of trainees in the HVAC/R trade. Following a thorough review of the heat pump operating cycle, troubleshooting procedures for components common to heat pumps are presented.

Objectives

Learning Objective 1
• Compare heat pumps to standard cooling systems and describe their operating cycles.
  a. Compare heat pump systems to standard cooling systems and identify the different types.
  b. Describe the three operating cycles of common heat pumps.

Learning Objective 2
• Describe the sequence of operation for the common operating modes.
  a. Describe the sequence of operation for the cooling mode.
  b. Describe the sequence of operation for the three heating modes.
  c. Describe the sequence of operation for the defrost mode.
  d. Describe the sequence of operation of dual-fuel systems.
  e. Describe the use of microprocessor controls in heat pump systems.

Learning Objective 3
• Explain how to check and/or troubleshoot various functions and components of heat pump systems.
  a. Explain how to check field and factory wiring.
  b. Explain how to check and troubleshoot heat pump thermostats.
  c. Explain how to test thermistors.
  d. Explain how to check the various types of valves found in heat pumps.
  e. Explain how to check defrost control circuits.

Performance Tasks

Performance Task 1 (Learning Objective 3)
• Demonstrate the ability to isolate and determine the solution for various electrical and mechanical malfunctions in heat pumps.

Performance Task 2 (Learning Objective 3)
• Initiate the defrost cycle of a heat pump.

Teaching Time: 12.5 hours
(Five 2.5-Hour Classroom Sessions)
Session time may be adjusted to accommodate your class size, schedule, and teaching style.

Prerequisites
Core Curriculum; HVAC Level One; HVAC Level Two.

Before You Begin
As you prepare for each session, allow sufficient time to review the course objectives, content, visual aids (including the PowerPoint® presentation), and these lesson plans, and to gather the required equipment and materials. Consider time required for demonstrations, laboratories, field trips, and testing.

Using your access code, download the written examinations and performance profile sheets from www.nccerirc.com. The passing score for submission into NCCER’s Registry is 70% or above for the written examination; performance testing is graded pass or fail.
**Safety Considerations**
This module requires that trainees work with refrigerants and other pressurized gases in addition to functioning HVAC equipment. In those instances, trainees should be carefully observed to ensure that they wear the proper PPE, follow safe practices, and give due respect to the hazards of operating HVAC systems and handling refrigerants. Any work performed on functioning HVAC equipment must be done under the direct supervision of the instructor.

**Classroom Equipment and Materials**
- Whiteboard/chalkboard
- Markers/chalk
- Pencils and paper
- *HVAC Level Three* PowerPoint® Presentations
- DVD player
- LCD projector and screen
- Computer
- Internet access during class (optional)
- Reversing valve assembly, with a portion of the housing cut away to show the internal mechanism
- One or more heat pump thermostat subbases or complete thermostat assemblies
- Copies of the Module Examination and Performance Profile Sheets

**Equipment and Materials for Laboratories and Performance Testing**
- Standard eye protection
- Work gloves
- Proper footwear as designated by the instructor or training facility provider
- Hearing protection as designated by the instructor or training facility provider
- Common hand tools
- Multimeters
- Ammeters or ammeter accessories for multimeters
- Flashlights
- Refrigerant gauge manifolds and hoses
- Digital or pocket thermometers
- Magnets for check valve testing
- Two or more operational air-to-air split system and packaged unit heat pumps.
- Any refrigerants that may be required for the troubleshooting of cooling systems used in this laboratory session.

**Additional Resources**
This module presents thorough resources for task training. The following resource material is suggested for further study.


There are a number of online resources available for trainees who would like more information on troubleshooting heat pumps. A search for additional information may be assigned as homework to interested trainees.

Instructors should view any videos that may be identified in the lesson plan before using them to ensure their suitability. The videos can provide teachable moments in both proper and improper work processes and behaviors. Be prepared to stop the videos at appropriate times to point out and discuss both proper and improper conduct and techniques.

Instructors are also encouraged to locate additional audiovisual aids available on the internet, make personal videos, and take photos related to the subject matter and add them to the PowerPoint® presentations throughout the program.
The Lesson Plan for this module is divided into five 2.5-hour sessions. This time includes 10 minutes for administrative tasks and a 10-minute break per session.

**SESSION ONE**

Session One focuses on the heat pump refrigeration cycle and the sequence of operation.
1. Show the Session One PowerPoint® presentation.
2. Use the Kickoff Activity to prepare trainees for more advanced instruction.
3. Review the heat pump refrigeration cycle.
4. Review the sequence of operation for the various operating modes.
5. Discuss the advantages and versatility of electronic heat pump controls.

**SESSION TWO**

Session Two introduces trainees to heat pump troubleshooting techniques.
1. Show the Session Two PowerPoint® presentation.
2. Present the information related to testing both field and factory wiring.
3. Review the troubleshooting procedures for thermostats.
4. Explain how to test thermistors for accuracy.
5. Describe how to troubleshoot various types of valves.
6. Explain how to troubleshoot defrost controls.

**SESSIONS THREE AND FOUR**

Sessions Three and Four are devoted to laboratories and the practice and completion of Performance Tasks 1 and 2.
1. Note that there is no PowerPoint® presentation associated with these sessions.
2. Trainees practice and/or complete the tasks associated with Performance Tasks 1 and 2 in these hands-on sessions.

**SESSION FIVE**

Session Five is a review and testing session. Have trainees complete the Module Review Questions. Go over the Module Review Questions in class prior to the exam and answer any questions that the trainees may have.
1. Have trainees complete the written examination. Any outstanding performance testing must be completed during this session as well.
2. Record the testing results on Training Report Form 200, and submit the report to your Training Program Sponsor.
Module Five (03209-13) provides trainees with the information and skills needed to troubleshoot gas-fired furnaces and boilers. Developing troubleshooting skills for heating equipment is vital to the future success of trainees in the HVAC/R trade. To that end, a portion of this module is devoted to hands-on practice and the successful completion of its required performance tasks.

**Objectives**

**Learning Objective 1**
- Describe how to troubleshoot the components related to gas heating.
  a. Describe the control circuits and typical sequence of operation of various gas heating units.
  b. Describe the operation and troubleshooting process for thermocouples.
  c. Describe the operation and troubleshooting process for ignition devices.
  d. Describe the operation and troubleshooting process for flame sensors.
  e. Identify common problems associated with system airflow.

**Learning Objective 2**
- Identify Infrared gas heaters and describe how they operate.
  a. Identify various types of infrared gas heaters.
  b. Describe the operating characteristics of infrared gas heaters.

**Learning Objective 3**
- Explain how to conduct a combustion analysis on a gas furnace.
  a. Identify combustion analysis equipment and the combustion byproducts that are of importance to the analysis.
  b. Describe the combustion analysis process and how to interpret basic results.

**Performance Tasks**

**Performance Task 1 (Learning Objective 1)**
- Using the proper tools, instruments, and control circuit diagrams, isolate and correct malfunctions in a gas heating system.

**Performance Task 2 (Learning Objective 3)**
- Complete a combustion analysis on a gas furnace or boiler.

**Teaching Time: 12.5 hours**
(Five 2.5-Hour Classroom Sessions)
Session time may be adjusted to accommodate your class size, schedule, and teaching style.

**Prerequisites**
Core Curriculum; HVAC Level One; HVAC Level Two.

**Before You Begin**
As you prepare for each session, allow sufficient time to review the course objectives, content, visual aids (including the PowerPoint® presentation), and these lesson plans, and to gather the required equipment and materials. Consider time required for demonstrations, laboratories, field trips, and testing.

Using your access code, download the written examinations and performance profile sheets from www.nccerirc.com. The passing score for submission into NCCER’s Registry is 70% or above for the written examination; performance testing is graded pass or fail.
Safety Considerations
This module requires that trainees work with fuel gases and operating heating equipment. In those instances, trainees should be carefully observed to ensure that they wear the proper PPE, follow safe practices, and give due respect to the hazards of operating heating systems. Any work performed on functioning heating equipment must be done under the direct supervision of the instructor.

Classroom Equipment and Materials
- Whiteboard/chalkboard
- Markers/chalk
- Pencils and paper
- HVAC Level Three PowerPoint® Presentations
- DVD player
- LCD projector and screen
- Computer
- Internet access during class (optional)
- Calculators
- Various burner ignition devices and flame sensors
- One or more furnace control boards, functional or defective
- Electronic or mechanical combustion analyzer(s)
- Copies of the Module Examination and Performance Profile Sheets

Equipment and Materials for Laboratories and Performance Testing
- Standard eye protection
- Work gloves
- Proper footwear as designated by the instructor or training facility provider
- Hearing protection as designated by the instructor or training facility provider
- Common hand tools
- Flashlights
- Jumper wires
- Multimeters
- Ammeters or ammeter accessories for multimeters (must be capable of measuring DC microamps)
- Digital or pocket thermometers
- Thermocouple test adapter(s)
- Manometers or instruments for testing furnace pressure switches (very low pressures)
- Manometers or gauges for testing gas pressure
- Adapters to connect manometers to gas valves
- Electronic or mechanical combustion analyzer kit(s)
- Copies of the user documentation for the analyzer(s) in use (a copy for each trainee)
- Copies of combustion analysis forms (a copy for each trainee)
- Drill and drill bits
- High-temperature sealant for sample holes
- One or more functional gas-fired furnaces and/or boilers, with their associated manufacturer’s service documentation and wiring diagrams

Additional Resources
This module presents thorough resources for task training. The following resource material is suggested for further study.


There are a number of online resources available for trainees who would like more information on troubleshooting gas heating equipment. A search for additional information may be assigned as homework to interested trainees.

Instructors should view any videos that may be identified in the lesson plan before using them to ensure their suitability. The videos can provide teachable moments in both proper and improper work processes and behaviors. Be prepared to stop the videos at appropriate times to point out and discuss both proper and improper conduct and techniques.

Instructors are encouraged to locate additional audiovisual aids available on the Internet, make personal videos, and take photos related to the subject matter and add them to the PowerPoint® presentations throughout the program.
The Lesson Plan for this module is divided into five 2.5-hour sessions. This time includes 10 minutes for administrative tasks and a 10-minute break per session.

**Session One**

Session One describes the sequence of operation of gas-fired furnaces and boilers and describes how to troubleshoot components related to gas heating.

1. Show the Session One PowerPoint® presentation.
2. Use the Kickoff Activity to demonstrate the importance of natural gas as a fuel gas.
3. Introduce the components found in various gas-fired furnaces and boilers and how they interact.
4. Review procedures for troubleshooting individual components and circuits that operate and control gas-fired heating equipment.
5. Present troubleshooting information related to system and burner airflow.

**Session Two**

Session Two is a laboratory devoted to Performance Task 1 in which trainees troubleshoot gas heating systems and isolate various faults.

1. Note that there is no PowerPoint® presentation associated with this session.
2. Demonstrate how to isolate various faults in gas heating equipment using wiring diagrams and common test equipment.
3. Trainees practice and/or complete the tasks associated with Performance Task 1 in this hands-on session.

**Session Three**

Session Three explores infrared gas heaters and presents the equipment and procedures related to combustion analysis.

1. Show the Session Three PowerPoint® presentation.
2. Describe the various types of gas infrared heaters and discuss their operating characteristics.
3. Explain the purpose of a combustion analysis and identify the products of combustion.
4. Identify the tools and equipment required to conduct a combustion analysis.
5. Review the steps to completing a combustion analysis.

**Session Four**

Session Four is a laboratory devoted to Performance Task 2 in which trainees conduct a combustion analysis on a gas-fired furnace or boiler.

1. Note that there is no PowerPoint® presentation associated with this session.
2. Using a combustion analyzer, demonstrate how to set up the equipment and conduct a combustion analysis.
3. Discuss the results of the analysis and explain how to make improvements in the combustion efficiency.
4. Trainees practice and/or complete the tasks associated with Performance Task 2 in this hands-on session.

**Session Five**

Session Five is a review and testing session. Have trainees complete the Module Review Questions. Go over the Module Review Questions in class prior to the exam and answer any questions that the trainees may have.

1. Have trainees complete the written examination. Any outstanding performance testing must be completed during this session as well.
2. Record the testing results on Training Report Form 200, and submit the report to your Training Program Sponsor.
Module Six (03310-13) describes the construction and operation of oil-fired heating systems and their components. It contains instructions for servicing and testing of oil furnaces, as well as procedures for isolating and correcting oil furnace malfunctions.

**Objectives**

**Learning Objective 1**
- Identify the primary components of an oil-fired furnace and explain its operation.
  a. Describe a basic oil-fired heating system.
  b. Describe the primary components and operation of a pressure-type oil burner.
  c. Describe the safety controls used on oil furnaces.
  d. Describe the fuel supply system used with oil furnaces.

**Learning Objective 2**
- Describe how to perform periodic servicing of a typical oil-fired heating system.
  a. Describe the basic servicing procedures performed on an oil-fired system.
  b. Describe how to perform a combustion efficiency test.

**Learning Objective 3**
- Describe how to troubleshoot a typical oil-fired heating system.
  a. Describe troubleshooting procedures for typical oil furnace controls.
  b. Describe troubleshooting procedures for common oil heating problems.

**Performance Tasks**

**Performance Task 1** (Learning Objective 2)
- Remove and reinstall an oil pump in single-pipe and two-pipe systems.
- Test a cad cell flame detector.
- Conduct a complete combustion analysis (smoke test and draft included).
- Remove and replace an oil burner nozzle and set the electrode gap.

**Teaching Time: 15 hours**
(Six 2.5-Hour Classroom Sessions)
Session time may be adjusted to accommodate your class size, schedule, and teaching style.

**Prerequisites**
*Core Curriculum; HVAC Level One; HVAC Level Two.*

**Before You Begin**
As you prepare for each session, allow sufficient time to review the course objectives, content, visual aids (including the PowerPoint® presentation), and these lesson plans, and to gather the required equipment and materials. Consider time required for demonstrations, laboratories, field trips, and testing.

Using your access code, download the written examinations and performance profile sheets from [www.nccerirc.com](http://www.nccerirc.com). The passing score for submission into NCCER’s Registry is 70% or above for the written examination; performance testing is graded pass or fail.
Safety Considerations
This module requires that trainees work with fuel oil and operational heating equipment. In those instances, trainees should be carefully observed to ensure that they wear the proper PPE, follow safe practices, and give due respect to the hazards of operating HVAC systems and the combustion process. Any work performed on functioning HVAC equipment must be done under the direct supervision of the instructor.

Classroom Equipment and Materials
- Whiteboard/chalkboard
- Markers/chalk
- Pencils and paper
- HVAC Level Three PowerPoint® Presentation Slides
- DVD player
- LCD projector and screen
- Computer
- Internet access during class (optional)
- Cad cell assemblies
- Oil burner nozzles of various sizes and flame patterns
- Gas-fired furnace
- Oil-fired furnace
- Copies of the Module Examination and Performance Profile Sheets

Equipment and Materials for Laboratories and Performance Testing
- Standard eye protection
- Work gloves
- Butyl gloves suitable for working with fuel oil
- Proper footwear as designated by the instructor or training facility provider
- Hearing protection as designated by the instructor or training facility provider
- One or more operating oil furnaces
- Common hand tools
- Flashlight
- Hand mirror
- Nozzle wrench
- Stiff brush
- Utility knife
- Digital thermometers
- Multimeter(s)
- Ammeters(s) or ammeter accessories for multimeters
- Oil combustion analyzer kit(s)
- Smoke spot tester
- Electrode gauge
- Insulated jumper wire(s)
- Oil pressure gauge kit

Additional Resources
This module presents thorough resources for task training. The following resource material is suggested for further study.


There are a number of online resources, including video, available for trainees who would like more information on servicing and troubleshooting oil furnaces. A search for additional information may be assigned as homework to interested trainees.

Instructors should view any videos before using them to ensure their suitability. The videos can provide teachable moments in both proper and improper work processes and behaviors. Be prepared to stop the videos at appropriate times to point out and discuss both proper and improper conduct and techniques. There are a number of helpful videos on combustion analysis and the related instruments available through TruTech Tools, found at www.trutechtools.com. In addition, videos from an industry veteran related to oil burner service can also be found at www.grayfurnaceman.com.

