MODULE OVERVIEW

This module covers the techniques for reading and understanding various types of construction drawings, specifications, and other related documents. Emphasis is placed on the types of drawings and specifications that are commonly used by those in the HVAC trade and other closely-related trades. The procedures and documents involved in an HVAC equipment and material takeoff are also covered.

PREREQUISITES

Prior to training with this module, it is recommended that the trainee shall have successfully completed *Core Curriculum*; *HVAC Level One*; *HVAC Level Two*; and *HVAC Level Three*.

OBJECTIVES

Upon completion of this module, the trainee will be able to do the following:

1. Read HVAC drawings and architect's plans and explain their relationships.
2. Compare mechanical plans with the actual installation of duct and pipe runs, fittings, and sections.
3. Interpret specification documents and apply them to the plans.
4. Interpret shop drawings and apply them to the plans and specifications.
5. Describe a submittal, its derivation, routing, and makeup.
6. Develop a field set of as-built drawings.
7. Identify the steps required for transferring design information to component production.
8. Identify, develop, and complete takeoff sheets.
9. List and classify materials most commonly used in HVAC systems.
10. Complete takeoff procedures for HVAC systems.

PERFORMANCE TASKS

Under the supervision of the instructor, the trainee should be able to do the following:

1. Identify and interpret a site plan drawing.
2. Identify and interpret the following on an architectural drawing:
   - Floor plans and details
   - Elevations
   - Foundation plan
   - Reflected ceiling plan
3. Identify and interpret the following on a plumbing plan drawing:
   - Sanitary plumbing plans
   - Domestic water plumbing plans
   - Isometric views
   - Riser diagrams
   - Schedules
   - Specification references
   - Legends
4. 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

continued

5. Identify and interpret the following on an electrical plan drawing:
   - Riser diagrams
   - Schedules
   - Specification references
   - Legends
6. Prepare a request for information (RFI) form.
7. Identify and interpret the information given in the specifications pertaining to a construction project.
8. Interpret all types of HVAC-related shop drawings.
9. Mark up HVAC mechanical plans to show as-built modifications.
10. Perform an HVAC equipment and material takeoff and prepare the takeoff forms.
11. Prepare building coordination drawings that show the composite installation of HVAC equipment relative to the equipment installed by other trades, such as the electrical and plumbing trades.

MATERIALS AND EQUIPMENT LIST

Overhead projector and screen

Transparencies

Blank acetate sheets

Transparency pens

Whiteboard/chalkboard

Markers/chalk

Pencils and scratch paper

Appropriate personal protective equipment

Complete set of drawings for a local construction project

Various site plans

Examples of floor, foundation, and reflected ceiling plans and elevation drawings

Drawings showing schedules

Various detail drawings

Section drawings

Plumbing plan drawings

Mechanical plan drawings

Electrical plan drawings

Complete specifications for a local construction project

Request for information (RFI) forms

Shop drawings

Coordination drawings

Cut sheets/lists

HVAC equipment catalogs

Equipment submittals

Complete set of as-built plans (drawings) for a local construction project

Various takeoff sheets

Drafting instruments

Drafting supplies

Drafting symbol template

Takeoff tools and materials including:
- Air devices and equipment takeoff sheets
- Piping and accessories takeoff sheets
- Ductwork takeoff sheets
- Colored pencils
- Electronic wheel scalers
- Metallic tape
- Architect's drafting scales
- Straightedges
- Automatic mechanical counters
- Adding machines or calculators
- Magnifying glasses
- HVAC-related manufacturers' catalogs
- HVAC-related technical books and manuals

Copies of the Quick Quiz*

Module Examinations**

Performance Profile Sheets**

* Located in the back of this module

**Located in the Test Booklet

SAFETY CONSIDERATIONS

Ensure that the trainees are equipped with appropriate personal protective equipment and know how to use it properly. Trainees may be required to visit a construction site.

ADDITIONAL RESOURCES

This module is intended to present thorough resources for task training. The following reference works are suggested for both instructors and motivated trainees interested in further study. These are optional materials for continued education rather than for task training.

Blueprint Reading for Construction, 1998. James A. S. Falzinger. Upper Saddle River, NJ: Prentice Hall.

Construction Blueprint Reading, 1985. Robert Putnam. Upper Saddle River, NJ: Prentice Hall.

Reading Architectural Work Drawings, 1996. Edward J. Muller. Upper Saddle River, NJ: Prentice Hall.

Reading Plans and Elevations, NCCER Carpentry Curriculum.

TEACHING TIME FOR THIS MODULE

An outline for use in developing your lesson plan is presented below. Note that each Roman numeral in the outline equates to one session of instruction. Each session has a suggested time period of 2½ hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 25 hours are suggested to cover *Construction Drawings and Specifications*. You will need to adjust the time required for hands-on activity and testing based on your class size and resources. Because laboratories often correspond to Performance Tasks, the proficiency of the trainees may be noted during these exercises for Performance Testing purposes.

Topic **Planned Time**

Session I. Introduction; Reading Drawings

A. Introduction _____

B. Reading Drawings _____

C. Laboratory _____

Have trainees practice interpreting a site plan drawing. This laboratory corresponds to Performance Task 1.

D. Laboratory _____

Have trainees practice interpreting architectural drawings. This laboratory corresponds to Performance Task 2.

Sessions II and III. Reading Plumbing Plans and Mechanical Plans

A. Reading Plumbing Plans _____

B. Laboratory _____

Have trainees practice interpreting plumbing plan drawings. This laboratory corresponds to Performance Task 3.

C. Reading Mechanical Plans _____

D. Laboratory _____

Have trainees practice interpreting mechanical plan drawings. This laboratory corresponds to Performance Task 4.

Session IV. Reading Electrical Plans

A. Reading Electrical Plans _____

B. Laboratory _____

Have trainees practice interpreting electrical plan drawings. This laboratory corresponds to Performance Task 5.

Session V. Request for Information Forms; Specifications

A. Request for Information Forms _____

B. Laboratory _____

Have trainees prepare a request for information (RFI) form. This laboratory corresponds to Performance Task 6.

C. Specifications _____

D. Laboratory _____

Have trainees practice interpreting the information given in the specifications pertaining to a construction project. This laboratory corresponds to Performance Task 7.