Instructors are also encouraged to locate additional audiovisual aids available on the internet, make personal videos, and take photos related to the HVAC/R trade and add them to the PowerPoint® presentations throughout the program.
Session Outline for 03310-13

TROUBLESHOOTING OIL HEATING

The Lesson Plan for this module is divided into six 2.5-hour sessions. This time includes 10 minutes for administrative tasks and a 10-minute break per session.

Session One

Session One introduces trainees to oil-fired heating systems and their components. It covers pressure-type oil burners and their subsystems, as well as the safety controls that are an integral part of oil-fired heating systems. The session concludes with a discussion of fuel oil supply systems and their piping configurations.

1. Show the Session One PowerPoint® presentation.
2. Use the Kickoff Activity to get trainees engaged and give them an idea of what they will learn in this module.
3. Describe the basic operation of an oil-fired furnace.
4. Describe the components and operating principles of a pressure-type oil burner.
5. Discuss the safety controls used in oil-fired heating systems.
6. Discuss oil supply systems and their piping configurations.

Session Two

Session Two covers the inspection and test procedures that are performed during periodic servicing of an oil furnace. These procedures include filter cleaning/replacement, checking safety controls, and servicing the oil burner. Other key elements of this session are the procedures for measuring combustion efficiency and evaluating flue gases.

1. Show the Session Two PowerPoint® presentation.
2. Discuss the basic servicing procedures that are performed at each periodic maintenance event.
3. Describe how to perform and evaluate a smoke spot test.
4. Describe how to perform and evaluate a combustion efficiency test.
5. Describe the various types of gases present in the flue gases and discuss their relationships to the safe and efficient operation of the furnace.
Session Three

Session Three deals with oil furnace troubleshooting. The session begins with a discussion of control circuit analysis based on schematic and wiring diagrams commonly provided with oil furnaces. This is followed by coverage of troubleshooting methods for specific oil furnace components. The session concludes with a discussion of troubleshooting for common oil heating problems.

1. Show the Session Three PowerPoint® presentation.
2. Discuss the typical operating sequence of an oil-fired furnace based on the diagrams provided.
3. Describe troubleshooting methods for oil furnace ignition components.
4. Describe troubleshooting methods for oil furnace components, including the oil burner and fuel supply.

Sessions Four and Five

Sessions Four and Five are lab sessions in which the trainees will learn to perform some of the common maintenance procedures associated with oil-fired furnaces. The instructor has the option of selecting two of the four Performance Tasks.

1. Note that there is no PowerPoint® presentation associated with this session.
2. Demonstrate the proper and safe method of performing common oil burner servicing procedures.
3. Select at least two of the four procedures listed under Performance Task 1 and have the trainees complete the tasks associated with the selected procedures.

Session Six

Session Six is a review and testing session. Have trainees complete the Module Review Questions. Go over the Module Review Questions in class prior to the exam and answer any questions that the trainees may have.

1. Have trainees complete the written examination. Any outstanding performance testing must be completed during this session as well.
2. Record the testing results on Training Report Form 200, and submit the report to your Training Program Sponsor.
Module Seven (03312-13) provides trainees with information and skills needed to troubleshoot various air treatment accessories used with heating and cooling equipment. Developing troubleshooting skills for accessories is vital to the future success of trainees in the HVAC/R trade. To that end, a portion of this module is devoted to hands-on practice and the successful completion of its required Performance Task.

**Objectives**

**Learning Objective 1**
- Describe how to troubleshoot various HVAC system accessories.
  a. Describe how to approach the troubleshooting process.
  b. Describe how to troubleshoot humidifiers.
  c. Describe how to troubleshoot electronic air cleaners.
  d. Describe how to troubleshoot UV lighting devices.

**Learning Objective 2**
- Describe how to troubleshoot accessories related to the introduction of outside air.
  a. Describe how to troubleshoot economizers.
  b. Describe how to troubleshoot recovery ventilators.

**Performance Task**

**Performance Task 1** (Learning Objectives 1 and 2)
- Using the correct tools and circuit diagrams, isolate and correct malfunctions in selected accessories.

**Teaching Time: 10 hours**
(Four 2.5-Hour Classroom Sessions)
Session time may be adjusted to accommodate your class size, schedule, and teaching style.

**Prerequisites**
*Core Curriculum; HVAC Level One; HVAC Level Two.*

**Before You Begin**
As you prepare for each session, allow sufficient time to review the course objectives, content, visual aids (including the PowerPoint® presentation), and these lesson plans, and to gather the required equipment and materials. Consider time required for demonstrations, laboratories, field trips, and testing.

Using your access code, download the written examinations and performance profile sheets from [www.nccerirc.com](http://www.nccerirc.com). The passing score for submission into NCCER's Registry is 70% or above for the written examination; performance testing is graded pass or fail.
Safety Considerations
This module requires that trainees work with different types of operating HVAC equipment. In those instances, trainees should be carefully observed to ensure that they wear the proper PPE, follow safe practices, and give due respect to the hazards of operating and energized systems. Any work performed on functioning equipment must be done under the direct supervision of the instructor.

Classroom Equipment and Materials
Whiteboard/chalkboard
Markers/chalk
Pencils and paper
HVAC Level Three PowerPoint® Presentations
DVD player
LCD projector and screen
Computer
Internet access during class (optional)
Fan-powered or similar residential humidifier that can be disassembled, with wiring diagram
Electronic air cleaner (duct-mounted style) that can be disassembled, with wiring diagram
Duct-mounted UV light assembly, with wiring diagram
A small HRV or ERV, with wiring diagram
Copies of the Module Examination and Performance Profile Sheets

Equipment and Materials for Laboratories and Performance Testing
Standard eye protection
Proper footwear as designated by the instructor or training facility provider
Hearing protection as designated by the instructor or training facility provider
Work gloves
Copies of manufacturer’s service literature and wiring diagrams for all accessories in use
Wiring diagrams for all primary HVAC equipment in use
Common hand tools required to access and disassemble the equipment
Multimeters
Digital or pocket thermometers
Flashlights
Humidifier(s) installed on a functional furnace or air handling unit
Electronic air cleaner(s) installed on a functional furnace or air handling unit
UV lighting device(s) installed on a functional HVAC system coil, air handling unit, or ductwork
Functional HRV or ERV packaged unit(s)
Functional packaged unit(s) equipped with an economizer

Additional Resources
This module presents thorough resources for task training. The following resource material is suggested for further study.


There are a number of online resources available for trainees who would like more information on troubleshooting accessories. A search for additional information may be assigned as homework to interested trainees.

Instructors should view any videos that may be identified in the lesson plan before using them to ensure their suitability. The videos can provide teachable moments in both proper and improper work processes and behaviors. Be prepared to stop the videos at appropriate times to point out and discuss both proper and improper conduct and techniques.

Instructors are encouraged to locate additional audiovisual aids available on the Internet, make personal videos, and take photos related to the subject matter and add them to the PowerPoint® presentations throughout the program.
The Lesson Plan for this module is divided into four 2.5-hour sessions. This time includes 10 minutes for administrative tasks and a 10-minute break per session.

## Session One

Session One discusses the troubleshooting process and describes how to troubleshoot various heating and cooling system accessories.

1. Show the Session One PowerPoint® presentation.
2. Use the Kickoff Activity to engage trainees in the subject of indoor comfort.
3. Describe how to approach the troubleshooting process.
4. Review the procedures for troubleshooting humidifiers and electronic air cleaners.

## Session Two

Session Two describes how to troubleshoot UV light accessories, and accessories related to the introduction of outside air.

1. Show the Session Two PowerPoint® presentation.
2. Describe how to troubleshoot UV lighting accessories.
3. Review the details of economizers and the various operating sequences.
4. Review the operation of HRVs and ERVs and how to approach troubleshooting them.

## Session Three

Session Three is a laboratory session devoted to practicing and completing Performance Task 1.

1. Note that there is no PowerPoint® presentation associated with this session.
2. Demonstrate how to isolate various faults in accessories using wiring diagrams and common test equipment.
3. Trainees practice and/or complete the tasks associated with Performance Task 1 in this hands-on session.

## Session Four

Session Four is a review and testing session. Have trainees complete the Module Review Questions. Go over the Module Review Questions in class prior to the exam and answer any questions that the trainees may have.

1. Have trainees complete the written examination. Any outstanding performance testing must be completed during this session as well.
2. Record the testing results on Training Report Form 200, and submit the report to your Training Program Sponsor.
Module Eight (03315-13) provides trainees with the information and skills needed to troubleshoot and repair zoned, ductless, and variable refrigerant flow systems. Developing troubleshooting and repair skills for these relatively new heating and cooling products is vital to the future success of trainees in the HVAC/R trade. To that end, a portion of this module is devoted to hands-on practice and the successful completion of its required Performance Tasks.

**Objectives**

**Learning Objective 1**
- Identify common zoning systems and describe the basic approach to troubleshooting.
  a. Describe common zoning system components.
  b. Describe the sequence of operation of common zoning systems.
  c. Describe the basic approach to troubleshooting common zoning systems.
  d. Describe common VVT system zoning components.
  e. Describe the operating characteristics of VVT control systems.

**Learning Objective 2**
- Identify ductless and variable refrigerant flow systems and describe the basic approach to troubleshooting.
  a. Identify and describe the operation of ductless split-system equipment.
  b. Describe the installation and troubleshooting of typical ductless systems.
  c. Identify and describe the operation of variable refrigerant flow systems.
  d. Describe the installation and troubleshooting of variable refrigerant flow systems.

**Performance Tasks**

**Performance Task 1** (Learning Objective 2)
- Troubleshoot and repair a typical ductless or variable refrigerant flow system.

**Performance Task 2** (Learning Objective 2)
- Program the controller for a ductless or variable refrigerant flow system.

**Teaching Time: 15.0 hours**
(Six 2.5-Hour Classroom Sessions)
Session time may be adjusted to accommodate your class size, schedule, and teaching style.

**Prerequisites**
Core Curriculum; HVAC Level One; HVAC Level Two.

**Before You Begin**
As you prepare for each session, allow sufficient time to review the course objectives, content, visual aids (including the PowerPoint® presentation), and these lesson plans, and to gather the required equipment and materials. Consider time required for demonstrations, laboratories, field trips, and testing.

Using your access code, download the written examinations and performance profile sheets from www.nccerirc.com. The passing score for submission into NCCER’s Registry is 70% or above for the written examination; performance testing is graded pass or fail.
**Safety Considerations**

This module requires that trainees work with different types of operating ductless and variable refrigerant flow equipment. In those instances, trainees should be carefully observed to ensure that they wear the proper PPE, follow safe practices, and give due respect to the hazards of operating systems. Any work performed on functioning equipment must be done under the direct supervision of the instructor.

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### Classroom Equipment and Materials

- Whiteboard/chalkboard
- Markers/chalk
- Pencils and paper
- HVAC Level Three PowerPoint® Presentations
- DVD player
- LCD projector and screen
- Computer
- Internet access during class (optional)
- Calculators
- Typical zone master control panel
- Typical zone thermostat
- Typical zone damper
- VVT terminal
- Refnet joint
- Refrigerant piping header
- Copies of the Module Examination and Performance Profile Sheets

### Equipment and Materials for Laboratories and Performance Testing

- Standard eye protection
- Work gloves
- Proper footwear as designated by the instructor or training facility provider
- Hearing protection as designated by the instructor or training facility provider
- Operational ductless and/or VRF systems with remote controllers
- Label diagrams, troubleshooting tables, and service information for the equipment in use

- Product-specific equipment tester (optional)
- Refrigerant gauge manifolds
- Multimeters
- Clamp-on ammeters or ammeter accessories for multimeters
- Digital thermometers
- Common hand tools

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### Additional Resources

This module presents thorough resources for task training. The following resource material is suggested for further study.


There are a number of online resources available for trainees who would like more information on troubleshooting zoned, ductless, and VRF systems. A search for additional information may be assigned as homework to interested trainees.

Instructors should view any videos that may be identified in the lesson plan before using them to ensure their suitability. The videos can provide teachable moments in both proper and improper work processes and behaviors. Be prepared to stop the videos at appropriate times to point out and discuss both proper and improper conduct and techniques.

Instructors are encouraged to locate additional audiovisual aids available on the Internet, make personal videos, and take photos related to the subject matter and add them to the PowerPoint® presentations throughout the program.
The Lesson Plan for this module is divided into six 2.5-hour sessions. This time includes 10 minutes for administrative tasks and a 10-minute break per session.

**SESSION ONE**

Session One describes typical zoning systems and discusses how to troubleshoot such systems.

1. Show the Session One PowerPoint® presentation.
2. Use the Kickoff Activity to introduce trainees to zoned and ductless systems.
3. Describe common zoning system components.
4. Describe the basic sequence of operation for common zoning systems.
5. Describe the basic approach to troubleshooting common zoning systems.

**SESSION TWO**

Session Two describes common VVT system components and the operating characteristics of VVT control systems. Ductless systems are also introduced to conclude the session.

1. Show the Session Two PowerPoint® presentation.
2. Describe common VVT system zoning components.
3. Describe the operating characteristics of VVT control systems.
4. Identify and describe the features of ductless system equipment.

**SESSION THREE**

Session Three describes how to install and troubleshoot ductless and variable refrigerant flow (VRF) systems.

1. Show the Session Three PowerPoint® presentation.
2. Describe the installation and troubleshooting strategies for typical ductless systems.
3. Identify and describe the features of VRF systems.
4. Describe the installation and troubleshooting process for VRF systems.

**SESSIONS FOUR AND FIVE**

Sessions Four and Five are devoted to laboratories and Performance Tasks 1 and 2. A total of two sessions are devoted to demonstrating and practicing these essential skills.

1. Note that there is no PowerPoint® presentation associated with this session.
2. Demonstrate how to troubleshoot and repair a typical ductless and/or VRF system.
3. Demonstrate how to program the controller for a ductless or VRF system.
4. Trainees practice and/or complete the tasks associated with Performance Tasks 1 and 2 in a series of hands-on sessions.

**SESSION SIX**

Session Six is a review and testing session. Have trainees complete the module Review Questions. Go over the module Review Questions in class prior to the exam and answer any questions that the trainees may have.

1. Have trainees complete the written examination. Any outstanding performance testing must be completed during this session as well.
2. Record the testing results on Training Report Form 200, and submit the report to your Training Program Sponsor.
Module Nine (03305-13) reviews some basic properties of water and describes how water pressure is related to the movement of water through piping systems. It also describes various types and components of commercial hot-water heating and chilled-water cooling systems, and examines how those systems function.

### Objectives

**Learning Objective 1**
- Describe basic concepts related to water as a substance and its movement.
  - a. Describe the basic properties of water and water pressure.
  - b. Explain how pressure drop, head pressure, and static pressure are related to hydronics.

**Learning Objective 2**
- Describe various commercial hot-water heating system components and subsystems.
  - a. Identify various types of hot-water boilers and their common controls.
  - b. Describe the construction of common centrifugal pumps.
  - c. Identify various types of valves and other commercial hydronic system components.
  - d. Identify common commercial piping systems and their characteristics.
  - e. Describe how a typical hydronic piping system is balanced.

**Learning Objective 3**
- Explain the basic concepts of chilled water systems and the related components.
  - a. Explain the basic concepts of chilled-water cooling systems.
  - b. Identify various types of chillers and their common controls.
  - c. Identify various types of cooling towers and evaporative condensers.

### Performance Tasks

**Performance Task 1** (Learning Objectives 2 and 3)
- Identify the major components of commercial hot-water heating and chilled-water cooling hydronic systems.

**Performance Task 2** (Learning Objective 2)
- Identify the types of common piping configurations used with commercial hot-water and chilled-water hydronic systems.

### Teaching Time: 12.5 hours

(Five 2.5-Hour Classroom Sessions)

Session time may be adjusted to accommodate your class size, schedule, and teaching style.

### Prerequisites

*Core Curriculum; HVAC Level One; HVAC Level Two.*

### Before You Begin

As you prepare for each session, allow sufficient time to review the course objectives, content, visual aids (including the PowerPoint® presentation), and these lesson plans, and to gather the required equipment and materials. Consider time required for demonstrations, laboratories, field trips, and testing.

Using your access code, download the written examinations and performance profile sheets from [www.nccerirc.com](http://www.nccerirc.com). The passing score for submission into NCCER’s Registry is 70% or above for the written examination; performance testing is graded pass or fail.
Safety Considerations
This module requires that trainees work with and in the vicinity of functioning heating and cooling equipment as well as live electrical circuits. Electrical, mechanical, combustible gas, and refrigerant safety must be emphasized at all times. Trainees should be carefully observed to ensure that they wear the proper PPE, follow safe practices, and give due respect to the hazards of energized and operating HVAC/R systems and refrigerant circuits. Any deficiencies must be corrected to ensure future trainee safety as they begin working with even more hazardous systems later in their training and career. All practice sessions and Performance Tasks must be completed under your direct supervision.