Sessions VI and VII. Shop Drawings; Submittals

A. Shop Drawings _____

1. Cut Lists _____
2. General Procedure _____

B. Laboratory _____

Have trainees prepare building coordination drawings that show the composite installation of HVAC equipment relative to the equipment installed by other trades. This laboratory corresponds to Performance Task 11.

C. Laboratory _____

Have trainees practice interpreting all types of HVAC-related shop drawings. This laboratory corresponds to Performance Task 8.

D. Submittals _____

Session VIII. As-Built Drawings

A. As-Built Drawings _____

B. Laboratory _____

Have trainees mark up an HVAC mechanical plan to show as-built modifications. This laboratory corresponds to Performance Task 9.

Session IX. Takeoffs

A Takeoffs _____

B. Takeoff Tools and Materials _____

C. Selecting Equipment and Materials _____

D. Takeoff Procedures _____

E. Laboratory _____

Have trainees perform an HVAC equipment and material takeoff and prepare the takeoff forms. This laboratory corresponds to Performance Task 10.

F. Building Codes _____

Session X. Review and Testing

A. Review _____

B. Module Examination _____

1. Trainees must score 70% or higher to receive recognition from NCCER.
2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.

C. Performance Testing _____

1. Trainees must perform each task to the satisfaction of the instructor to receive recognition from NCCER. If applicable, proficiency noted during laboratory exercises can be used to satisfy the Performance Testing requirements.
2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.

System Balancing
Annotated Instructor's Guide

Module 03402-09

MODULE OVERVIEW

This module builds on the information previously studied in the Level One module, *Air Distribution Systems*. Among the subjects covered in this module is psychrometrics, and trainees will be introduced to the psychrometric chart and its use in determining the various properties of air. The procedures, equipment, and instrumentation used for testing, adjusting, and balancing air distribution systems are also covered.

PREREQUISITES

Prior to training with this module, it is recommended that the trainee shall have successfully completed *Core Curriculum*; *HVAC Level One*; *HVAC Level Two*; *HVAC Level Three*; and *HVAC Level Four*, Module 03401-09.

OBJECTIVES

Upon completion of this module, the trainee will be able to do the following:

1. Explain the gas laws (Dalton, Boyle, and Charles) used when dealing with air and its properties.
2. Explain the fan and pump laws.
3. Use a psychrometric chart to evaluate air properties and changes in air properties.
4. Explain the principles involved in the balancing of air and water distribution systems.
5. Define common terms used by manufacturers when describing grilles, registers, and diffusers.
6. Identify and use the tools and instruments needed to balance air distribution systems.
7. Balance an air distribution system.
8. Change the speed of an air distribution system supply fan.

PERFORMANCE TASKS

Under the supervision of the instructor, the trainee should be able to do the following:

1. Select and properly use test instruments for balancing air distribution systems.
2. Balance a selected air system:
   - Measure fan and fan motor rpm.
   - Measure supply and return duct static pressures.
   - Use fan curve charts.
   - Adjust supply fan speed to provide higher or lower air quantities.
   - Measure airflow at air supply outlets.
   - Adjust dampers in branch supply ducts and at air terminals and diffusers.
   - Prepare system balancing report forms.
3. Balance an air distribution system using the thermometer method.
4. Measure the temperature rise and drop across ducted heating and cooling equipment, respectively.

MATERIALS AND EQUIPMENT LIST

Overhead projector and screen

Transparencies

Blank acetate sheets

Transparency pens

Whiteboard/chalkboard

Markers/chalk

Pencils and scratch paper

Appropriate personal protective equipment

Air distribution system component manufacturers' catalogs

Plans and specifications for selected building air distribution systems

Psychrometric chart

Operating air distribution system

Tachometers

Sling psychrometer

Electronic hygrometer

Clamp-on ammeters

Multimeters

Differential pressure gauge

Manometers (as available)
- U-tube
- Inclined
- Inclined vertical
- Electronic

Pitot tubes

Static pressure tips

Velometers/anemometers (as available)
- Rotating vane
- Swinging vane
- Hot wire
- Flow hood
- Air volume balancer
- Digital thermometers

Optional blowers and fans and related manufacturers' fan curve charts

Samples of system balancing report forms

Copies of the Quick Quiz*

Module Examinations**

Performance Profile Sheets**

* Located in the back of this module

**Located in the Test Booklet

SAFETY CONSIDERATIONS

Ensure that the trainees are equipped with appropriate personal protective equipment and know how to use it properly. Trainees will be required to balance air distribution systems and perform supply air fan adjustments.

ADDITIONAL RESOURCES

This module is intended to present thorough resources for task training. The following reference works are suggested for both instructors and motivated trainees interested in further study. These are optional materials for continued education rather than for task training.

ASHRAE HVAC Applications Handbook, 1999. Atlanta, GA: American Society of Heating and Air Conditioning Engineers, Inc.

HVAC Systems – Testing, Balancing, and Adjusting, 1993. Arlington, VA: Sheet Metal and Air Conditioning Contractor's National Association, Inc. (SMACNA).

Psychrometrics Introduction, 1993. Syracuse, NY: Carrier Corporation.

Testing and Balancing HVAC Air and Water Systems, 2001. Samuel C. Monger. Lilburn, GA: The Fairmont Press, Inc.

TEACHING TIME FOR THIS MODULE

An outline for use in developing your lesson plan is presented below. Note that each Roman numeral in the outline equates to one session of instruction. Each session has a suggested time period of 2½ hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 20 hours are suggested to cover *System Balancing*. You will need to adjust the time required for hands-on activity and testing based on your class size and resources. Because laboratories often correspond to Performance Tasks, the proficiency of the trainees may be noted during these exercises for Performance Testing purposes.

Topic **Planned Time**

Session I. Introduction; Air Properties; Psychrometrics

A. Introduction _____
B. Air Properties _____
   1. Atmospheric Pressure and Gauge Pressure _____
   2. Temperature, Pressure, and Volume Relationships _____
C. Psychrometrics _____
   1. Dry Air _____
   2. Humidity _____
   3. Dew point _____
   4. Enthalpy _____
D. Laboratory _____

   Have trainees use sling psychometers and/or electronic hygrometers to measure dry-bulb and wet-bulb temperatures and relative humidity.

Session II. Psychrometric Chart

A. Psychrometric Chart _____
   1. Psychrometric Chart Layout _____
   2. Use of the Psychrometric Chart _____
B. Laboratory _____

   Have trainees use a psychrometric chart to find unknown properties of air based on measured dry-bulb and wet-bulb temperatures.

Session III. Air Balance

A. Air Balance _____
   1. Air Balance Terminology _____
      a. Laboratory _____

         Have trainees calibrate and use a manometer and pitot tube to make pressure, velocity pressure, and total pressure measurements in a duct system.
   2. Air System Measuring Instruments _____
      a. Laboratory _____

         Have trainees calibrate and properly use velometers and anemometers to make airflow measurements at selected air system grilles and registers. This laboratory corresponds to Performance Task 1.
   3. Air System Balancing Considerations _____
      a. Airflow _____
      b. Air Weight _____

Session IV. Air System Balancing Procedures I

A. Air System Balancing Procedures _____

1. Pre-Balance Checks _____

a. Laboratory _____

Have trainees perform pre-balance checks on an air distribution system. This laboratory corresponds to Performance Task 2.

2. Duct System Balancing: Mains _____

a. Laboratory _____

Have trainees balance the mains in a selected air system and then record measured balancing data on selected system balance reporting forms. This laboratory corresponds to Performance Task 2.

3. Terminal Balancing _____

a. Laboratory _____

Have trainees balance the terminals in a selected air system and then record measured balancing data on selected system balance reporting forms. This laboratory corresponds to Performance Task 2.

Session V. Air System Balancing Procedures II

A. Air System Balancing Procedures _____

1. Mixed Air System Adjustment _____
2. Balancing Dual-Duct Systems _____
3. Balancing Induction Systems _____
4. Measuring Temperature Rise _____

a. Laboratory _____

Have trainees measure the temperature rise across ducted heating equipment. This laboratory corresponds to Performance Task 4.

5. Measuring Temperature Drop _____

a. Laboratory _____

Have trainees measure the temperature drop across ducted cooling equipment. This laboratory corresponds to Performance Task 4.

Session VI. Air System Balancing Procedures III

A. Balancing by Thermometer _____

B. Laboratory _____

1. Have trainees balance an air system for cooling using the thermometer method. This laboratory corresponds to Performance Task 3.
2. Have trainees balance an air system using the thermometer and velocity meter method. This laboratory corresponds to Performance Task 3. _____

Session VII. Supply Air Fan Adjustments

A. Supply Air Fan Adjustments _____

1. Fan Laws _____

a. Laboratory _____

Have trainees measure fan and fan motor rpm. This laboratory corresponds to Performance Task 2.

2. Fan Curve Charts _____

a. Laboratory _____

Have trainees use a fan curve chart to find the value of an unknown fan characteristic when the values of any two of the three fan characteristics are known. This laboratory corresponds to Performance Task 2.

3. Changing the Speed of the Fan _____

    a. Laboratory _____

    Have trainees change the speed of a belt-driven fan with a fan motor that has a variable pitch pulley. For a fixed-drive pulley, have trainees calculate new pulley diameters to achieve specified speed changes. This laboratory corresponds to Performance Task 2.

Session VIII. Review and Testing

A. Review _____

B. Module Examination _____

1. Trainees must score 70% or higher to receive recognition from NCCER.
2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.

C. Performance Testing _____

1. Trainees must perform each task to the satisfaction of the instructor to receive recognition from NCCER. If applicable, proficiency noted during laboratory exercises can be used to satisfy the Performance Testing requirements.
2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.

MODULE OVERVIEW

This module covers indoor air quality and its effect on the health and comfort of building occupants. It provides guidelines for performing a building IAQ survey and identifies the equipment and methods used to test and control indoor air quality.

PREREQUISITES

Prior to training with this module, it is recommended that the trainee shall have successfully completed *Core Curriculum*; *HVAC Level One*; *HVAC Level Two*; *HVAC Level Three*; and *HVAC Level Four*, Modules 03401-09 and 03402-09.

OBJECTIVES

Upon completion of this module, the trainee will be able to do the following:

1. Explain the need for good indoor air quality.
2. List the symptoms of poor indoor air quality.
3. Perform an inspection/evaluation of a building's structure and equipment for potential causes of poor indoor air quality.
4. Identify the causes and corrective actions used to remedy common indoor air problems.
5. Identify the HVAC equipment and accessories that are used to sense, control, and/or enhance indoor air quality.
6. Use selected test instruments to measure or monitor the quality of indoor air.
7. Clean HVAC air system ductwork and components.

PERFORMANCE TASKS

Under the supervision of the instructor, the trainee should be able to do the following:

1. Use selected radon monitors and/or test kits.
2. Perform a building indoor air quality (IAQ) inspection/evaluation.
3. Make air measurements using each of the following:
   - Carbon dioxide (CO_2) detector/sensor
   - Carbon monoxide (CO) detector/sensor
   - Volatile organic compound (VOC) detector/sensor
   - Combustion analyzer
4. Use a manufacturer's humidifier capacity chart to find the humidifier capacity needed for various building types and sizes.
5. Use a manufacturer's portable dehumidifier capacity chart to find the dehumidifier capacity needed for various building types and sizes.
6. Clean and inspect ductwork using one or more approved methods:
   - Contact vacuum
   - Air washing
   - Power brushing

MATERIALS AND EQUIPMENT LIST

Overhead projector and screen
Transparencies
Blank acetate sheets
Transparency pens
Whiteboard/chalkboard
Markers/chalk
Pencils and scratch paper
Appropriate personal protective equipment
Copy of *ASHRAE Standard 62.1-2007, Ventilation for Acceptable Indoor Air Quality*

continued

Manufacturer's operation and service literature for demonstration equipment

Radon monitors and/or test kits

Access to a building to be IAQ inspected/surveyed

Checklists for IAQ evaluation

Set of building plans and specifications for the specific building to be IAQ inspected/surveyed

Manufacturers' humidifier and dehumidifier capacity charts

Access to a commercial or industrial facility with operating HVAC systems incorporating one or more of the following:
- Air handler units
- Unit ventilators
- Mechanical filters
  - Conventional
  - Extended surface
  - Electrostatic permanent
  - Steel/aluminum mesh
  - Bag-type
  - Box
  - Close-pleated rigid
  - HEPA

Adsorption filters

Electronic and nonelectronic air cleaners

Ultraviolet light air purification equipment

Humidifiers
- Wetted-element
- Atomizing
- Infrared
- Steam
- Portable dehumidifiers