Classroom Equipment and Materials
Whiteboard/chalkboard
Markers/chalk
Pencils and paper
HVAC Level Three PowerPoint® Presentations
DVD player
LCD projector and screen
Computer
Internet access during class (optional)
Copies of the Module Examination and Performance Profile Sheets

Equipment and Materials for Laboratories and Performance Testing
Standard eye protection
Work gloves
Proper footwear as designated by the instructor or training facility provider
Hearing protection as designated by the instructor or training facility provider
Copies of Figures 31 and 32 from the Trainee Guide, with all callout text removed
A sufficient number of paper tags, each bearing an identification number, to attach to various hydronic components
Master list of hydronic system components to be identified with their corresponding tag number
One or more commercial hot-water heating systems and chilled-water cooling systems in a suitable facility

Additional Resources
This module presents thorough resources for task training. The following resource material is suggested for further study.


Fans and V-Belt Drives. Leo A. Mayer. LAMA Books.


There are a number of online resources, including video, available for trainees who would like more information on commercial hydronic systems. A search for additional information may be assigned as homework to interested trainees.

Instructors should view any videos before using them to ensure their suitability. The videos can provide teachable moments in both proper and improper work processes and behaviors. Be prepared to stop the videos at appropriate times to point out and discuss both proper and improper conduct and techniques.

Instructors are also encouraged to locate additional audiovisual aids available on the internet, make personal videos, and take photos related to the HVAC/R trade and add them to the PowerPoint® presentations throughout the program.
The Lesson Plan for this module is divided into five 2.5-hour sessions. This time includes 10 minutes for administrative tasks and a 10-minute break per session.

**Session One**

Session One begins with a review of basic water properties. Basic components of commercial hot-water heating systems are described, including various types of boilers and centrifugal pumps.

1. Show the Session One PowerPoint® presentation.
2. Use the Kickoff Activity to get trainees engaged and refresh their memories of previous hydronic training.
3. Discuss basic properties of water.
4. Review the factors related to water movement through piping systems.
5. Present the different types of commercial hot-water boilers.
6. Examine the different types of centrifugal pumps.

**Session Two**

Session Two covers the components in commercial hot-water heating systems, including types of valves, flow meters, and tanks. Common types of commercial piping systems are also examined. The last part of the session is devoted to a laboratory and the completion of Performance Task 2.

1. Show the Session Two PowerPoint® presentation.
2. Identify and discuss various types of valves and other components found in commercial hydronic systems.
3. Present the types of piping systems commonly found in commercial buildings.
4. Trainees practice and/or complete the tasks associated with Performance Task 2 to conclude the session.

**Session Three**

Session Three describes the process of balancing a hydronic system. It also presents the basic concepts of chilled-water systems, including various types of chillers and water-based heat rejection equipment.

1. Show the Session Three PowerPoint® presentation.
2. Identify and discuss the preparations and steps required to balance a hydronic system.
3. Present the basic concepts of chilled-water systems.
4. Identify and describe various types of chillers and their common controls.
5. Identify and describe various styles of cooling towers and evaporative condensers.

**Session Four**

Session Four is devoted to a laboratory and the completion of Performance Task 1.

1. Note that there is no PowerPoint® presentation associated with these sessions.
2. Trainees practice and/or complete the tasks associated with Performance Task 1 in this hands-on session.

**Session Five**

Session Five is a review and testing session. Have trainees complete the Module Review Questions. Alternatively, these may be assigned as homework at the end of Session Four. Go over the Module Review Questions in class prior to the exam and answer any questions that the trainees may have.

1. Have trainees complete the written examination. Any outstanding performance testing must be completed during this session as well.
2. Record the testing results on Training Report Form 200, and submit the report to your Training Program Sponsor.
Module Ten (03306-13) focuses on the use of steam for storing and moving energy in HVAC systems. It reviews the fundamentals of water that relate to steam and describes the basic steam system cycle. It discusses a steam system's operational components—steam boilers and their accessories and controls; steam system loads, including heat exchangers/converters and terminal devices. Steam system valves and piping are covered in detail, including common types of steam system piping arrangements, the components of a condensate return/feedwater system, steam and condensate pipe sizing; and pressure-reducing valves and thermostatic valves. Various types of steam traps and their maintenance requirements are also presented.

**Objectives**

**Learning Objective 1**
- Describe the properties of water as they are related to steam systems.
  a. Describe the properties of water.
  b. Describe the pressure-temperature relationship of water.

**Learning Objective 2**
- Describe the basic steam cycle and the primary components related to its operation.
  a. Describe the steam cycle principles of operation.
  b. Identify steam boilers and their common accessories.
  c. Identify common steam heat exchangers and terminal devices.

**Learning Objective 3**
- Identify common steam system piping arrangements and valves.
  a. Identify common steam system piping arrangements.
  b. Identify common condensate return systems and describe waterside care.
  c. Explain how steam and condensate system piping is sized.
  d. Identify steam-based pressure-reducing and thermostatic control valves.

**Learning Objective 4**
- Identify, install, and maintain various types of steam traps.
  a. Identify various types of steam traps.
  b. Explain the basic concepts of installing steam traps.
  c. Explain how to maintain various steam traps.
  d. Explain how to troubleshoot various steam traps.

**Performance Tasks**
Trainees must perform at least two of the following tasks:

**Performance Task 1** (Learning Objective 2)
- Perform selected operating procedures on low-pressure steam boilers and systems.

**Performance Task 2** (Learning Objective 4)
- Maintain selected steam traps.

**Performance Task 3** (Learning Objective 3)
- Identify common piping configurations used with steam systems.

**Teaching Time:** 10 hours
(Four 2.5-Hour Classroom Sessions)
Session time may be adjusted to accommodate your class size, schedule, and teaching style.

**Prerequisites**
Core Curriculum; HVAC Level One; HVAC Level Two.

**Before You Begin**
As you prepare for each session, allow sufficient time to review the course objectives, content, visual aids (including the PowerPoint® presentation), and these lesson plans, and to gather the required equipment and materials. Consider time required for demonstrations, laboratories, field trips, and testing.

Using your access code, download the written examinations and performance profile sheets from [www.nccerirc.com](http://www.nccerirc.com). The passing score for submission into NCCER’s Registry is 70% or above for the written examination; performance testing is graded pass or fail.
Classroom Equipment and Materials

- Whiteboard/chalkboard
- Markers/chalk
- Pencils and paper
- HVAC Level Three PowerPoint® Presentations
- DVD player
- LCD projector and screen
- Computer
- Internet access during class (optional)
- Calculators
- One or more examples of steam tables (a copy for each trainee)
- Pigtail siphon and/or gauge siphon
- Gauge glass and/or a water column
- At least one of the following devices, preferably disassembled:
  - A float-operated and/or an electronic low-water/high-water cutoff control
  - An electric water feeder control
  - A feeder-cutoff combination control
  - A high-pressure limit control (pressuretrol)
- Inverted bucket trap(s)
- One or more types of thermostatic steam trap
- A thermodynamic disc trap
- Copies of the Module Examination and Performance Profile Sheets

Equipment and Materials for Laboratories and Performance Testing

- Standard eye protection
- Work gloves
- Proper footwear as designated by the instructor or training facility provider
- Hearing protection as designated by the instructor or training facility provider
- Hand tools and testing devices for performing the selected operating procedures on a low-pressure steam boiler and system
- Several different types of steam traps
- Hand tools for disassembling, cleaning and/or repairing, and reassembling different types of steam traps
- Ultrasonic tester(s)
- Infrared thermometer(s)
- Two or more steam system piping plans, each showing a different piping configuration
- Operating low-pressure steam boiler and system

Safety Considerations

This module requires that trainees work with steam in addition to functioning HVAC equipment and pressurized lines and vessels at a wide range of temperatures. Trainees should be carefully observed to ensure that they wear the proper PPE, follow safe practices, and give due respect to the hazards of energized and operating HVAC systems. Any work performed on functioning HVAC equipment must be done under the direct supervision of the instructor.
Additional Resources

This module presents thorough resources for task training. The following resource material is suggested for further study.


There are a number of online resources available for trainees who would like more information on steam systems. A search for additional information may be assigned as homework to interested trainees.

Instructors should view any videos that may be identified in the lesson plan before using them to ensure their suitability. The videos can provide teachable moments in both proper and improper work processes and behaviors. Be prepared to stop the videos at appropriate times to point out and discuss both proper and improper conduct and techniques.

Armstrong International, Inc. ([www.armstronginternational.com](http://www.armstronginternational.com)) has produced a number of videos and other training materials on the steam cycle, steam systems, and steam traps. Many of the materials can be viewed online without charge; others are available for purchase online. Instructors are encouraged to review these materials and incorporate them into the classroom presentations where appropriate.

Instructors are also encouraged to locate additional audiovisual aids available on the internet, make personal videos, and take photos related to the subject matter and add them to the PowerPoint® presentations throughout the program.
The Lesson Plan for this module is divided into four 2.5-hour sessions. This time includes 10 minutes for administrative tasks and a 10-minute break per session.

**SESSION ONE**

Session One introduces trainees to the fundamentals of water that relate to steam and describes the basic steam system cycle. Various steam system piping arrangements are introduced, including the components of a condensate return and feedwater system.

1. Show the Session One PowerPoint® presentation.
2. Use the Kickoff Activity to engage trainees in considering why steam systems are likely to require attention and regular maintenance.
3. Review the basic properties of water that relate to steam, including the pressure-temperature relationship of water.
4. Describe the basic steam system cycle and review the operational components.
5. Describe piping arrangements for steam system piping.
6. Present and discuss the components of a condensate return/feedwater system.

**SESSION TWO**

Session Two covers the sizing of steam and condensate lines. Special control valves used in steam systems are covered, as well as the many types of traps and their maintenance requirements.

1. Show the Session Two PowerPoint® presentation.
2. Review steam and condensate pipe sizing.
3. Describe the functions and features of pressure-reducing valves and thermostatic valves.
4. Present the functions and features of various steam traps.
5. Explain how to install and service steam traps.

**SESSION THREE**

Session Three is devoted to laboratories and Performance Tasks 1, 2, and 3.

1. Note that there is no PowerPoint® presentation associated with this session.
2. Demonstrate performing selected operating procedures on low-pressure steam boilers and systems; installing and maintaining selected steam traps; and identifying common piping configurations used with steam systems.
3. Trainees practice and/or complete the tasks associated with any two of the module’s three Performance Tasks in this hands-on session.

**SESSION FOUR**

Session Four is a review and testing session. Have trainees complete the Module Review Questions. Go over the Module Review Questions in class prior to the exam and answer any questions that the trainees may have.

1. Have trainees complete the written examination. Any outstanding performance testing must be completed during this session as well.
2. Record the testing results on Training Report Form 200, and submit the report to your Training Program Sponsor.
Lesson Plans for Module 03304-13

RETAIL REFRIGERATION SYSTEMS

Module Eleven (03304-13) provides trainees with guidance related to retail refrigeration systems. Developing the necessary skills to understand the applications, principles, and troubleshooting of retail refrigeration systems are vital to the future success of trainees in the HVAC/R trade.

Objectives

Learning Objective 1
- Describe retail refrigeration applications and the related refrigeration cycle.
  a. Describe the operation of the refrigeration cycle for medium-temperature systems.
  b. Describe the operation of the refrigeration cycle for low-temperature systems.
  c. Describe the various approaches to defrosting.

Learning Objective 2
- Identify various types of refrigeration equipment used in retail refrigeration applications.
  a. Identify reach-in coolers and freezers.
  b. Identify walk-in coolers and freezers.
  c. Identify various types of commercial ice machines.

Learning Objective 3
- Identify and describe components related to the operation of retail refrigeration systems.
  a. Identify and describe the primary components used in retail refrigeration applications.
  b. Identify and describe secondary components and accessories used in retail refrigeration applications.
  c. Identify and describe common refrigeration system controls.

Learning Objective 4
- Explain the basic principles of maintaining and troubleshooting various retail refrigeration systems.
  a. Explain how to maintain and troubleshoot a typical reach-in freezer.
  b. Explain how to maintain and troubleshoot a typical cubed-ice machine.

Performance Tasks

Performance Task 1 (Learning Objective 4)
- Clean an ice machine.

Performance Task 2 (Learning Objective 4)
- Isolate a fault in refrigeration equipment or an ice machine.

Performance Task 3 (Learning Objective 1)
- Set up a defrost timer for a freezer.

Teaching Time: 15 hours
(Six 2.5-Hour Classroom Sessions)
Session time may be adjusted to accommodate your class size, schedule, and teaching style.

Prerequisites
Core Curriculum; HVAC Level One; HVAC Level Two.

Before You Begin
As you prepare for each session, allow sufficient time to review the course objectives, content, visual aids (including the PowerPoint® presentation), and these lesson plans, and to gather the required equipment and materials. Consider time required for demonstrations, laboratories, field trips, and testing.

Using your access code, download the written examinations and performance profile sheets from www.nccerirc.com. The passing score for submission into NCCER’s Registry is 70% or above for the written examination; performance testing is graded pass or fail.
### Safety Considerations
This module requires that trainees work with functioning refrigeration equipment. In those instances, trainees should be carefully observed to ensure that they wear the proper PPE, follow safe practices, and give due respect to the hazards of operating refrigeration systems. Any work performed on functioning refrigeration equipment must be done under the direct supervision of the instructor.

### Classroom Equipment and Materials
- Whiteboard/chalkboard
- Markers/chalk
- Pencils and paper
- HVAC Level Three PowerPoint® Presentations
- DVD player
- LCD projector and screen
- Computer
- Internet access during class (optional)
- Two or more defrost timers
- Copies of the Module Examination and Performance Profile Sheets

### Equipment and Materials for Laboratories and Performance Testing
- Standard eye protection/face shields
- Work gloves
- Rubber gloves
- Proper footwear as designated by the instructor or training facility provider
- Hearing protection as designated by the instructor or training facility provider
- One or more functional cubed-ice machines
- One or more functional retail refrigeration fixtures
- Flashlights
- Common hand tools
- Refrigerant gauge manifolds
- Multimeters
- Ammeters or ammeter accessories for multimeters
- Digital or pocket thermometers
- Ice machine cleaning products, approved by the equipment manufacturer
- Rags
- Any refrigerants that may be required for the systems used in this laboratory session

### Additional Resources
This module presents thorough resources for task training. The following resource material is suggested for further study.


There are a number of online resources available for trainees who would like more information on retail refrigeration systems. A search for additional information may be assigned as homework to interested trainees.

Instructors should view any videos that may be identified in the lesson plan before using them to ensure their suitability. The videos can provide teachable moments in both proper and improper work processes and behaviors. Be prepared to stop the videos at appropriate times to point out and discuss both proper and improper conduct and techniques. In addition to any videos that may have been incorporated into the training sessions, other sources of relevant video include:

Instructors are also encouraged to locate additional audiovisual aids available on the internet, make personal videos, and take photos related to the subject matter and add them to the PowerPoint® presentations throughout the program.
The Lesson Plan for this module is divided into six 2.5-hour sessions. This time includes 10 minutes for administrative tasks and a 10-minute break per session.

**SESSION ONE**
Session One reviews the basic operation of a refrigeration system.
1. Show the Session One PowerPoint® presentation.
2. Use the Kickoff Activity to review the roles of compressors and metering devices.
3. Discuss low- and medium-temperature refrigerant cycles.
4. Review the different types of defrost systems.
5. Demonstrate and have trainees perform Performance Task 3.

**SESSION TWO**
Session Two presents retail refrigeration equipment. In addition, the primary components used in retail refrigeration systems are reviewed.
1. Show the Session Two PowerPoint® presentation.
2. Introduce refrigeration equipment such as coolers, freezers, ice merchandisers, and ice machines.
3. Discuss the primary components used in retail refrigeration systems.