Portable or stationary gas detectors and analyzers, including:
- Carbon dioxide detectors
- Carbon monoxide detectors
- VOC sensors/detectors
- Combustion analyzers
- Other gas detectors

Access to a building with a radon control subslab depressurization system

Duct cleaning equipment:
- Portable HEPA-filtered vacuuming equipment
- Power brushing, air washing, and power whip equipment

Borescopes

Black and white and/or color video cameras and portable videocassette recorder

Copies of the Quick Quiz*

Module Examinations**

Performance Profile Sheets**

* Located in the back of this module

**Located in the Test Booklet

SAFETY CONSIDERATIONS

Ensure that the trainees are equipped with appropriate personal protective equipment and know how to use it properly. Trainees will be required to use radon monitors and/or test kits, perform building IAQ inspection/evaluation, use gas detectors and combustion analyzers to make air measurements, and clean and inspect ductwork. Trainees may be required to visit facilities and/or construction sites. Ensure that trainees are briefed on site safety procedures.

ADDITIONAL RESOURCES

This module is intended to present thorough resources for task training. The following reference works are suggested for both instructors and motivated trainees interested in further study. These are optional materials for continued education rather than for task training.

Building Air Quality, a Guide for Building Owners and Facility Managers, Latest Edition. Washington, DC: U.S. Environmental Protection Agency.

Indoor Air Quality, Latest Edition. Chantilly, VA: Sheet Metal and Air Conditioning Contractors National Association (SMACNA).

Indoor Air Quality in the Building Environment. Troy, MI: Business News Publishing Company.

ACR 2006, Assessment, Cleaning, and Restoration of HVAC Systems, Latest Edition. Washington, DC: National Air Duct Cleaners Association.

TEACHING TIME FOR THIS MODULE

An outline for use in developing your lesson plan is presented below. Note that each Roman numeral in the outline equates to one session of instruction. Each session has a suggested time period of 2½ hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 15 hours are suggested to cover *Indoor Air Quality*. You will need to adjust the time required for hands-on activity and testing based on your class size and resources. Because laboratories often correspond to Performance Tasks, the proficiency of the trainees may be noted during these exercises for Performance Testing purposes.

Topic **Planned Time**

Session I. Introduction to Indoor Air Quality (IAQ)

A. Introduction _____
B. Long-Term and Short-Term Effects of Poor IAQ _____
C. Good Indoor Air Quality _____
D. Sources of Building Contaminants _____
   1. Building Construction _____
   2. Human Occupancy _____
   3. Building Materials and Furnishings _____
   4. HVAC and Other Building Equipment _____
   5. Cleaning Compounds and Pesticides _____
   6. Contaminant Sources Located Outside the Building _____
E. Laboratory _____

   Have trainees use selected radon monitors and/or test kits. This laboratory corresponds to Performance Task 1.

Session II. Elements of a Building IAQ Inspection Survey

A. Elements of a Building IAQ Inspection Survey _____
   1. Problem Description _____
   2. Site Visit and Building Walk-Through _____
   3. Building HVAC Equipment and Ventilation System Inspection _____
   4. Air Sampling and Testing for Specific Contaminants _____
   5. Interpreting Test Results and Corrective Actions _____
B. Laboratory _____

   Have trainees perform a building indoor air quality (IAQ) inspection/evaluation. This laboratory corresponds to Performance Task 2.

Session III. Achieving Acceptable Indoor Air Quality; IAQ and Energy-Efficient Systems and Equipment

A. Achieving Acceptable Indoor Air Quality _____
   1. Initial Building Design _____
   2. Ventilation Control _____
   3. Thermal Comfort Control _____
   4. Controlling Chemical Contaminants _____
   5. Controlling Microbial Contaminants _____
B. IAQ and Energy-Efficient Systems and Equipment _____
   1. Automated Building Management Systems _____
   2. Air Handling Units _____
   3. Unit Ventilators _____
   4. Air Filtration Equipment _____
   5. Humidifiers and Dehumidifiers _____
   6. Ozone Generators _____
   7. Ultraviolet Light Air Purification Systems _____

C. Laboratory _____

Have trainees use manufacturers' capacity charts to find the humidifier and dehumidifier capacities needed for various building types and sizes. This laboratory corresponds to Performance Tasks 4 and 5.

Session IV. Gas Detectors and Analyzers

A. Gas Detectors and Analyzers _____
   1. Carbon Dioxide Detectors _____
   2. Carbon Monoxide Detectors _____
   3. Volatile Organic Compound Sensors _____
   4. Other Gas Detectors/Analyzers _____

B. Laboratory _____

Have trainees make air measurements using selected detectors/sensors and combustion analyzers. This laboratory corresponds to Performance Task 3.

Session V. Duct Cleaning

A. Duct Cleaning _____
   1. Duct Cleaning Equipment _____
   2. Duct Cleaning Methods _____

B. Laboratory _____

Have trainees clean and inspect ductwork using one or more approved methods. This laboratory corresponds to Performance Task 6.

Session VI. IAQ and Forced-Air Duct Systems; HVAC Contractor Liability; Review and Testing

A. IAQ and Forced-Air Duct Systems _____
   1. Supply and Return Duct Leaks _____
   2. Sealing Air Duct Leaks _____

B. HVAC Contractor Liability _____

C. Review _____

D. Module Examination _____
   1. Trainees must score 70% or higher to receive recognition from NCCER.
   2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.

E. Performance Testing _____
   1. Trainees must perform each task to the satisfaction of the instructor to receive recognition from NCCER. If applicable, proficiency noted during laboratory exercises can be used to satisfy the Performance Testing requirements.
   2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.

Energy Conservation Equipment
Annotated Instructor's Guide

Module 03404-09

MODULE OVERVIEW

This module covers various heat recovery/reclaim devices and other energy conservation equipment. It includes information on their operation as well as maintenance procedures.

PREREQUISITES

Prior to training with this module, it is recommended that the trainee shall have successfully completed *Core Curriculum*; *HVAC Level One*; *HVAC Level Two*; *HVAC Level Three*; and *HVAC Level Four*, Modules 03401-09 through 03403-09.

OBJECTIVES

Upon completion of this module, the trainee will be able to do the following:

1. Identify selected air-to-air heat exchangers and describe how they operate.
2. Identify selected condenser heat recovery systems and explain how they operate.
3. Identify a coil energy recovery loop and explain how it operates.
4. Identify a heat pipe heat exchanger and explain how it operates.
5. Identify a thermosiphon heat exchanger and explain how it operates.
6. Identify a twin tower enthalpy recovery loop system and explain how it operates.
7. Identify air-side and water-side economizers and explain how each type operates.
8. Identify selected steam system heat recovery systems and explain how they operate.
9. Identify an ice bank-type off-peak hours energy reduction system.
10. Operate selected energy conversion equipment.

PERFORMANCE TASK

Under the supervision of the instructor, the trainee should be able to do the following:

1. Adjust an economizer for the proper setting in a local area.

MATERIALS AND EQUIPMENT LIST

Overhead projector and screen

Transparencies

Blank acetate sheets

Transparency pens

Whiteboard/chalkboard

Markers/chalk

Pencils and scratch paper

Appropriate personal protective equipment

As available, operating HVAC systems incorporating one or more of the following:
- Heat recovery ventilators/fixed-plate ERV and/or HRV energy/heat recovery units
- Dual-condenser refrigeration system
- Chilled-water system with heat recovery condenser
- Swimming pool heat recovery system
- Coil energy recovery loops
- Heat pipe heat exchangers
- Coil-loop thermosiphon heat exchangers
- Twin tower enthalpy recovery loops
- Air-side economizers
- Water-side economizers
- Flash steam (flash tank) heat recovery system
- Flue gas heat recovery system
- Blowdown and heat recovery system

Manufacturer's operation and service literature for demonstration equipment

Electric utility energy demand reduction system interface equipment, such as modems, radio receivers, etc.

Copies of the Quick Quiz*

Module Examinations**

Performance Profile Sheets**

*Located in the back of this module

**Located in the Test Booklet

SAFETY CONSIDERATIONS

Ensure that the trainees are equipped with appropriate personal protective equipment and know how to use it properly. Trainees will be required to operate selected energy conversion equipment. Ensure that trainees are briefed on site safety procedures.

ADDITIONAL RESOURCES

This module is intended to present thorough resources for task training. The following reference works are suggested for both instructors and motivated trainees interested in further study. These are optional materials for continued education rather than for task training.

ASHRAE Handbook – HVAC Systems and Equipment. Atlanta, GA: American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc.

HVAC Systems Design Handbook. Blue Ridge Summit, PA: TAB Books, Inc.

TEACHING TIME FOR THIS MODULE

An outline for use in developing your lesson plan is presented below. Note that each Roman numeral in the outline equates to one session of instruction. Each session has a suggested time period of 2½ hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 10 hours are suggested to cover *Energy Conservation Equipment*. You will need to adjust the time required for hands-on activity and testing based on your class size and resources. Because laboratories often correspond to Performance Tasks, the proficiency of the trainees may be noted during these exercises for Performance Testing purposes.

Topic	**Planned Time**
Session I. Introduction; Heat Recovery/Reclaim Methods and Equipment	
A. Introduction	_____
B. Heat Recovery/Reclaim Methods and Equipment	_____
1. Energy and Heat Recovery Ventilators	_____
2. Fixed-Plate and Rotary Air-to-Air Heat Exchangers	_____
3. Condenser Heat Recovery Systems	_____
4. Coil Energy Recovery Loops	_____
5. Heat Pipe Heat Exchangers	_____
6. Thermosiphon Heat Exchangers	_____
7. Twin Tower Enthalpy Recovery Loops	_____
Session II. Economizers; Heat Recovery in Steam Systems	
A. Economizers	_____
1. Air-side Economizers	_____
2. Water-side Economizers	_____
B. Heat Recovery in Steam Systems	_____
1. Flash Steam (Flash Tank) Heat Recovery	_____
2. Flue Gas Heat Recovery System	_____
3. Blowdown and Heat Recovery System	_____
C. Laboratory	_____
Have trainees adjust an economizer for the proper setting in a local area. This laboratory corresponds to Performance Task 1.	
Session III. Electric Utility Energy Demand Reduction Systems; Food Processing Cooling Water Recovery System	
A. Electric Utility Energy Demand Reduction Systems	_____
1. Off-Peak Utility Usage	_____
B. Food Processing Cooling Water Recovery System	_____

Session IV. Review and Testing

A. Review _____

B. Module Examination _____

1. Trainees must score 70% or higher to receive recognition from the NCCER.
2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.

C. Performance Testing _____

1. Trainees must perform each task to the satisfaction of the instructor to receive recognition from NCCER. If applicable, proficiency noted during laboratory exercises can be used to satisfy the Performance Testing requirements.
2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.

MODULE OVERVIEW

This module explains how computers and microprocessor controls are used to manage zoned HVAC systems in residential and commercial buildings locally and through computer networks. This module also covers the installation of building management systems and related components.

PREREQUISITES

Prior to training with this module, it is recommended that the trainee shall have successfully completed *Core Curriculum*; *HVAC Level One*; *HVAC Level Two*; *HVAC Level Three*; and *HVAC Level Four*, Modules 03401-09 through 03404-09.

OBJECTIVES

Upon completion of this module, the trainee will be able to do the following:

1. Identify the major components of a building management system and describe how they fit together.
2. Operate a basic direct digital controller.
3. List the types of information available on a typical front-end computer screen for a building management system.
4. List the typical steps required to install a building management system.
5. Demonstrate how to install typical sensors, actuators, power wiring, and communication wiring.

PERFORMANCE TASKS

Under the supervision of the instructor, the trainee should be able to do the following:

1. Program an electronic thermostat.
2. Interpret operating data received at the central control computer of a building management system.
3. Under the supervision of the instructor, select and modify operating parameters for a building management system.
4. Interpret basic diagnostic and test data provided by a building management system.

MATERIALS AND EQUIPMENT LIST

Overhead projector and screen
Transparencies
Blank acetate sheets
Transparency pens
Whiteboard/chalkboard
Markers/chalk
Pencils and scratch paper
Appropriate personal protective equipment
Programmable electronic thermostats
Selection of automatic zone dampers
Battery-powered zone controller
Operating building management system
Copies of the Quick Quiz*
Module Examinations**
Performance Profile Sheets**

* Located in the back of this module

**Located in the Test Booklet

SAFETY CONSIDERATIONS

Ensure that the trainees are equipped with appropriate personal protective equipment and know how to use it properly. This module may require trainees to visit a site that has a BMS in operation. Ensure that trainees are briefed on site safety policies prior to any site visits.