**SESSION THREE**
Session Three discusses additional refrigerant circuit devices and components, as well as basic refrigeration system troubleshooting.
1. Show the Session Three PowerPoint® presentation.
2. Describe the functions of receivers, accumulators, pressure valves, and pressure controls in retail refrigeration systems.
3. Discuss the application of thermostats, pressure controls, time-delay relays, and solenoid valves in retail refrigeration systems.
4. Explore the troubleshooting and maintenance of reach-in freezers.
5. Explore the troubleshooting, maintenance, and cleaning of cubed-ice machines.

**SESSIONS FOUR AND FIVE**
Sessions Four and Five are devoted to laboratories and Performance Tasks 1 and 2. Two sessions are devoted to demonstrating and practicing these essential skills.
1. Note that there is no PowerPoint® presentation associated with this session.
2. Demonstrate the ability to clean an ice machine and isolate refrigeration equipment or ice machine fault.
3. Trainees practice and/or complete the tasks associated with Performance Tasks 1 and 2 in two hands-on sessions.

**SESSION SIX**
Session Six is a review and testing session. Have trainees complete the Module Review Questions. Go over the Module Review Questions in class prior to the exam and answer any questions that the trainees may have.
1. Have trainees complete the written examination. Any outstanding performance testing must be completed during this session as well.
2. Record the testing results on Training Report Form 200, and submit the report to your Training Program Sponsor.
Module Twelve (03316-13) presents the importance of establishing good relations with customers and provides guidance on how to achieve that goal. The module focuses on the ways that a technician can make a good first impression and describes how to communicate in a positive way with customers. It further covers the elements of a service call and provides guidance for dealing with different types of problem customers.

**Objectives**

**Learning Objective 1**
- Explain the service technician’s role in customer relations.
  - Explain how personal habits, behaviors, and attitudes affect customer relations.
  - Explain how to properly communicate with customers.

**Learning Objective 2**
- Describe basic conduct required for a service call.
  - Describe how to conduct the three phases of a service call.
  - Describe ways to handle challenging customer situations.

**Performance Task**
**Performance Task 1**
(Learning Objectives 1 and 2)
- Participate in at least three different role-playing scenarios related to challenging customer situations.

**Teaching Time: 5 hours**
(Two 2.5-Hour Classroom Sessions)
Session time may be adjusted to accommodate your class size, schedule, and teaching style.

**Prerequisites**
Core Curriculum; HVAC Level One; HVAC Level Two.

**Before You Begin**
As you prepare for each session, allow sufficient time to review the course objectives, content, visual aids (including the PowerPoint® presentation), and these lesson plans, and to gather the required equipment and materials. Consider time required for demonstrations, laboratories, field trips, and testing.

Using your access code, download the written examinations and performance profile sheets from www.nccerirc.com. The passing score for submission into NCCER’s Registry is 70% or above for the written examination; performance testing is graded pass or fail.
**Safety Considerations**
This module should be conducted in a classroom or conference room environment. Therefore, no special safety precautions should be needed.

**Classroom Equipment and Materials**
- Whiteboard/chalkboard
- Markers/chalk
- Pencils and paper
- HVAC Level Three PowerPoint Presentation Slides
- DVD player
- LCD projector and screen
- Computer
- Copies of the Module Exam and Performance Profile sheets

**Additional Resources**
This module presents thorough resources for task training. The following resource material is suggested for further study.


There are a number of online resources, including video, available for trainees who would like more information on customer relations and providing quality services. A search for additional information may be assigned as homework to interested trainees.

Instructors should view any videos before using them to ensure their suitability. The videos can provide teachable moments in both proper and improper work processes and behaviors. Be prepared to stop the videos at appropriate times to point out and discuss both proper and improper conduct and techniques.

Instructors are also encouraged to locate additional audiovisual aids available on the internet, make personal videos, and take photos related to the HVAC/R trade and add them to the PowerPoint presentations throughout the program.
The Lesson Plan for this module is divided into two 2.5-hour sessions. This time includes 10 minutes for administrative tasks and a 10-minute break per session.

**Session One**

Session One begins by covering two key aspects of customer relations: making a good first impression and communicating with customers in a positive way. It also covers the three primary elements of a service call: the opening; performing the service; and the closing. This session also provides examples of difficult customers and how to deal with them in positive ways.

1. Show the Session One PowerPoint® presentation.
2. Use the Kickoff Activity to get trainees engaged and give them an idea of what they will learn in this module.
3. Describe the various factors that influence a customer’s first impression of the service technician.
4. Discuss methods of communicating with customers in a way that gives them confidence in the service technician.
5. Discuss the three elements of a service call.
6. Review the examples of difficult customers.

**Session Two**

Session Two is a review and testing session in which trainees will participate in role playing of customer relations scenarios in order to satisfy the module Performance Task. Trainees will also complete the module Review Questions. Alternatively, these may be assigned as homework at the end of Session One. Go over the module Review Questions in class prior to the exam and answer any questions that the trainees may have.

1. Have trainees practice customer relations by participating in role-playing of customer relations scenarios.
2. Have trainees complete the module Review Questions. Alternatively, these may be assigned as homework at the end of Session One. Go over the answers to the Review Questions in class prior to the exam and answer any questions that the trainees may have.
3. Have trainees complete the written examination. Any outstanding performance testing must be completed during this session as well.
4. Record the testing results on Training Report Form 200, and submit the report to your Training Program Sponsor.
Lesson Plans for Module 03308-13

WATER TREATMENT

Module One (03308-13) focuses on the methods and devices that are used to treat water in HVAC systems. It introduces the main characteristics of water and explains how they affect HVAC system performance, pointing out the problems that could occur if improperly treated water were used. It presents various types of filtration devices and water treatment equipment. It also covers how to use water analysis test kits and emphasizes the importance of following safety precautions when working with water treatment chemicals. It explores in detail how to identify and address specific water-related problems in various types of recirculating water systems.

Objectives

Learning Objective 1
- Describe problems that the properties of water can cause in HVAC systems.
  a. Describe the properties of water that relate to water treatment in HVAC systems.
  b. Identify water quality problems that affect HVAC system performance.
  c. Describe how water test kits are used to collect samples for analysis.
  d. State the common safety precautions related to working with water treatment chemicals.

Learning Objective 2
- Identify types of mechanical water treatment devices and equipment.
  a. Identify types of filtration devices.
  b. Identify types of water treatment equipment.

Learning Objective 3
- Identify and describe how to address water-related problems that occur in specific types of hydronic and steam systems.
  a. Identify and describe how to treat water-related problems that occur in open recirculating water systems.
  b. Identify and describe how to treat water-related problems that occur in closed recirculating water systems.
  c. Identify and describe how to treat water-related problems that occur in steam systems.

Performance Tasks

Performance Task 1 (Learning Objective 1)
- Use a water analysis test kit to test water.

Performance Task 2 (Learning Objective 3)
- Inspect a cooling tower or steam boiler and its related water piping system for signs of water treatment problems.

Teaching Time: 10 hours
(Four 2.5-Hour Classroom Sessions)
Session time may be adjusted to accommodate your class size, schedule, and teaching style.

Prerequisites
Core Curriculum; HVAC Level One; HVAC Level Two; HVAC Level Three.

Before You Begin
As you prepare for each session, allow sufficient time to review the course objectives, content, visual aids (including the PowerPoint® presentation), and these lesson plans, and to gather the required equipment and materials. Consider time required for demonstrations, laboratories, field trips, and testing.

Using your access code, download the written examinations and performance profile sheets from www.nccerirc.com. The passing score for submission into NCCER’s Registry is 70% or above for the written examination; performance testing is graded pass or fail.
Classroom Equipment and Materials

Whiteboard/chalkboard  
Markers/chalk  
Pencils and paper  
HVAC Level Four PowerPoint®  
Presentation Slides  
DVD player  
LCD projector and screen  
Computer  
Internet access during class (optional)  
Copies of the Module Examination and Performance Profile Sheets

Equipment and Materials for Laboratories and Performance Testing

Standard eye protection  
Face shield and safety goggles/safety glasses with side shields as designated by the instructor or training facility provider  
Work gloves  
Chemical-resistant gloves as designated by the instructor or training facility provider  
Chemical-resistant apron as designated by the instructor or training facility provider  
Proper footwear as designated by the instructor or training facility provider  
Hearing protection as designated by the instructor or training facility provider  
Respiratory protection as designated by the instructor or training facility provider

Common hand tools  
Water analysis test kits for quick, on-site analysis (including testing pH, alkalinity, and hardness)  
Comprehensive water analysis test kits with data sheets (optional)  
An electronic pH meter  
One or more duplex strainers  
One or more single basket strainers  
One or more surface type cartridge filters  
One or more depth type cartridge filters  
Several different types of multimedia filters  
One or more bag-type filters  
Open or closed loop condenser, chilled, or hot water piping system(s)

Safety Considerations

This module requires that trainees work with and in the vicinity of functioning HVAC equipment as well as water treatment chemicals. Electrical, mechanical, and chemical safety must be emphasized at all times. Trainees should be carefully observed to ensure that they wear the proper PPE, follow safe practices, and give due respect to the hazards of water treatment chemicals and energized and operating HVAC systems. All work performed on functioning HVAC equipment must be completed under the direct supervision of the instructor.

Additional Resources

This module presents thorough resources for task training. The following resource material is suggested for further study.


There are a number of on-line resources available for trainees who would like more information on HVAC water treatment. A search for additional information may be assigned as homework to interested trainees.

Instructors should view any videos that may be identified in the lesson plan before using them to ensure their suitability. The videos can provide teachable moments in both proper and improper work processes and behaviors. Be prepared to stop the videos at appropriate times to point out and discuss both proper and improper conduct and techniques.

Instructors are also encouraged to locate additional audiovisual aids available on the internet, make personal videos, and take photos related to the subject matter and add them to the PowerPoint® presentations throughout the program.
The Lesson Plan for this module is divided into four 2.5-hour sessions. This time includes 10 minutes for administrative tasks and a 10-minute break per session.

## Session One

Session One introduces the importance of water treatment in HVAC system operation. It explains how water quality is assessed. It reviews the use of water treatment chemicals. It also covers several types of water filtration equipment.

1. Show the Session One PowerPoint® presentation.
2. Use the Kickoff Activity to encourage trainees to think about how using improperly treated water in HVAC systems can have serious consequences.
3. Discuss how the properties of water and water quality affect HVAC system performance.
4. Explain how test kits are used for water quality analysis.
5. Describe safety precautions related to the use of water treatment chemicals.
6. Review the features and functions of various types of water filtration equipment.

## Session Two

Session Two begins with an overview of mechanical equipment that is typically used for water treatment. The remainder of the session focuses on how to address system-specific water treatment problems.

1. Show the Session Two PowerPoint® presentation.
2. Review the features and functions of various types of water treatment equipment.
3. Discuss how to recognize and correct water treatment problems that are most common in open recirculating water systems.
4. Discuss how to recognize and correct water treatment problems that are most common in closed recirculating water systems.
5. Discuss how to recognize and correct water treatment problems that are most common in steam systems.

## Session Three

Session Three is devoted to laboratories and Performance Tasks 1 and 2.

1. Note that there is no PowerPoint® presentation associated with these sessions.
2. Demonstrate how to use a water analysis test kit and how to inspect a cooling tower or a steam boiler and its related piping system for signs of water treatment problems.
3. Trainees practice and/or complete the tasks associated with Performance Tasks 1 and 2 in this hands-on session.

## Session Four

Session Four is a review and testing session. Have trainees complete the module Review Questions. Alternatively, these may be assigned as homework at the end of Session Three. Go over the module Review Questions in class prior to the exam and answer any questions that the trainees may have.

1. Have trainees complete the written examination. Any outstanding performance testing must be completed during this session as well.
2. Record the testing results on Training Report Form 200, and submit the report to your Training Program Sponsor.
Module Two (03403-13) provides trainees with guidance on how to maintain good indoor air quality (IAQ) and comply with established IAQ standards. It describes how the health and comfort of people are affected by contaminants contained in the air that circulates through a building. It covers in detail how to detect sources of building air contaminants. It explains how control of ventilation, temperature, humidity, and chemical and microbial contaminants helps maintain acceptable IAQ. It explores various methods and HVAC devices and equipment that are used to address IAQ problems. It also discusses liability issues associated with servicing HVAC systems.

### Objectives

**Learning Objective 1**
- Describe how indoor air quality (IAQ) affects human occupants.
  a. Define IAQ.
  b. Describe good IAQ and how the lack of it affects humans.

**Learning Objective 2**
- Identify sources of building air contaminants and describe how such problems are detected.
  a. Describe how building construction, materials, and equipment can affect IAQ.
  b. Describe how human occupancy can affect IAQ.
  c. Describe how external sources can affect IAQ.
  d. Explain how an IAQ survey is conducted.
  e. Describe the air sampling process.

**Learning Objective 3**
- Explain how acceptable IAQ can be achieved.
  a. Explain how the building design can affect IAQ.
  b. Explain how ventilation, temperature, and humidity control affect IAQ.
  c. Explain how to control chemical and microbial contaminants.

**Learning Objective 4**
- Identify IAQ-related HVAC equipment and describe specific activities used to address IAQ problems.
  a. Identify and describe HVAC equipment and devices used to improve IAQ and/or energy consumption.
  b. Explain how air distribution systems can contribute to poor IAQ and how these problems are addressed.
  c. Describe the liability that HVAC contractors may accept by servicing HVAC systems.

### Performance Tasks

**Performance Task 1** (Learning Objective 2)
- Use selected radon monitors and/or test kits.

**Performance Task 2** (Learning Objectives 2 and 3)
- Perform a building indoor air quality (IAQ) inspection/evaluation.

**Performance Task 3** (Learning Objective 2)
- Make air measurements using at least one of the following devices:
  - CO₂ detector/sensor
  - CO detector/sensor

**Performance Task 4** (Learning Objective 4)
- Use a manufacturer’s humidifier capacity chart to find the humidifier capacity needed for various building types and sizes.

### Teaching Time: 12.5 hours

(Five 2.5-Hour Classroom Sessions)

Session time may be adjusted to accommodate your class size, schedule, and teaching style.

### Prerequisites

*Core Curriculum; HVAC Level One; HVAC Level Two; HVAC Level Three.*

### Before You Begin

As you prepare for each session, allow sufficient time to review the course objectives, content, visual aids (including the PowerPoint® presentation), and these lesson plans, and to gather the required equipment and materials. Consider time required for demonstrations, laboratories, field trips, and testing.

Using your access code, download the written examinations and performance profile sheets from [www.nccerirc.com](http://www.nccerirc.com). The passing score for submission into NCCER’s Registry is 70% or above for the written examination; performance testing is graded pass or fail.
Safety Considerations
This module requires that trainees work with or in the vicinity of functioning HVAC equipment. Trainees should be carefully observed to ensure that they wear the proper PPE, follow safe practices, and give due respect to the hazards of operating HVAC systems. Any work performed on functioning HVAC equipment must be done under the direct supervision of the instructor.

Classroom Equipment and Materials
- Whiteboard/chalkboard
- Markers/chalk
- Pencils and paper
- HVAC Level Four PowerPoint® Presentations
- DVD player
- LCD projector and screen
- Computer
- Internet access during class (optional)
- Calculators
- Copies of the HVAC Checklist – Short Form provided in Appendix B, from the EPA Building Air Quality guide
- Two or more humidifier capacity charts from different humidifier manufacturers
- Copies of the Module Examination and Performance Profile Sheets

Equipment and Materials for Laboratories and Performance Testing
- Standard eye protection
- Work gloves
- Proper footwear as designated by the instructor or training facility provider
- Hearing protection as designated by the instructor or training facility provider
- One or more of each of the following devices:
  - Passive radon test kit
  - Alpha particle detector (alpha track)
  - Electret ion chamber detector
  - Continuous radon monitor
  - A building with an operational HVAC system
  - Copies of the building plans and specifications for the building to be evaluated (optional)

Additional Resources
This module presents thorough resources for task training. The following resource material is suggested for further study.


There are a number of online resources available for trainees who would like more information on indoor air quality. A search for additional information may be assigned as homework to interested trainees.

Instructors are encouraged to locate additional audiovisual aids available on the internet, make personal videos, and take photos related to the subject matter and add them to the PowerPoint® presentations throughout the program. Instructors should view any videos that may be identified in the lesson plan before using them to ensure their suitability. The videos can provide teachable moments in both proper and improper work processes and behaviors.