ADDITIONAL RESOURCES

This module is intended to present thorough resources for task training. The following reference works are suggested for both instructors and motivated trainees interested in further study. These are optional materials for continued education rather than for task training.

ASHRAE Educational Manual – Fundamentals of HVAC Control Systems, Latest Edition. Atlanta, GA: American Society of Heating, Refrigerating, and Air Conditioning Engineers.

ASHRAE Handbook – HVAC Applications, Latest Edition. Atlanta, GA: American Society of Heating, Refrigerating, and Air Conditioning Engineers.

HVAC Controls and Systems. Troy, MI: Business News Publishing Co.

TEACHING TIME FOR THIS MODULE

An outline for use in developing your lesson plan is presented below. Note that each Roman numeral in the outline equates to one session of instruction. Each session has a suggested time period of 2½ hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 17½ hours are suggested to cover *Building Management Systems*. You will need to adjust the time required for hands-on activity and testing based on your class size and resources. Because laboratories often correspond to Performance Tasks, the proficiency of the trainees may be noted during these exercises for Performance Testing purposes.

Topic	**Planned Time**
Session I. Introduction; Basic Digital Controller; DDC Network Types	
A. Introduction	_____
B. Basic Digital Controller	_____
1. Control Point Classification	_____
2. Input and Output Devices	_____
3. Closed Control Loop	_____
4. Control Algorithms	_____
C. DDC Network Types	_____
1. Polling Networks	_____
2. Peer-to-Peer Networks	_____
Session II. Building Management System Architecture	
A. Packaged HVAC Systems	_____
B. Laboratory	_____
Have trainees program an electronic thermostat. This laboratory corresponds to Performance Task 1.	
C. Applied HVAC Systems	_____
D. Building Management Functions	_____
Sessions III and IV. User Interfaces; Interoperability; Interpreting Front-End Software	
A. User Interfaces	_____
B. Interoperability	_____
1. BACnet	_____
2. LON Technologies	_____
3. Modbus	_____
4. Hypertext Transfer Protocol	_____
5. Web Browser System Integration	_____
6. The Future of Interoperability	_____

C. Interpreting Front-End Software _____
   1. Sign-On/Off and Operator Management _____
   2. Database Management _____
   3. Graphical Interface _____
   4. Alarm Management _____
   5. Report Management _____
D. Laboratory _____

   Have trainees access and interpret status reports, diagnostics, and other basic operating data received at the central control computer of a building management system. This laboratory corresponds to Performance Task 2.

Session V. Installation

A. Sensor Installation _____
B. Control Panel Installation _____
C. Running Sensor, Power, and Communication Wiring _____
D. Controller Programming _____
E. Controller Installation and Wiring Termination _____
F. Central Computer Installation and Programming _____
G. Modem Programming _____
H. Web Page Server Programming _____
I. Laboratory _____

   Under your supervision, have trainees select and modify operating parameters for a building management system. This laboratory corresponds to Performance Task 3.

J. Laboratory _____

   Have trainees interpret basic diagnostic and test data provided by a building management system. This laboratory corresponds to Performance Task 4.

Session VI. System Control Strategies

A. VVT Control Sequence _____
B. VAV Control Sequence _____
C. Night-Time Free Cooling _____
D. Demand-Control Ventilation _____
E. Humidity Control _____
F. Building Pressurization _____
G. Smoke Control _____
H. Interoperability Strategies _____

Session VII. Review and Testing

A. Review _____
B. Module Examination _____
   1. Trainees must score 70% or higher to receive recognition from NCCER.
   2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.
C. Performance Testing _____
   1. Trainees must perform each task to the satisfaction of the instructor to receive recognition from NCCER. If applicable, proficiency noted during laboratory exercises can be used to satisfy the Performance Testing requirements.
   2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.

System Startup and Shutdown
Annotated Instructor's Guide

Module 03406-09

MODULE OVERVIEW

This module covers procedures for the startup and shutdown of hot-water and steam-heating systems, chilled-water systems, and forced-air distribution systems. Emphasis is on startup after initial equipment installation or after an extended period of shutdown. Procedures to prepare these systems for extended periods of shutdown are also included.

PREREQUISITES

Prior to training with this module, it is recommended that the trainee shall have successfully completed *Core Curriculum*; *HVAC Level One*; *HVAC Level Two*; *HVAC Level Three*; and *HVAC Level Four*, Modules 03401-09 through 03405-09.

OBJECTIVES

Upon completion of this module, the trainee will be able to do the following:

1. Prepare a boiler for dry storage.
2. Prepare a boiler for wet storage.
3. Clean, start up, and shut down a steam boiler.
4. Clean, start up, and shut down a hot-water boiler.
5. Start up and shut down a reciprocating liquid chiller and related water system.
6. Start up and shut down a selected centrifugal or screw liquid chiller and related water system.
7. Start up and shut down an air handler and related forced-air distribution system.
8. Test compressor oil for acid contamination.
9. Add or remove oil from a semi-hermetic or open reciprocating compressor.
10. Inspect and clean shell and tube condensers/evaporators and other water-type heat exchangers.

PERFORMANCE TASKS

Under the supervision of the instructor, the trainee should be able to do the following:

1. Develop a checklist for shutting down a steam boiler and preparing it for dry storage.
2. Develop a checklist for shutting down a steam boiler and preparing it for wet storage.
3. Develop a checklist for starting up a steam (or hot-water) boiler and preparing it for normal operation.
4. Start up a reciprocating chiller and prepare it for normal operation.
5. Shut down a reciprocating chiller and chilled-water system.
6. Shut down a cooling tower and prepare it for an extended period of shutdown.
7. Develop a checklist for starting up a centrifugal (or screw) chiller and preparing it for normal operation.
8. Develop a checklist for shutting down a centrifugal (or screw) chiller and preparing it for an extended shutdown.
9. Start up an air handling unit and its related air distribution system and prepare it for normal operation.
10. Shut down an air handling unit and its related air distribution system and prepare it for an extended shutdown.
11. Remove and charge oil from and into a compressor.