Abatement Technologies, Inc. (www.abatement.com) provides a number of videos on duct cleaning procedures and equipment that can be viewed online. Instructors are encouraged to review these videos and incorporate any of them that they choose into the classroom presentation about air duct cleaning.
The Lesson Plan for this module is divided into five 2.5-hour sessions. This time includes 10 minutes for administrative tasks and a 10-minute break per session.

**SESSION ONE**

Session One introduces trainees to the importance of good indoor air quality (IAQ) and identifies and describes sources of contaminants that degrade the air quality in a building.

1. Show the Session One PowerPoint® presentation.
2. Use the Kickoff Activity to encourage trainees to consider the consequences of poor IAQ and to become engaged in learning about what HVAC technicians can do to achieve and maintain good IAQ.
3. Discuss indoor environmental quality issues that affect IAQ.
4. Describe how building materials and furnishings, HVAC and other building equipment, and cleaning compounds and pesticides affect IAQ.
5. Describe how human occupancy affects IAQ.
6. Describe how IAQ is affected by contaminant sources located outside a building, and explain how and why to perform radon testing.
7. Explain how to perform the various elements of a building IAQ inspection/survey.

**SESSION TWO**

Session Two explains how to perform air sampling and testing for specific contaminants. Means and methods for achieving acceptable IAQ are described. Solving IAQ problems through the use of energy-efficient systems and equipment is discussed in detail.

1. Show the Session Two PowerPoint® presentation.
2. Explain how to use gas detectors and analyzers for air sampling and testing for specific contaminants, and discuss how to interpret test results and take appropriate corrective actions.
3. Describe how the design of a building affects IAQ.
4. Explain how ventilation control and thermal comfort control are used to achieve acceptable IAQ.
5. Describe how chemical and microbial contaminants are controlled to achieve acceptable IAQ.
6. Describe the role of building and equipment maintenance in maintaining acceptable IAQ.
7. Describe how the following systems and equipment are used to solve IAQ problems: automated building management systems, air handling units, unit ventilators, and air filtration equipment.
**SESSION THREE**

Session Three continues the discussion of energy-efficient systems and equipment that are used to solve IAQ problems. Maintaining good IAQ in forced-air duct systems is described in detail. In addition, liability issues related to HVAC system servicing are discussed. The session includes an instructor demonstration and a laboratory/practice activity for trainees that corresponds to Performance Task 4.

1. Show the Session Three PowerPoint® presentation.
2. Describe how humidifiers and dehumidifiers are used to solve IAQ problems.
3. Demonstrate how to use a manufacturer’s humidifier capacity chart to find the humidifier capacity needed for various building types and sizes.
4. Observe trainees as they use a manufacturer’s humidifier capacity chart to find the humidifier capacity needed for various building types and sizes. This activity corresponds to Performance Task 4.
5. Describe how UV light air purification systems are used to solve IAQ problems.
6. Describe how supply and return duct leaks affect IAQ in forced-air duct systems, and explain how to seal air duct leaks.
7. Describe the contact vacuuming, air washing, and power brushing methods of duct cleaning.

**SESSION FOUR**

Session Four is devoted to laboratories and Performance Tasks 1, 2, and 3.

1. Note that there is no PowerPoint® presentation associated with this session.
2. Demonstrate the five steps for performing a building indoor air quality (IAQ) inspection/evaluation. Included among these steps are demonstrating how to use selected radon monitors and/or test kits and how to make air measurements using at least one of the following devices:
   - CO₂ detector/sensor
   - CO detector/sensor
3. Trainees practice and/or complete the tasks associated with Performance Tasks 1, 2, and 3 in this hands-on session.

**SESSION FIVE**

Session Five is a review and testing session. Have trainees complete the Module Review Questions. Go over the Module Review Questions in class prior to the exam and answer any questions that the trainees may have.

1. Have trainees complete the written examination. Any outstanding performance testing must be completed during this session as well.
2. Record the testing results on Training Report Form 200, and submit the report to your Training Program Sponsor.
Module Three (03404-13) explores the energy conservation technologies and devices used in residential and commercial HVAC systems. It covers the operation of various energy recycling and reclamation systems equipment. It also discusses the operation of electric utility energy demand reduction and energy storage systems, including the operation of ice storage systems.

Objectives

Learning Objective 1
- Identify and describe the operation of various energy recycling and reclamation systems and equipment.
  a. Identify and describe the operation of energy- and heat-recovery ventilators.
  b. Identify and describe the operation of fixed- and rotary-plate air-to-air heat exchangers.
  c. Identify and describe the operation of condenser heat recovery systems.
  d. Identify and describe the operation of coil energy recovery loops.
  e. Identify and describe the operation of heat pipe exchangers.
  f. Identify and describe the operation of thermosiphon heat exchangers.
  g. Identify and describe the operation of twin-tower enthalpy recovery loops.
  h. Identify and describe the operation of flue-gas heat recovery systems.
  i. Identify and describe the operation of steam heat recovery systems.

Learning Objective 2
- Identify and describe the operation of electric utility energy demand reduction and energy storage systems.
  a. Identify and describe the operation of electric utility demand reduction systems.
  b. Identify and describe the operation of ice storage systems.

Performance Tasks
This is a knowledge-based module; there are no performance tasks.

Teaching Time: 7.5 hours  
(Three 2.5-Hour Classroom Sessions)
Session time may be adjusted to accommodate your class size, schedule, and teaching style.

Prerequisites
Core Curriculum; HVAC Level One; HVAC Level Two; HVAC Level Three.

Before You Begin
As you prepare for each session, allow sufficient time to review the course objectives, content, visual aids (including the PowerPoint® presentation), and these lesson plans, and to gather the required equipment and materials. Consider time required for demonstrations, laboratories, field trips, and testing.

Using your access code, download the written examinations and performance profile sheets from www.nccerirc.com. The passing score for submission into NCCER’s Registry is 70% or above for the written examination; performance testing is graded pass or fail.
**Classroom Equipment and Materials**

- Whiteboard/chalkboard
- Markers/chalk
- Pencils and paper
- HVAC Level Four PowerPoint® Presentation Slides
- DVD player
- LCD projector and screen
- Computer
- Internet access during class (optional)
- Calculators
- Copies of the Module Examination

**Safety Considerations**

This is a knowledge-based module. As such, trainees are not required to work with or in the vicinity of functioning HVAC equipment. However, electrical and mechanical safety must be emphasized at all times. Trainees should be reminded to always wear the proper PPE, follow safe practices, and give due respect to the hazards of energized and operating HVAC systems.

**Additional Resources**

This module presents thorough resources for task training. The following resource material is suggested for further study.


There are a number of online resources available for trainees who would like more information on energy conservation equipment. A search for additional information may be assigned as homework to interested trainees.

Instructors should view any videos that may be identified in the lesson plan before using them to ensure their suitability. The videos can provide teachable moments in both proper and improper work processes and behaviors. Be prepared to stop the videos at appropriate times to point out and discuss both proper and improper conduct and techniques.

Instructors are also encouraged to locate additional audiovisual aids available on the internet, make personal videos, and take photos related to the subject matter and add them to the PowerPoint® presentations throughout the program.
The Lesson Plan for this module is divided into three 2.5-hour sessions. This time includes 10 minutes for administrative tasks and a 10-minute break per session.

**SESSION ONE**

Session One begins by introducing factors that have led to an increased use of heat recovery and/or energy-saving devices in HVAC systems. It goes on to describe various energy recycling and reclamation systems and equipment.

1. Show the Session One PowerPoint® presentation.
2. Use the Kickoff Activity to get trainees engaged and to expand their awareness of heat generation and recovery within a building.
3. Discuss how energy-recovery ventilators (ERVs) and heat-recovery ventilators (HRVs) improve indoor air quality and efficiency.
4. Explain how fixed-plate and rotary air-to-air heat exchangers work.
5. Describe how different types of condenser heat recovery systems work.
6. Explain how a coil energy recovery loop pre-heats or pre-cools incoming air in an HVAC system.

**SESSION TWO**

Session Two concludes the discussion of energy recycling and reclamation equipment. It also covers the operation of electric utility energy demand reduction systems and energy storage systems.

1. Show the Session Two PowerPoint® presentation.
2. Explain how a heat pipe heat exchanger increases the dehumidification capacity of a system and reduces its energy consumption.
3. Discuss how sealed-tube thermosiphon and coil-loop thermosiphon heat exchangers work.
4. Describe the operation of twin-tower enthalpy recovery loops.
5. Explain how a flue-gas heat recovery system preheats a boiler’s feedwater supply.
6. Discuss various types of steam heat recovery systems.
7. Identify and discuss demand-side management approaches used by electric utilities to reduce energy consumption.
8. Describe an ice storage system and explain how the system operates.

**SESSION THREE**

Session Three is a review and testing session. Have trainees complete the module Review Questions. Alternatively, these may be assigned as homework at the end of Session Two. Go over the module Review Questions in class prior to the exam and answer any questions that the trainees may have.

1. Have trainees complete the written examination.
2. Record the testing results on Training Report Form 200, and submit the report to your Training Program Sponsor.
Module Four (03405-13) provides trainees with guidance related to building management systems. Developing the necessary skills to understand the applications, principles, and troubleshooting of building management systems are vital to the future success of trainees in the HVAC trade.

### Objectives

**Learning Objective 1**
- Identify and describe the operation of basic digital controllers.
  - a. Identify the four primary control point classifications.
  - b. Describe analog and discrete input and output devices.
  - c. Describe closed control loops and the related algorithms.

**Learning Objective 2**
- Describe the architecture of a building management system.
  - a. Describe a DDC peer-to-peer network.
  - b. Describe the functions of a packaged unit digital controller.
  - c. Describe BMS control of an applied VAV system.

**Learning Objective 3**
- Describe various user-related tasks that can be achieved through a building management system.
  - a. Describe the ways in which users interface with and access the system.
  - b. Identify various tasks that are not related to temperature control that can be accomplished through the system.

**Learning Objective 4**
- Describe various building management system control strategies.
  - a. Describe occupied building temperature control strategies.
  - b. Describe unoccupied building temperature control strategies.
  - c. Describe other building control strategies that are not related to temperature control.

**Learning Objective 5**
- Define the concept of interoperability and describe the various related protocols.
  - a. Describe the four primary protocols in use.
  - b. Define and describe web browser system integration.
  - c. Project the course of interoperability in building management.

### Performance Task

**Performance Task 1** (Learning Objective 3)
- Interpret operating data received through building management system software.

### Prerequisites

Core Curriculum; HVAC Level One; HVAC Level Two, HVAC Level Three.

### Before You Begin

As you prepare for each session, allow sufficient time to review the course objectives, content, visual aids (including the PowerPoint presentation), and these lesson plans, and to gather the required equipment and materials. Consider time required for demonstrations, laboratories, field trips, and testing.

Using your access code, download the written examinations and performance profile sheets from www.nccerirc.com. The passing score for submission into NCCER’s Registry is 70% or above for the written examination; performance testing is graded pass or fail.
Classroom Equipment and Materials
Whiteboard/chalkboard
Markers/chalk
Pencils and paper
HVAC Level Four PowerPoint® Presentations
DVD player
LCD projector and screen
Computer
Internet access during class (optional)
Copies of the Module Examination and Performance Profile Sheets

Equipment and Materials for Laboratories and Performance Testing
One or more computers with access to the HVAC system through building management software

Additional Resources
There are a number of online resources available for trainees who would like more information on building management systems. A search for additional information may be assigned as homework to interested trainees.

Instructors should view any videos that may be identified in the lesson plan before using them to ensure their suitability. The videos can provide teachable moments in both proper and improper work processes and behaviors. Be prepared to stop the videos at appropriate times to point out and discuss both proper and improper conduct and techniques.

Instructors are also encouraged to locate additional audiovisual aids available on the internet, make personal videos, and take photos related to the subject matter and add them to the PowerPoint® presentations throughout the program.
Session Outline for 03405-13

BUILDING MANAGEMENT SYSTEMS

The Lesson Plan for this module is divided into five 2.5-hour sessions. This time includes 10 minutes for administrative tasks and a 10-minute break per session.

SESSION ONE
Session One discusses basic digital controllers and introduces system architecture.

1. Show the Session One PowerPoint® presentation.
2. Use the Kickoff Activity to familiarize trainees with building management systems software.
3. Discuss control point classification.
4. Address the input and output devices.
5. Discuss closed control loop algorithms.

SESSION TWO
Session Two discusses system architecture related to applied systems. Various system user interfaces are also presented. The session concludes with coverage of a wide variety of additional functions provided by a BMS.

1. Show the Session Two PowerPoint® presentation.
2. Talk about the application of a BMS to applied HVAC systems.
3. Explain the various BMS user interfaces.
4. Review the many valuable functions of a BMS.

SESSION THREE
Session Three discusses system control strategies and interoperability.

1. Show the Session Three PowerPoint® presentation.
2. Discuss occupied and unoccupied building temperature control.
3. Discuss accessory and other equipment control strategies.
4. Present the different building system protocols that affect interoperability.
5. Address web browser system integration.
6. Discuss the potential future of interoperability.

SESSION FOUR
Session Four is devoted to a laboratory and the completion of Performance Task 1.

1. Note that there is no PowerPoint® presentation associated with this session.
2. Demonstrate the interpretation of operating data received through building management system software.
3. Trainees practice and complete Performance Task 1.

SESSION FIVE
Session Five is a review and testing session. Have trainees complete the module Review Questions. Go over the module Review Questions in class prior to the exam and answer any questions that the trainees may have.

1. Have trainees complete the written examination. Any outstanding performance testing must be completed during this session as well.
2. Record the testing results on Training Report Form 200, and submit the report to your Training Program Sponsor.
Lesson Plans for Module 03402-13

SYSTEM AIR BALANCING

Module Five (03402-13) provides trainees with information and skills needed to balance air systems. Developing air balancing skills is vital to the future success of trainees in the HVAC/R trade. To that end, a portion of this module is devoted to hands-on practice and the successful completion of its required performance tasks.

**Objectives**

**Learning Objective 1**
- Describe the properties of air and the laws related to its temperature, pressure, and volume.
  a. Describe the basic properties of air that are related to airflow and balancing.
  b. Explain Dalton's, Boyle's, and Charles' laws.

**Learning Objective 2**
- Describe the study of psychrometrics and how to use the psychrometric chart.
  a. Describe psychrometrics and the related properties of air.
  b. Describe the structure of the psychrometric chart.
  c. Explain how to use the psychrometric chart to determine specific air properties.

**Learning Objective 3**
- Describe the air balancing process and identify the required tools and instruments.
  a. Describe air balancing and define common terminology.
  b. Identify the tools and instruments used in air balancing.
  c. Describe the fan laws and explain how to make changes to the supply air volume.

**Learning Objective 4**
- Explain how to balance an air distribution system.
  a. Describe the steps to take prior to beginning an air balancing task.
  b. Explain how to measure temperature rise and drop and then use the acquired information.
  c. Explain how to measure system and terminal airflow and adjust as required.
  d. Explain how to balance using the thermometer methods.

**Performance Tasks**

**Performance Task 1** (Learning Objectives 3 and 4)
- Select and properly use test instruments for balancing air distribution systems.

**Performance Task 2** (Learning Objective 4)
- Measure the temperature rise and drop across ducted heating and cooling equipment.

**Performance Task 3** (Learning Objective 3)
- Adjust supply fan speed to provide higher or lower air volume.

**Performance Task 4** (Learning Objective 4)
- Measure airflow at air supply outlets.

**Performance Task 5** (Learning Objective 4)
- Adjust dampers in branch supply ducts and at air terminals and diffusers.

**Teaching Time: 15 hours**
(Six 2.5-Hour Classroom Sessions)
Session time may be adjusted to accommodate your class size, schedule, and teaching style.

**Prerequisites**
*Core Curriculum; HVAC Level One; HVAC Level Two; HVAC Level Three.*

**Before You Begin**
As you prepare for each session, allow sufficient time to review the course objectives, content, visual aids (including the PowerPoint® presentation), and these lesson plans, and to gather the required equipment and materials. Consider time required for demonstrations, laboratories, field trips, and testing.

Using your access code, download the written examinations and performance profile sheets from www.nccerirc.com. The passing score for submission into NCCER's Registry is 70% or above for the written examination; performance testing is graded pass or fail.
### Safety Considerations

This module requires that trainees work on or near operating HVAC equipment. In those instances, trainees should be carefully observed to ensure that they wear the proper PPE, follow safe practices, and give due respect to the hazards of operating systems. Any work performed on functioning equipment must be done under the direct supervision of the instructor.

### Classroom Equipment and Materials

- Whiteboard/chalkboard
- Markers/chalk
- Pencils and paper
- HVAC Level Four PowerPoint® Presentations
- DVD player
- LCD projector and screen
- Computer
- Internet access during class (optional)
- Calculators
- Psychrometric charts
- Sling psychrometer
- Electronic psychrometer
- Differential pressure gauge
- U-tube manometer with accessory probes and fittings
- Inclined-tube manometer with accessory probes and fittings
- Electronic manometer with accessory probes and fittings
- Copies of the Module Examination and Performance Profile Sheets

### Equipment and Materials for Laboratories and Performance Testing

- Standard eye protection
- Work gloves
- Proper footwear as designated by the instructor or training facility provider
- Hearing protection as designated by the instructor or training facility provider
- Air balance forms for the systems to be balanced (instructor-created or acquired)
- Engineering data for the air terminals in use
- Multimeters
- Clamp-on ammeters or ammeter accessories for multimeters
- Common hand tools
- Digital or pocket thermometers
- Velometer(s)
- Anemometer(s)
- Flow hood(s)
- One or more functional, ducted heating and/or cooling systems

### Additional Resources

This module presents thorough resources for task training. The following resource material is suggested for further study.


There are a number of online resources available for trainees who would like more information on system air balancing. A search for additional information may be assigned as homework to interested trainees.

Instructors should view any videos that may be identified in the lesson plan before using them to ensure their suitability. The videos can provide teachable moments in both proper and improper work processes and behaviors. Be prepared to stop the videos at appropriate times to point out and discuss both proper and improper conduct and techniques.

Instructors are encouraged to locate additional audiovisual aids available on the Internet, make personal videos, and take photos related to the subject matter and add them to the PowerPoint® presentations throughout the program.
Session Outline for 03402-13

SYSTEM AIR BALANCING

The Lesson Plan for this module is divided into six 2.5-hour sessions. This time includes 10 minutes for administrative tasks and a 10-minute break per session.

SESSION ONE

Session One discusses air properties and presents the science of psychrometrics.
1. Show the Session One PowerPoint® presentation.
2. Use the Kickoff Activity to introduce trainees to the importance of system air balancing.
3. Describe the basic properties of air and discuss the various laws related to air.
4. Introduce the science of psychrometrics.
5. Describe the structure of a psychrometric chart and describe how to determine various air properties.

SESSION TWO

Session Two describes the air balancing process and identifies the tools used in air balancing.
1. Show the Session Two PowerPoint® presentation.
2. Describe air balancing and define common terminology.
3. Identify the tools and instruments used in air balancing.
4. Describe the fan laws and explain how to make changes to supply air volume.

SESSION THREE

Session Three describes how to balance an air distribution system.
1. Show the Session Three PowerPoint® presentation.
2. Describe the steps to take before beginning a system air balance.
3. Explain how to measure temperature rise and drop and how to use that information.
4. Explain how to measure and adjust system and terminal airflow.
5. Explain how to balance airflow using the thermometer-based methods.

SESSION FOUR AND FIVE

Sessions Four and Five are devoted to laboratories and Performance Tasks 1 through 5. A total of two sessions are devoted to demonstrating and practicing these essential skills.
1. Note that there is no PowerPoint® presentation associated with this session.
2. Demonstrate how to select and use tools and instruments for air balancing.
3. Demonstrate how to measure temperature rise and drop in ducted HVAC systems.
4. Demonstrate how to increase or decrease air volume by adjusting supply air fan speed.
5. Demonstrate how to measure airflow at air supply outlets.
6. Demonstrate how to adjust various supply air duct dampers.
7. Trainees practice and/or complete the tasks associated with Performance Tasks 1 through 5 in this hands-on sequence of sessions.

SESSION SIX

Session Six is a review and testing session. Have trainees complete the module Review Questions. Go over the module Review Questions in class prior to the exam and answer any questions that the trainees may have.
1. Have trainees complete the written examination. Any outstanding performance testing must be completed during this session as well.
2. Record the testing results on Training Report Form 200, and submit the report to your Training Program Sponsor.
Module Six (03406-13) provides trainees with information and skills needed to start up and shut down commercial HVAC equipment, including boilers and chillers. Developing these skills is vital to the future success of trainees in the HVAC/R trade. To that end, a portion of this module is devoted to hands-on practice and the successful completion of its required Performance Tasks.

Objectives

Learning Objective 1
- Explain how to properly shut down and start up boilers.
  a. Explain how to shut down and prepare boilers for dry storage.
  b. Explain how to shut down and prepare boilers for wet storage.
  c. Explain how to prepare and start up a steam boiler.
  d. Explain how to prepare and start up a hot water boiler.

Learning Objective 2
- Explain how to start up and shut down various chillers and water systems.
  a. Explain how to start up and shut down a reciprocating chiller system.
  b. Explain how to start up and shut down a centrifugal or screw chiller system.
  c. Explain how to start up and shut down cooling towers.
  d. Describe the process of inspecting and cleaning various heat exchange components.

Learning Objective 3
- Explain how to start up and shut down air handling and packaged rooftop systems.
  a. Explain how to start up and shut down air handling units and their associated air distribution systems.
  b. Explain how to start up and shut down packaged rooftop units.

Performance Tasks

Performance Task 1 (Learning Objective 3)
- Start up and shut down an air handling unit and prepare it for normal operation.

Performance Task 2
(Learning Objectives 1, 2, and 3)
- Start up and shut down at least one of the following:
  - Steam boiler
  - Hot-water boiler
  - Reciprocating chiller
  - Screw chiller
  - Centrifugal chiller
  - Cooling tower
  - Evaporative condenser

Teaching Time: 15 hours
(Six 2.5-Hour Classroom Sessions)

Session time may be adjusted to accommodate your class size, schedule, and teaching style.

Prerequisites
Core Curriculum; HVAC Level One; HVAC Level Two; HVAC Level Three.

Before You Begin
As you prepare for each session, allow sufficient time to review the course objectives, content, visual aids (including the PowerPoint® presentation), and these lesson plans, and to gather the required equipment and materials. Consider time required for demonstrations, laboratories, field trips, and testing.

Using your access code, download the written examinations and performance profile sheets from www.nccerirc.com. The passing score for submission into NCCER's Registry is 70% or above for the written examination; performance testing is graded pass or fail.
### Classroom Equipment and Materials
- Whiteboard/chalkboard
- Markers/chalk
- Pencils and paper
- HVAC Level Four PowerPoint® Presentations
- DVD player
- LCD projector and screen
- Computer
- Internet access during class (optional)
- Calculators
- Copies of the Module Examination and Performance Profile Sheets

### Equipment and Materials for Laboratories and Performance Testing
- Face mask
- Goggles
- Protective clothing
- Standard eye protection
- Work gloves
- Rubber gloves
- Proper footwear as designated by the instructor or training facility provider
- Hearing protection as designated by the instructor or training facility provider
- Product-specific service literature (from different equipment manufacturers)
- Equipment startup checklists
- Acid/moisture test kits
- pH test kits
- Air filters
- U-tube manometers
- Refrigerant gauge manifolds
- Ammeters or ammeter accessories for multimeters
- Operational air handlers
- Common hand tools
- Digital thermometers
- Screw chiller
- Centrifugal chiller
- Evaporative condenser

### Additional Resources
This module presents thorough resources for task training. The following resource material is suggested for further study.


There are a number of online resources available for trainees who would like more information on system startup and shutdown. A search for additional information may be assigned as homework to interested trainees.

Instructors should view any videos that may be identified in the lesson plan before using them to ensure their suitability. The videos can provide teachable moments in both proper and improper work processes and behaviors. Be prepared to stop the videos at appropriate times to point out and discuss both proper and improper conduct and techniques.

Instructors are encouraged to locate additional audiovisual aids available on the Internet, make personal videos, and take photos related to the subject matter and add them to the PowerPoint® presentations throughout the program.

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### Safety Considerations
This module requires that trainees work with, or in the vicinity of, operating HVAC equipment. In those instances, trainees should be carefully observed to ensure that they wear the proper PPE, follow safe practices, and give due respect to the hazards of operating systems. Any work performed on functioning equipment must be done under the direct supervision of the instructor.
The Lesson Plan for this module is divided into six 2.5-hour sessions. This time includes 10 minutes for administrative tasks and a 10-minute break per session.

**SESSION ONE**

Session One describes how to properly start up and shut down boilers and prepare them for storage.

1. Show the Session One PowerPoint® presentation.
2. Use the Kickoff Activity to introduce trainees to the focus of this module.
3. Explain how to shut down and prepare boilers for storage.
4. Explain how to prepare and start up a steam boiler.
5. Explain how to prepare and start up a hot water boiler.

**SESSION TWO**

Session Two describes how to start up and shut down various chillers and water systems.

1. Show the Session Two PowerPoint® presentation.
2. Explain how to start up and shut down centrifugal, reciprocating, and screw chiller systems.
3. Explain how to start up and shut down cooling towers.
4. Describe the process of inspecting and cleaning various heat exchanger components.

**SESSION THREE**

Session Three describes how to start up and shut down air handling and packaged rooftop systems.

1. Show the Session Three PowerPoint® presentation.
2. Explain how to start up and shut down air handling units and their associated air distribution systems.
3. Explain how to start up and shut down packaged rooftop units.

**SESSIONS FOUR AND FIVE**

Sessions Four and Five are devoted to laboratories and Performance Tasks 1 and 2. A total of two sessions are devoted to demonstrating and practicing these essential skills due to their complex nature.

1. Note that there is no PowerPoint® presentation associated with this session.
2. Demonstrate how to prepare, start up, and shut down an air handling unit.
3. Demonstrate how to start up and shut down at least one of the types of listed equipment.
4. Trainees practice and/or complete the tasks associated with Performance Tasks 1 and 2 in a series of hands-on sessions.

**SESSION SIX**

Session Six is a review and testing session. Have trainees complete the module Review Questions. Go over the module Review Questions in class prior to the exam and answer any questions that the trainees may have.

1. Have trainees complete the written examination. Any outstanding performance testing must be completed during this session as well.
2. Record the testing results on Training Report Form 200, and submit the report to your Training Program Sponsor.
Module Seven (03401-13) focuses on the interpretation of construction drawings and specifications associated with HVAC installations in new construction. It explores the many different types of drawings that HVAC technicians and installers work with. It covers the use of specifications and submittals for HVAC equipment installation. It also covers the performance of the takeoff process for HVAC equipment and materials.

**Objectives**

**Learning Objective 1**
- Describe the types of drawings HVAC technicians work with and how they are used.
  a. Explain the initial approach to viewing a set of drawings.
  b. Describe site plans and their purpose.
  c. Describe plan views, elevations, detail drawings, and section drawings and their purposes.
  d. Describe plumbing, mechanical, and electrical drawings and their purposes.
  e. Describe shop drawings and their purpose.
  f. Describe as-built drawings and their purpose.
  g. Describe schedules and their purpose.
  h. Describe the Request for Information (RFI) and how it is prepared.
  i. Explain the importance of building codes to the design process.

**Learning Objective 2**
- Describe the uses of specifications and submittals in construction projects.
  a. Describe specifications and their purpose.
  b. Describe submittals and their purpose.

**Learning Objective 3**
- Describe the takeoff process and how it is performed.
  a. Identify and describe the tools and materials used in the takeoff process.
  b. Explain how to conduct a takeoff.

**Performance Tasks**

**Performance Task 1** (Learning Objective 1)
- Identify and interpret the following on an architectural drawing:
  - Floor plans and details
  - Elevations
  - Foundation plan
  - Reflected ceiling plan

**Performance Task 2** (Learning Objective 1)
- Identify and interpret at least four of the following on a plumbing plan drawing:
  - Sanitary plumbing plans
  - Domestic water plumbing plans
  - Riser diagrams
  - Schedules
  - Specification references
  - Legends

**Performance Task 3** (Learning Objective 1)
- Identify and interpret the following on a mechanical plan drawing:
  - Hot- and chilled-water coil piping
  - HVAC piping
  - Chiller piping/installation
  - Refrigeration piping schematics
  - Air handling unit installation/connecting ductwork
  - Hot- and chilled-water flow diagrams
  - Schedules
  - Specification references
  - Legends

**Performance Task 4** (Learning Objective 1)
- Identify and interpret the following on an electrical plan drawing:
  - Riser diagrams
  - Schedules
  - Specification references
  - Legends

**Performance Task 5** (Learning Objective 1)
- Interpret HVAC-related shop drawings.

**Performance Task 6** (Learning Objective 3)
- Perform an HVAC equipment and material takeoff and prepare the takeoff forms.

**Teaching Time: 12.5 hours**
*(Five 2.5-Hour Classroom Sessions)*
Session time may be adjusted to accommodate your class size, schedule, and teaching style.
Prerequisites
Core Curriculum; HVAC Level One; HVAC Level Two; HVAC Level Three.

Before You Begin
As you prepare for each session, allow sufficient time to review the course objectives, content, visual aids (including the PowerPoint® presentation), and these lesson plans, and to gather the required equipment and materials. Consider time required for demonstrations, laboratories, field trips, and testing.

Using your access code, download the written examinations and performance profile sheets from www.nccerirc.com. The passing score for submission into NCCER’s Registry is 70% or above for the written examination; performance testing is graded pass or fail.

Safety Considerations
This module does not require that trainees work with or in the vicinity of functioning HVAC equipment. However, the recommended Kickoff Activity does include a field trip to a building that houses such systems. Electrical and mechanical safety must be emphasized at all times. Trainees should be carefully observed to ensure that they wear the proper PPE, follow safe practices, and give due respect to the hazards of energized and operating HVAC systems.

Classroom Equipment and Materials
Whiteboard/chalkboard
Markers/chalk
Pencils and paper
HVAC Level Four PowerPoint® Presentations
DVD player
LCD projector and screen
Computer
Internet access during class (optional)
Calculators
Copies of the list of Search Items for the Session One Wrap Up Exercise
Multiple copies of HVAC equipment and material takeoff forms
Copies of the Module Examination and Performance Profile Sheets
Multiple copies separated into packages of various types of construction drawings, schedules, submittals, takeoff sheets, and reference documents for the Session One Wrap Up exercise. Each package should include at least one example of each of the following:
- Mechanical plan that includes refrigeration piping schematics
- Site/plot plan
- Plumbing plan showing the layout of water supply lines and natural gas piping
- Elevation drawing that indicates the material used for the exterior finish of a building
- Electrical plan that includes a power riser diagram
- Reflected ceiling plan showing the locations of supply diffusers, exhaust grilles, and access panels
- Mechanical plan showing the location of the main HVAC system components
- Section drawing showing a cut-away view of an air handling unit installation
- Floor plan showing the direction in which doors swing
- Detail drawing of a diffuser
- Tools for performing an HVAC equipment and material takeoff, such as:
  - Colored pencils
  - Automatic mechanical counters
  - Drafting scales
  - Calculators

Equipment and Materials for Laboratories and Performance Testing
Sets of building plans for different projects, each of which includes the following types of drawings and/or drawing components:
- Architectural drawings showing the following:
  - Floor plans and details
  - Elevations
  - Foundation plan
  - Reflected ceiling plan
- Plumbing drawings showing at least four of the following:
  - Sanitary plumbing plans
  - Domestic water plumbing plans
  - Riser diagrams
  - Schedules
  - Specification references
  - Legends
- Mechanical drawings showing the following:
  - Hot- and chilled-water coil piping
  - HVAC piping
  - Chiller piping/installation
  - Refrigeration piping schematics
  - Air handling unit installation/connecting ductwork
  - Hot- and chilled-water flow diagrams
  - Schedules
  - Specification references
  - Legends
- Electrical drawings showing the following:
  - Riser diagrams
  - Schedules
  - Specification references
  - Legends
- Various types of HVAC-related shop drawings (two or more)
Additional Resources

This module presents thorough resources for task training. The following resource material is suggested for further study.


There are a number of online resources available for trainees who would like more information on construction drawings and specifications. A search for additional information may be assigned as homework to interested trainees.

Instructors should view any videos that may be identified in the lesson plan before using them to ensure their suitability. The videos can provide teachable moments in both proper and improper work processes and behaviors. Be prepared to stop the videos at appropriate times to point out and discuss both proper and improper conduct and techniques.