MATERIALS AND EQUIPMENT LIST

Overhead projector and screen
Transparencies
Blank acetate sheets
Transparency pens
Whiteboard/chalkboard
Markers/chalk
Pencils and scratch paper
Appropriate personal protective equipment
Manufacturer's operation and service literature for all demonstration equipment
Water analysis test kits
Samples of high-temperature bonding mortar
Samples of anti-corrosive materials
Samples of desiccants
Acid and moisture test kits
Water treatment chemicals (as recommended by the equipment manufacturer)
Refrigerant oil (as recommended by the equipment manufacturer)
Lockout/tagout lock and tags
HVAC systems and equipment:
- Steam boiler and related water system
- Hot-water boiler and related water system
- Reciprocating chiller and related water system
- Centrifugal (or screw) chiller with water-cooled condenser and related cooling tower
- Air handling unit/air distribution system
- Packaged year-round air conditioning unit/air distribution system

HVAC technician's tool set
Multimeters (VOMs/DMMs)
Clamp-on ammeters
Gauge manifold sets and hoses
Electronic leak detectors
Electronic thermometers
Tube cleaning equipment and brushes
Copies of the Quick Quiz*
Module Examinations**
Performance Profile Sheets**

* Located in the back of this module

**Located in the Test Booklet

SAFETY CONSIDERATIONS

Ensure that the trainees are equipped with appropriate personal protective equipment and know how to use it properly. Trainees will perform procedures for the startup and shutdown of a chilled-water system and an air-handling unit. They will also shut down a cooling tower and charge oil into and remove oil from a compressor. Ensure that they are briefed on appropriate safety procedures.

ADDITIONAL RESOURCES

This module is intended to present thorough resources for task training. The following reference works are suggested for both instructors and motivated trainees interested in further study. These are optional materials for continued education rather than for task training.

ASHRAE Handbook—HVAC Applications. Atlanta, GA: American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc.

ASHRAE Handbook—HVAC Systems and Equipment. Atlanta, GA: American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc.

Boilers Simplified. Troy, MI: Business News Publishing Company.

HVAC Systems Testing, Adjusting & Balancing. Chantilly, VA: Sheet Metal and Air Conditioning Contractors National Association (SMACNA).

Water Treatment Specification Manual. Troy, MI: Business News Publishing Company.

TEACHING TIME FOR THIS MODULE

An outline for use in developing your lesson plan is presented below. Note that each Roman numeral in the outline equates to one session of instruction. Each session has a suggested time period of 2½ hours.

This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 22½ hours are suggested to cover *System Startup and Shutdown*. You will need to adjust the time required for hands-on activity and testing based on your class size and resources. Because laboratories often correspond to Performance Tasks, the proficiency of the trainees may be noted during these exercises for Performance Testing purposes.

Topic	**Planned Time**
Session I. Introduction; Steam/Hot-Water Boilers and Systems I	
A. Introduction	_____
B. Steam/Hot-Water Boilers and Systems	_____
1. Shutdown	_____
C. Laboratory	_____
Have trainees develop checklists for shutting down a steam boiler and preparing it for both wet and dry storage. This laboratory corresponds to Performance Tasks 1 and 2.	
Session II. Steam/Hot-Water Boilers and Systems II	
A. Steam/Hot-Water Boilers and Systems	_____
1. Steam Boiler System Startup for Normal Operation	_____
2. Hot-Water Boiler Startup	_____
3. Boiler Cleaning Prior to Startup for Normal Operation	_____
B. Laboratory	_____
Have trainees develop a checklist for starting up a steam (or hot-water) boiler and preparing it for normal operation. This laboratory corresponds to Performance Task 3.	
Session III. Reciprocating Chillers and Water Systems	
A. Reciprocating Chillers and Water Systems	_____
1. Startup	_____
2. Shutdown	_____
B. Laboratory	_____
Have trainees start up a reciprocating chiller and prepare it for normal operation. This laboratory corresponds to Performance Task 4.	
C. Laboratory	_____
Have trainees shut down a reciprocating chiller and chilled-water system. This laboratory corresponds to Performance Task 5.	
Session IV. Centrifugal Chillers and Water Systems; Screw Chillers and Water Systems	
A. Centrifugal Chillers and Water Systems	_____
1. Startup	_____
2. Normal Shutdown	_____
3. Extended Shutdown	_____
B. Screw Chillers and Water Systems	_____
C. Laboratory	_____
Have trainees develop a checklist for starting up a centrifugal (or screw) chiller and preparing it for normal operation. This laboratory corresponds to Performance Task 7.	
D. Laboratory	_____
Have trainees develop a checklist for shutting down a centrifugal (or screw) chiller and preparing it for an extended shutdown. This laboratory corresponds to Performance Task 8.	

Session V. Cooling Tower Water Systems

A. Cooling Tower Water Systems _____
   1. Startup _____
   2. Periodic Maintenance After Startup _____
   3. Winter Operation _____
   4. Shutdown _____

B. Laboratory _____
   Have trainees shut down a cooling tower and prepare it for an extended period of shutdown. This laboratory corresponds to Performance Task 6.

Session VI. Air Handling Unit/Air Distribution System

A. Air Handling Unit/Air Distribution System _____
   1. Startup _____
   2. Shutdown _____

B. Laboratory _____
   Have trainees start up an air handling unit and its related air distribution system and prepare it for normal operation. This laboratory corresponds to Performance Task 9.

C. Laboratory _____
   Have trainees shut down an air handling unit and its related air distribution system and prepare it for an extended shutdown. This laboratory corresponds to Performance Task 10.

Session VII. Packaged Year-Round Air Conditioning Units

A. Packaged Year-Round Air Conditioning Units _____
   1. Startup _____
   2. Shutdown _____

B. Laboratory _____
   Have trainees start up and shut down a packaged year-round air conditioning unit and its related air distribution system.

Session VIII. Post-Shutdown Maintenance

A. Post-Shutdown Maintenance _____
   1. Oil Charging/Removal in a Semi-Hermetic or Open Reciprocating Compressor _____
   2. Inspecting and Cleaning Shell and Tube Condensers and Evaporators (Coolers)
   3. Inspecting and Cleaning Heat Exchangers _____

B. Laboratory _____
   Have trainees remove and charge oil from and into a compressor. This laboratory corresponds to Performance Task 11.