Instructors are also encouraged to locate additional audiovisual aids available on the internet, make personal videos, and take photos related to the subject matter and add them to the PowerPoint® presentations throughout the program.
Session Outline for 03401-13

CONSTRUCTION DRAWINGS AND SPECIFICATIONS

The Lesson Plan for this module is divided into five 2.5-hour sessions. This time includes 10 minutes for administrative tasks and a 10-minute break per session.

<table>
<thead>
<tr>
<th>Session One</th>
</tr>
</thead>
<tbody>
<tr>
<td>Session One introduces several of the many types of drawings that HVAC technicians work with and explains how each type of drawing is used. Specific types of drawings covered in this session include: site plans; plan views, elevations, detail drawings, and section drawings; and plumbing, mechanical, and electrical drawings.</td>
</tr>
<tr>
<td>1. Show the Session One PowerPoint® presentation.</td>
</tr>
<tr>
<td>2. Use the Kickoff Activity to show trainees how a set of drawings relates to an actual building, and to emphasize the importance of properly interpreting a set of plans and specifications.</td>
</tr>
<tr>
<td>3. Explain the initial approach to viewing sets of drawings.</td>
</tr>
<tr>
<td>4. Describe the following types of drawings and their purposes: site plans; plan views, elevations, detail drawings, and section drawings; and plumbing, mechanical, and electrical drawings.</td>
</tr>
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<table>
<thead>
<tr>
<th>Session Two</th>
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<tbody>
<tr>
<td>Session Two concludes the discussion of the types of HVAC drawings by describing shop drawings and as-built drawings and how they are used. It also covers the use of schedules and the Request for Information (RFI). In addition, it reviews the importance of building codes to the design process.</td>
</tr>
<tr>
<td>1. Show the Session Two PowerPoint® presentation.</td>
</tr>
<tr>
<td>2. Describe shop and as-built drawings and explain how they are used.</td>
</tr>
<tr>
<td>3. Describe schedules and discuss their purpose.</td>
</tr>
<tr>
<td>4. Describe the Request for Information (RFI) and explain how it is prepared.</td>
</tr>
<tr>
<td>5. Discuss the importance of building codes to the design process.</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Sessions Three and Four</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sessions Three and Four are devoted to laboratories and Performance Tasks 1 through 6.</td>
</tr>
<tr>
<td>1. Note that there is no PowerPoint® presentation associated with these sessions.</td>
</tr>
<tr>
<td>2. Provide trainees with sets of plans from multiple projects to create questions for other teams to answer.</td>
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<tr>
<td>3. Demonstrate how to perform an HVAC equipment and material takeoff and prepare the takeoff forms.</td>
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<tr>
<td>4. Trainees practice and/or complete the tasks associated with Performance Tasks 1 through 6 in two hands-on sessions.</td>
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</tbody>
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<table>
<thead>
<tr>
<th>Session Five</th>
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<tbody>
<tr>
<td>Session Five is a review and testing session. Have trainees complete the module Review Questions. Alternatively, these may be assigned as homework at the end of Session Four. Go over the module Review Questions in class prior to the exam and answer any questions that the trainees may have.</td>
</tr>
<tr>
<td>1. Have trainees complete the written examination. Any outstanding performance testing must be completed during this session as well.</td>
</tr>
<tr>
<td>2. Record the testing results on Training Report Form 200, and submit the report to your Training Program Sponsor.</td>
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</tbody>
</table>
Module Eight (03407-13) focuses on the selection of proper heating and cooling equipment along with proper design of air distribution and refrigerant piping systems. It emphasizes how a good understanding of the many factors that influence HVAC system design enables HVAC contractors to select the most effective equipment while minimizing installation costs.

### Objectives

**Learning Objective 1**
- Describe the design process and explain how to evaluate a structure for load estimating.
  - a. Describe the design process.
  - b. Explain how to evaluate a structure for load estimating.

**Learning Objective 2**
- Explain how to complete a heating and cooling load estimate.
  - a. Describe how heat is gained or lost through a building structure.
  - b. Identify specific cooling and heating load factors.

**Learning Objective 3**
- Explain how to select equipment based on the load estimate and describe common support systems to be considered.
  - a. Explain how to select cooling equipment.
  - b. Explain how to select heating equipment.
  - c. Explain how to select heat pumps.
  - d. Describe common support systems to be considered.

**Learning Objective 4**
- Explain how to design air distribution systems.
  - a. Identify basic duct design considerations.
  - b. Identify various duct system layouts.
  - c. Identify various duct system components.
  - d. Describe how to design and size duct systems.
  - e. Identify system design factors unique to commercial buildings.

### Performance Tasks

**Performance Task 1** (Learning Objectives 1 and 2)
- Using plans provided by the instructor, perform a load estimate using a standardized method.

**Performance Task 2** (Learning Objective 3)
- Use manufacturer's product data to select the appropriate heating and cooling equipment based on a load estimate and airflow requirements.

**Performance Task 3** (Learning Objective 4)
- Determine the number, location, and sizes of supply outlets and return inlets needed in a building.

**Performance Task 4** (Learning Objective 4)
- Use standard duct sizing tables, a duct design calculator, or a software application to size the trunk and branch ducts for a selected low-volume air distribution system.

**Performance Task 5** (Learning Objective 4)
- Calculate the total system friction loss (external static pressure) for a selected air distribution system.

### Teaching Time: 22.5 hours
(Nine 2.5-Hour Classroom Sessions)
Session time may be adjusted to accommodate your class size, schedule, and teaching style.

### Prerequisites

*Core Curriculum; HVAC Level One; HVAC Level Two; HVAC Level Three.*

### Before You Begin
As you prepare for each session, allow sufficient time to review the course objectives, content, visual aids (including the PowerPoint presentation), and these lesson plans, and to gather the required equipment and materials. Consider time required for demonstrations, laboratories, field trips, and testing.

Using your access code, download the written examinations and performance profile sheets from [www.nccerirc.com](http://www.nccerirc.com). The passing score for submission into NCCER’s Registry is 70% or above for the written examination; performance testing is graded pass or fail.
**Classroom Equipment and Materials**

Whiteboard/chalkboard  
Markers/chalk  
Pencils and paper  
HVAC Level Four PowerPoint® Presentations  
DVD player  
LCD projector and screen  
Computer  
Internet access during class (optional)  
Calculators  
Residential data takeoff form with a corresponding floor plan  
Two or more examples of manufacturer’s product data for cooling equipment, including packaged units and components of split systems  
One or more fan curves/fan performance charts

**Equipment and Materials for Laboratories and Performance Testing**

A secondary drain pan switch  
One or more handheld duct design calculators  
One or more copies of ACCA Manual J, Load Calculation for Residential Winter and Summer Air Conditioning  
One or more copies of FEMA 412 Installing Seismic Restraints for Mechanical Equipment  
One or more copies of SMACNA’s Seismic Restraint Manual: Guidelines for Mechanical Systems  
A copy of ACCA Manual N, Load Calculation for Commercial Winter and Summer Air Conditioning  
Copies of the Module Examination and Performance Profile Sheets

**Additional Resources**

This module presents thorough resources for task training. The following resource material is suggested for further study.


*HVAC Duct Construction Standards – Metal and Flexible.* Chantilly, VA: Sheet Metal and Air Conditioning Contractors National Association (SMACNA).


There are a number of online resources available for trainees who would like more information on heating and cooling system design. A search for additional information may be assigned as homework to interested trainees.

Instructors should view any videos that may be identified in the lesson plan before using them to ensure their suitability. The videos can provide teachable moments in both proper and improper work processes and behaviors. Be prepared to stop the videos at appropriate times to point out and discuss both proper and improper conduct and techniques.

Instructors are also encouraged to locate additional audiovisual aids available on the internet, make personal videos, and take photos related to the subject matter and add them to the PowerPoint® presentations throughout the program.
### Session One

Session One provides an overview of HVAC design processes. It also initiates coverage of load estimating, focusing on heat transfer.

1. Show the Session One PowerPoint® presentation.
2. Use the Kickoff Activity to encourage trainees to consider why accurate estimates are essential when designing heating and cooling systems and selecting the equipment to be installed in the systems.
3. Describe HVAC design processes and explain how to survey and evaluate a building for load estimating.
4. Describe how heat is transferred through the structure of a building.

### Session Two

Session Two continues the discussion of load estimating, focusing on cooling and heating load factors. It also covers equipment selection and support systems.

1. Show the Session Two PowerPoint® presentation.
2. Describe the cooling and heating load factors involved in load estimating.
3. Explain how to select cooling equipment, heating equipment, heat pumps, and support systems based on a load estimate.

### Session Three

Session Three initiates coverage of air distribution system design. It focuses on duct design and air distribution system layouts. It describes the construction, assembly, and installation of the main trunk and branch ducts of various types of duct in detail.

1. Show the Session Three PowerPoint® presentation.
2. Describe basic duct design considerations, including pressure relationships within ducts, friction losses, dynamic losses, static regain, external static pressure, and required airflow.
3. Describe air distribution system layouts used in differing climates.
4. Describe the ways in which duct systems are classified.
5. Compare and contrast low-velocity and high-velocity duct systems.
6. Identify the main components of an air distribution system.
7. Describe the locations/applications in which ductwork is installed, the types of materials used for ducts, and devices that are used in conjunction with ductwork.
8. Describe the construction, assembly, and installation of the following types of duct: square or rectangular metal duct, round metal duct, fiberglass ductboard, and flexible round duct.
9. Explain how to determine the pressure loss and the equivalent-length-of-straight duct value for duct system fittings.
10. Review the purpose, selection, and installation of supply air outlets, return air inlets, and volume dampers.
### SESSION FOUR

Session Four concludes the discussion of air distribution system design. It covers the steps of the duct design process. It explains duct system sizing and design in detail. It also reviews commercial building design factors.

1. Show the Session Four PowerPoint® presentation.

2. Describe the seven steps of the duct design process.

3. Explain how to select supply outlets and return inlets and how to calculate their volume and size.

4. Describe the equal friction method of sizing ductwork.

5. Explain how to calculate the capacity ratio of a new system’s air volume requirements to total capacity of an existing duct system; how to calculate the capacity ratio for each supply outlet or return grille; and how to determine whether additional outlets are needed to meet the air volume requirements for an upgraded system.

6. Describe the ways in which metal duct can be insulated, and under what conditions this is necessary.

7. Review system design factors that are unique to commercial buildings.

### SESSIONS FIVE - EIGHT

Sessions Five through Eight are devoted to laboratories and Performance Tasks 1 through 5.

1. Note that there is no PowerPoint® presentation associated with these sessions.

2. Perform a demonstration of the following tasks:
   - Perform a load estimate using a standardized method
   - Use manufacturer’s product data to select appropriate heating and cooling equipment
   - Determine the number, location, and sizes of supply outlets and return inlets
   - Size the trunk and branch ducts for a low-volume air distribution system
   - Calculate the total system friction loss for an air distribution system.

3. Trainees practice and/or complete the tasks associated with Performance Tasks 1 through 5 in this series of four sessions.

### SESSION NINE

Session Nine is a review and testing session. Have trainees complete the module Review Questions. Alternatively, these may be assigned as homework at the end of Session Eight. Go over the module Review Questions in class prior to the exam and answer any questions that the trainees may have.

1. Have trainees complete the written examination. Any outstanding performance testing must be completed during this session as well.

2. Record the testing results on Training Report Form 200, and submit the report to your Training Program Sponsor.
Module Nine (03408-13) focuses on commercial and industrial applications of refrigeration. It covers the equipment, control systems, and refrigerants used for these purposes. It compares and contrasts the methods and components used in commercial and industrial applications with those used in comfort cooling systems.

### Objectives

**Learning Objective 1**
- Describe methods used to freeze, store, and transport food products.
  - a. Describe methods used to freeze food products.
  - b. Describe methods used to store food products.
  - c. Describe methods used to transport refrigerated food products.

**Learning Objective 2**
- Identify and describe various commercial and industrial refrigeration system components.
  - a. Identify and describe various compressor configurations.
  - b. Describe the application, control, and installation of air-cooled condensers.
  - c. Identify and describe various evaporator and display case configurations.
  - d. Identify and describe various refrigeration system accessories.
  - e. Identify and describe various refrigerant control devices.

**Learning Objective 3**
- Identify and describe various types of defrost systems.
  - a. Identify and describe off-cycle defrost systems.
  - b. Identify and describe electric defrost systems.
  - c. Identify and describe hot-gas defrost systems.

**Learning Objective 4**
- Describe the main characteristics of ammonia-based refrigeration systems.
  - a. Describe the properties and safety considerations of ammonia as a refrigerant.
  - b. Describe ammonia systems and the basic components.

### Performance Tasks

**Performance Task 1** (Learning Objectives 2 and 3)
- Install or make repairs to a packaged refrigeration condensing unit.

**Performance Task 2** (Learning Objectives 2 and 3)
- Install or make repairs to a packaged unit cooler in a refrigeration system.

**Performance Task 3** (Learning Objective 2)
- Identify at least three of the following devices (selection provided by the instructor) commonly used in refrigeration systems:
  - a. Crankcase pressure regulator
  - b. Evaporator pressure regulator
  - c. Condenser head pressure regulator
  - d. Hot gas bypass regulator
  - e. Pressure-controlled cylinder unloader
  - f. Solenoid-controlled cylinder unloader

### Teaching Time: 20 hours

(Eight 2.5-Hour Classroom Sessions)

Session time may be adjusted to accommodate your class size, schedule, and teaching style.

### Prerequisites

*Core Curriculum; HVAC Level One; HVAC Level Two; HVAC Level Three.*

### Before You Begin

As you prepare for each session, allow sufficient time to review the course objectives, content, visual aids (including the PowerPoint® presentation), and these lesson plans, and to gather the required equipment and materials. Consider time required for demonstrations, laboratories, field trips, and testing.

Using your access code, download the written examinations and performance profile sheets from [www.nccerirc.com](http://www.nccerirc.com). The passing score for submission into NCCER’s Registry is 70% or above for the written examination; performance testing is graded pass or fail.
Safety Considerations
This module requires that trainees work with and in the vicinity of functioning refrigeration equipment. Electrical and mechanical safety must be emphasized at all times. Trainees should be carefully observed to ensure that they wear the proper PPE, follow safe practices, and give due respect to the hazards of energized and operating HVAC systems. All work performed on functioning HVAC equipment must be completed under the direct supervision of the instructor.

Classroom Equipment and Materials
- Whiteboard/chalkboard
- Markers/chalk
- Pencils and paper
- *HVAC Level Four PowerPoint® Presentation Slides*
- DVD player
- LCD projector and screen
- Computer
- Internet access during class (optional)
- Calculators
- A temperature-controlled condenser fan speed control and/or a pressure-controlled condenser fan speed control
- Oil differential check valve
- Oil level control
- Oil separator
- Safety data sheet (MSDS/SDS) for ammonia
- Copies of the Module Examination and Performance Profile Sheets

Equipment and Materials for Laboratories and Performance Testing
- Standard eye protection
- Hearing protection as designated by the instructor or training facility provider
- Proper footwear as designated by the instructor or training facility provider
- Work gloves
- Common hand tools
- Refrigerant gauge manifolds
- Multimeters
- Ammeters or ammeter accessories for multimeters
- Refrigerant
- Digital thermometers
- Numbered tags to attach to the selected control devices
- Functional walk-in cooler or freezer, with installed refrigeration equipment
- At least three of the following control devices:
  - Crankcase pressure regulator/valve
  - Evaporator pressure regulator/valve
  - Condenser head pressure regulator/three-way modulating valve
  - Hot gas bypass regulator/valve
  - Pressure-controlled cylinder unloader
  - Solenoid-controlled cylinder unloader

Additional Resources
This module presents thorough resources for task training. The following resource material is suggested for further study.


There are a number of online resources available for trainees who would like more information on commercial and industrial refrigeration. A search for additional information may be assigned as homework to interested trainees.

Instructors should view any videos that may be identified in the lesson plan before using them to ensure their suitability. The videos can provide teachable moments in both proper and improper work processes and behaviors. Be prepared to stop the videos at appropriate times to point out and discuss both proper and improper conduct and techniques.

Instructors are also encouraged to locate additional audiovisual aids available on the internet, make personal videos, and take photos related to the subject matter and add them to the PowerPoint® presentations throughout the program.
The Lesson Plan for this module is divided into eight 2.5-hour sessions. This time includes 10 minutes for administrative tasks and a 10-minute break per session.

**Session One**

Session One examines the use of commercial refrigeration and freezing methods to preserve food and other perishable commodities. It also covers equipment that is used to store and transport refrigerated or frozen food products.

1. Show the Session One PowerPoint® presentation.
2. Use the Kickoff Activity to encourage trainees to consider the many applications of commercial refrigeration.
3. Describe commercial freezing methods and their applications.
4. Describe the use of chill rooms and freezer rooms for food storage.
5. Identify and describe the different modes of transporting refrigerated products.

**Session Two**

Session Two initiates the examination of the various components of a refrigeration system. It focuses on compressors and condensers.

1. Show the Session Two PowerPoint® presentation.
2. Describe the types of compressors used in commercial refrigeration systems, as well as the physical arrangements of compressors within the system.
3. Describe concerns related to oil and refrigerant flow in multiple compressor applications.
4. Describe the types of condensers and the condenser ratings used in commercial and industrial refrigeration systems.
5. Describe pressure control methods for air-cooled condensers in refrigeration systems.
6. Explain the purpose of increasing liquid line refrigerant subcooling and describe four methods used to increase subcooling.
7. Discuss factors to consider when installing air-cooled condensers or condensing units; review general guidelines for installing remote air-cooled condensers.

**Session Three**

Session Three continues the discussion of refrigeration system components. It focuses on evaporators and display cases and also covers refrigeration system accessories.

1. Show the Session Three PowerPoint® presentation.
2. Describe the features, installation, operation, and typical applications of evaporators used in commercial refrigeration systems.
3. Describe the purpose, features, installation, operation, and maintenance of common commercial refrigeration system accessories and specialty valves.
Session Four concludes the discussion of refrigeration system components, focusing on control devices. It also covers defrost systems and ammonia refrigeration.

1. Show the Session Four PowerPoint® presentation.
2. Describe the purpose, features, installation, operation, and maintenance of common commercial refrigeration system accessories and specialty valves.
3. Describe the components, installation, operation, and typical applications of the various defrost systems.
4. Describe the characteristics of anhydrous ammonia and the safety considerations associated with its use.
5. Describe the various types of common ammonia-based refrigeration systems.
6. Describe the types, arrangement, and installation of various ammonia refrigeration system components.

Sessions Five – Seven

Sessions Five through Seven are devoted to laboratories and Performance Tasks 1, 2, and 3.

1. Note that there is no PowerPoint® presentation associated with these sessions.
2. Provide a walk-in cooler or freezer, or similar refrigeration equipment, for trainees to service and test.
3. Create faults in equipment for trainees to diagnose and solve.
4. Provide an assortment of refrigeration circuit components for trainees to identify.
5. Trainees practice and/or complete the tasks associated with Performance Tasks 1, 2, and 3 in this series of hands-on sessions.

Session Eight

Session Eight is a review and testing session. Have trainees complete the module Review Questions. Alternatively, these may be assigned as homework at the end of Session Seven. Go over the module Review Questions in class prior to the exam and answer any questions that the trainees may have.

1. Have trainees complete the written examination. Any outstanding performance testing must be completed during this session as well.
2. Record the testing results on Training Report Form 200, and submit the report to your Training Program Sponsor.
Module Ten (03409-13) provides trainees with guidance related to alternative and specialized heating and cooling systems. Developing the necessary skills to understand the applications, principles, and troubleshooting of these systems are vital to the future success of trainees in the HVAC/R trade.

### Objectives

**Learning Objective 1**
- Identify and describe various alternative heating and cooling systems.
  a. Identify and describe solid-fuel heating equipment.
  b. Identify and describe waste-oil heating equipment.
  c. Identify and describe passive and active solar heating systems.
  d. Identify and describe evaporative coolers.

**Learning Objective 2**
- Identify and describe various unique heating and cooling systems and equipment.
  a. Identify and describe direct-fired make-up air units.
  b. Identify and describe computer room cooling systems and equipment.
  c. Identify and describe enclosure- and spot-cooling equipment.
  d. Identify and describe valance and chilled-beam cooling approaches.
  e. Identify and describe air turnover systems.

### Performance Tasks
This is a knowledge-based module; there are no performance tasks.

### Teaching Time: 7.5 hours
(Three 2.5-Hour Classroom Sessions)
Session time may be adjusted to accommodate your class size, schedule, and teaching style.

### Prerequisites
*Core Curriculum; HVAC Level One; HVAC Level Two; HVAC Level Three.*

### Before You Begin
As you prepare for each session, allow sufficient time to review the course objectives, content, visual aids (including the PowerPoint® presentation), and these lesson plans, and to gather the required equipment and materials. Consider time required for demonstrations, laboratories, field trips, and testing.

Using your access code, download the written examinations and performance profile sheets from [www.nccerirc.com](http://www.nccerirc.com). The passing score for submission into NCCER's Registry is 70% or above for the written examination; performance testing is graded pass or fail.
**Safety Considerations**

This is a knowledge-based module. As such, trainees are not required to work with or in the vicinity of functioning HVAC equipment. However, electrical and mechanical safety must be emphasized at all times. Trainees should be reminded to always wear the proper PPE, follow safe practices, and give due respect to the hazards of energized and operating HVAC systems.

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**Classroom Equipment and Materials**

- Whiteboard/chalkboard
- Markers/chalk
- Pencils and paper
- *HVAC Level Four* PowerPoint® Presentations
- DVD player
- LCD projector and screen
- Computer
- Calculators
- Internet access during class (optional)
- Copies of the Module Examination and Performance Profile Sheets

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**Additional Resources**

This module presents thorough resources for task training. The following resource material is suggested for further study.


There are a number of online resources available for trainees who would like more information on alternative and specialized heating and cooling systems. A search for additional information may be assigned as homework to interested trainees.

Instructors should view any videos that may be identified in the lesson plan before using them to ensure their suitability. The videos can provide teachable moments in both proper and improper work processes and behaviors. Be prepared to stop the videos at appropriate times to point out and discuss both proper and improper conduct and techniques.

Instructors are also encouraged to locate additional audiovisual aids available on the internet, make personal videos, and take photos related to the subject matter and add them to the PowerPoint® presentations throughout the program.
Session Outline for 03409-13

Alternative and Specialized Heating and Cooling Systems

The Lesson Plan for this module is divided into three 2.5-hour sessions. This time includes 10 minutes for administrative tasks and a 10-minute break per session.

**Session One**

Session One introduces trainees to various alternative heating and cooling systems.

1. Show the Session One PowerPoint® presentation.
2. Use the Kickoff Activity to engage trainees in conversation regarding their futures in the trade.
3. Describe solid-fuel heating equipment.
4. Discuss waste-oil heating equipment and their operating features.
5. Describe and compare passive and active solar heating systems.
6. Discuss the application of evaporative cooling.

**Session Two**

Session Two introduces various unique heating and cooling systems and their applications.

1. Show the Session Two PowerPoint® presentation.
2. Describe direct-fired make-up air units and their options.
3. Describe computer room cooling systems, system layouts, and relevant equipment.
4. Discuss enclosure-and spot-cooling equipment.
5. Describe valance and chilled-beam cooling equipment and applications.
6. Introduce air turnover systems and describe their primary applications.

**Session Three**

Session Three is a review and testing session. Have trainees complete the module Review Questions. Alternatively, these may have been assigned as homework at the end of Session Two. Go over the module Review Questions in class prior to the exam and answer any questions that the trainees may have.

1. Have trainees complete the written examination.
2. Record the testing results on Training Report Form 200, and submit the report to your Training Program Sponsor.
**Objective**

**Section One**
1. Describe the opportunities in the construction and power industries.
2. Describe how workers’ values change over time.
3. Explain the importance of training and safety for the leaders in the construction and power industries.
4. Describe how new technologies are beneficial to the construction and power industries.
5. Identify the gender and minority issues associated with a changing workforce.
6. Describe what employers can do to prevent workplace discrimination.
7. Differentiate between formal and informal organizations.
8. Describe the difference between authority, responsibility, and accountability.
9. Explain the purpose of job descriptions and what they should include.
10. Distinguish between company policies and procedures.

**Section Two**
1. Describe the role of a crew leader.
2. List the characteristics of effective leaders.
3. Be able to discuss the importance of ethics in a supervisor’s role.
4. Identify the three styles of leadership.
5. Describe the forms of communication.
6. Describe the four parts of verbal communication.
7. Describe the importance of active listening.
8. Explain how to overcome the barriers to communication.
9. List ways that leaders can motivate their employees.
10. Explain the importance of delegating and implementing policies and procedures.
11. Distinguish between problem solving and decision making.

**Section Three**
1. Explain the importance of safety.
2. Give examples of direct and indirect costs of workplace accidents.
3. Identify safety hazards of the construction industry.
4. Explain the purpose of OSHA.
5. Discuss OSHA inspection procedures.
6. Identify the key points of a safety program.
7. List steps to train employees on how to perform new tasks safely.
8. Identify a crew leader’s safety responsibilities.
9. Explain the importance of having employees trained in first aid and cardiopulmonary resuscitation (CPR).
10. Describe the indications of substance abuse.
11. List the essential parts of an accident investigation.
12. Describe ways to maintain employee interest in safety. Distinguish between company policies and procedures.

**Section Four**
1. Describe the three phases of a construction project.
2. Define the three types of project delivery systems.
3. Define planning and describe what it involves.
4. Explain why it is important to plan.
5. Describe the two major stages of planning.
6. Explain the importance of documenting job site work.
7. Describe the estimating process.
8. Explain how schedules are developed and used.
9. Identify the two most common schedules.
10. Explain how the critical path method (CPM) of scheduling is used.
11. Describe the different costs associated with building a job.
12. Explain the crew leader’s role in controlling costs.
13. Illustrate how to control the main resources of a job: materials, tools, equipment, and labor.
14. Explain the differences between production and productivity and the importance of each.

**Performance Tasks**

**Performance Task 1 (Section Four)**
- Develop and present a look-ahead schedule.

**Performance Task 2 (Section Four)**
- Develop an estimate for a given work activity.
Teaching Time: 20 hours
(Eight 2.5-Hour Classroom Sessions)
Session time may be adjusted to accommodate your class size, schedule, and teaching style.

Prerequisites
The prerequisites for this module are dependent upon the structure of the specific craft training program in which trainees are specifically enrolled.

Before You Begin
As you prepare for each session, allow sufficient time to review the course objectives, content, visual aids (including the PowerPoint® presentation), and these lesson plans, and to gather the required equipment and materials. Consider time required for demonstrations, laboratories, field trips, and testing.

Using your access code, download the written examinations and performance profile sheets from www.nccerirc.com. The passing score for submission into NCCER’s Registry is 70% or above for the written examination; performance testing is graded pass or fail.

Safety Considerations
This module should be conducted in a classroom or conference room environment. Therefore, no special safety precautions are required.

Classroom Equipment and Materials
Whiteboard/chalkboard
Markers/chalk
Pencils and paper
*HVAC Level Four* PowerPoint® Presentations
DVD player
LCD projector and screen
Computer
Internet access during class (optional)
A drawing marked to show as-built changes.
Copies of the Module Examination and Performance Profile Sheets
Additional Resources
This module presents thorough resources for task training. The following resources are suggested for further study.

*Aging Workforce News, [www.agingworkforcenews.com](http://www.agingworkforcenews.com).*
*American Society for Training and Development (ASTD), [www.astd.org](http://www.astd.org).*
*Architecture, Engineering, and Construction Industry (AEC), [www.aecinfo.com](http://www.aecinfo.com).*
*CIT Group, [www.citgroup.com](http://www.citgroup.com).*
*Equal Employment Opportunity Commission (EEOC), [www.eeoc.gov](http://www.eeoc.gov).*
*National Association of Women in Construction (NAWIC), [www.nawic.org](http://www.nawic.org).*
*National Census of Fatal Occupational Injuries (NCFOI), [www.bls.gov](http://www.bls.gov).*
*National Center for Construction Education and Research, [www.nccer.org](http://www.nccer.org).*
*National Institute of Occupational Safety and Health (NIOSH), [www.cdc.gov/niosh](http://www.cdc.gov/niosh).*
*National Safety Council, [www.nsc.org](http://www.nsc.org).*
*NCCER Publications:
  * Your Role in the Green Environment*
  * Sustainable Construction Supervisor*
*Occupational Safety and Health Administration (OSHA), [www.osha.gov](http://www.osha.gov).*
*Society for Human Resources Management (SHRM), [www.shrm.org](http://www.shrm.org).*
*United States Census Bureau, [www.census.gov](http://www.census.gov).*
*United States Department of Labor, [www.dol.gov](http://www.dol.gov).*

There are a number of online resources, including video, available for trainees who would like more information on crew leadership. A search for additional information may be assigned as homework to interested trainees.

Instructors should view any videos before using them to ensure their suitability. The videos can provide teachable moments in both proper and improper work processes and behaviors. Be prepared to stop the videos at appropriate times to point out and discuss both proper and improper conduct and techniques.

Instructors are also encouraged to locate additional audiovisual aids available on the internet, make personal videos, and take photos related to the relevant trade and add them to the PowerPoint® presentations throughout the program.
Session Outline for 46101-11

FUNDAMENTALS OF CREW LEADERSHIP

The Lesson Plan for this module is divided into eight 2.5-hour sessions. This time includes 10 minutes for administrative tasks and a 10-minute break per session.

**SESSION ONE**

Session One introduces the trainees to the basic elements of leadership. It covers an overview of industry and the need for a trained workforce; gender and cultural issues; and the structure and dynamics of business organizations.

1. Show the Session One PowerPoint® presentation.
2. Use the Kickoff Activity to get trainees engaged and give them an idea of what they will learn in this module.
3. Describe how to understand and motivate crew members.
4. Discuss the importance of gender and cultural issues in the workplace.
5. Describe the various types of organizational structures found in businesses.
6. Discuss the relationships of authority, responsibility, and accountability.

**SESSION TWO**

Session Two covers leadership skills. It focuses on the role of the crew leader and the transition from crew member. It discusses the characteristics of good leaders, leadership styles, and ethics. Key elements of this session are effective communication; motivating others; team building; delegating; and problem solving. A number of exercises will allow the trainees to test their leadership skills.

1. Show the Session Two PowerPoint® presentation.
2. Describe the qualities of an effective leader.
3. Discuss methods of communication and the importance of listening.
4. Describe how to motivate others.
5. Discuss the elements of team building and delegating.
6. Describe how to deal with problems on the job.
7. Discuss how to resolve special problems that often confront a crew leader.

**SESSION THREE**

Session Three focuses on safety. It presents the role of the crew leader in maintaining crew safety. Trainees will learn the relationship between safety and cost and will learn to view safety from a leadership perspective. Included in this lesson are discussions of company and crew leader responsibility for safety and accident investigation, as well as methods of promoting safety among the workforce.

1. Show the Session Three PowerPoint® presentation.
2. Describe how safety issues can directly and indirectly affect a company’s cost of doing business.
3. Discuss OSHA inspections and penalties for safety violations.
4. Describe how an employer safety program is structured and the role of the crew leader in the program.
5. Explain how a crew leader is involved in day-to-day safety issues such as conducting safety training sessions and assisting in accident investigations.
6. Describe how crew leaders can promote safe work practices within their crews.
**Session Four**

Session Four introduces the subject of project control. It deals with the fundamentals, including project phases, project scheduling, cost estimating, and planning. It introduces the trainee to the contractual aspects of a project and the steps in completing a project, from its initial concept through the final delivery. Trainees will learn how to estimate labor and materials.

1. Show the Session Four PowerPoint® presentation.
2. Describe the different types of contracts and the three phases of a project.
3. Explain how to estimate the manpower and materials required for a project.
4. Discuss the function of planning and the planning process.
5. Describe how to plan the various resources such as manpower, tools, equipment and materials required for a project.

**Sessions Six and Seven**

Sessions Six and Seven are laboratory sessions in which the trainees will practice the development of a project schedule and a cost estimate.

1. Note that there is no PowerPoint® presentation associated with this session.
2. Using an instructor-prepared scenario appropriate for the trade, trainees complete the tasks associated with Performance Tasks 1 and 2.

**Session Eight**

Session Eight is a review and testing session.

1. Review any material that has not been fully presented and answer any questions that the trainees may have.
2. Have the trainees complete the written examination. Any outstanding performance testing must be completed during this session as well.
3. Record the testing results on Training Report Form 200, and submit the report to your Training Program Sponsor.