Session IX. Review and Testing

A. Review _____

B. Module Examination _____
   1. Trainees must score 70% or higher to receive recognition from NCCER.
   2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.

C. Performance Testing _____
   1. Trainees must perform each task to the satisfaction of the instructor to receive recognition from NCCER. If applicable, proficiency noted during laboratory exercises can be used to satisfy the Performance Testing requirements.
   2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.

Heating and Cooling System Design
Annotated Instructor's Guide

Module 03407-09

MODULE OVERVIEW

This module identifies the factors that affect the heating and cooling loads of a building. It describes the process by which heating and cooling loads are calculated, and shows how load information is used to select heating and cooling equipment, including duct systems.

PREREQUISITES

Prior to training with this module, it is recommended that the trainee shall have successfully completed *Core Curriculum*; *HVAC Level One*; *HVAC Level Two*; *HVAC Level Three*; and *HVAC Level Four*, Modules 03401-09 through 03406-09.

OBJECTIVES

Upon completion of this module, the trainee will be able to do the following:

1. Identify and describe the steps in the system design process.
2. From construction drawings or an actual job site, obtain information needed to complete heating and cooling load estimates.
3. Identify the factors that affect heat gains and losses to a building and describe how these factors influence the design process.
4. With instructor supervision, complete a load estimate to determine the heating and/or cooling load of a building.
5. State the principles that affect the selection of equipment to satisfy the calculated heating and/or cooling load.
6. With instructor supervision, select heating and/or cooling equipment using manufacturers' product data.
7. Identify the various types of duct systems and explain why and where each type is used.
8. Demonstrate the effect of fittings and transitions on duct system design.
9. Use a friction loss chart and duct sizing table to size duct.
10. Install insulation and vapor barriers used in duct systems.
11. Following proper design principles, select and install refrigerant and condensate piping.
12. Estimate the electrical load for a building and calculate the effect of the comfort system on the electrical load.

PERFORMANCE TASKS

Under the supervision of the instructor, the trainee should be able to do the following:

1. Develop a list of factors that affect heating and cooling loads.
2. Develop a floor plan that contains all the information needed to perform a load estimate.
3. Perform a load estimate using a standardized method.
4. Use manufacturer's product data to select the appropriate heating and cooling equipment based on a load estimate and airflow requirements.
5. Determine the number, location, and sizes of supply outlets and return inlets needed in a building.
6. Use a friction chart and/or standard duct sizing tables to size the trunk and branch ducts for a selected low-volume air distribution system.
7. Use a duct design calculator to size the trunk and branch ducts for a selected low-volume air distribution system.
8. Calculate the total system friction loss (external static pressure) for a selected air distribution system.

MATERIALS AND EQUIPMENT LIST

Overhead projector and screen

Transparencies

Blank acetate sheets

Transparency pens

Whiteboard/chalkboard

Markers/chalk

Pencils and scratch paper

Appropriate personal protective equipment

ACCA Manual J (one copy for each trainee, if possible)

Load estimating software

Metal duct sections of various sizes and shapes

Metal duct installation fasteners and attaching hardware

Ductboard sections of various sizes and shapes

Ductboard installation materials and attaching hardware

Samples of foil- and/or vinyl-backed fiberglass duct insulation

Examples of building floor plans and/or distribution system layouts

Examples of heating and cooling load estimate forms

Manufacturer's product literature for cooling equipment, furnaces, and heat pumps

Examples of friction loss charts

Operating air distribution duct system

Examples of air distribution system fans and blowers

Duct design calculators

Air diffusers, registers, and grilles

Copies of the Quick Quiz*

Module Examinations**

Performance Profile Sheets**

* Located in the back of this module

**Located in the Test Booklet

SAFETY CONSIDERATIONS

Ensure that the trainees are equipped with appropriate personal protective equipment and know how to use it properly.

ADDITIONAL RESOURCES

This module is intended to present thorough resources for task training. The following reference works are suggested for both instructors and motivated trainees interested in further study. These are optional materials for continued education rather than for task training.

Air Distribution System Selection. York, PA: International Corporation.

HVAC Duct Construction Standards – Metal and Flexible. Chantilly, VA: Sheet Metal and Air Conditioning Contractors National Association (SMACNA).

Manual D, Duct Design for Residential Winter and Summer Air Conditioning. Washington, DC: Air Conditioning Contractors of America (ACCA).

Manual G, Selection of Distribution Systems. Washington, DC: Air Conditioning Contractors of America (ACCA).

Manual J, Load Calculation for Residential Winter and Summer Air Conditioning. Washington, DC: Air Conditioning Contractors of America (ACCA).

Manual N, Load Calculation for Commercial Winter and Summer Air Conditioning. Washington, DC: Air Conditioning Contractors of America (ACCA).

Residential Air System Design. Syracuse, NY: Carrier Corporation.

TEACHING TIME FOR THIS MODULE

An outline for use in developing your lesson plan is presented below. Note that each Roman numeral in the outline equates to one session of instruction. Each session has a suggested time period of 2½ hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 25 hours are suggested to cover *Heating and Cooling System Design*. You will need to adjust the time required for hands-on activity and testing based on your class size and resources. Because laboratories often correspond to Performance Tasks, the proficiency of the trainees may be noted during these exercises for Performance Testing purposes.

Topic **Planned Time**

Session I. Introduction; Overview of the Design Process
Building Evaluation/Survey

A. Introduction _____
B. Overview of the Design Process _____
C. Building Evaluation/Survey _____

Sessions II-V. Load Estimating

A. Heat Transfer _____
B. Heat Gain and Loss _____
C. Cooling and Heating Load Factors _____
1. Laboratory _____

Have trainees develop a list of factors that affect heating and cooling loads. This laboratory corresponds to Performance Task 1.

D. Preparing the Load Estimate _____
1. Laboratory _____

Have trainees develop a floor plan that contains all the information needed to perform a load estimate. This laboratory corresponds to Performance Task 2.

2. Laboratory _____

Have trainees prepare a load estimate based on their floor plan. This laboratory corresponds to Performance Task 3.

E. Load Estimating Software _____

Session VI. Equipment Selection

A. Equipment Selection _____
1. Cooling Equipment Selection _____
2. Heating Equipment Selection _____
3. Heat Pump Selection _____

B. Laboratory _____

Have trainees use manufacturer's product data to select the appropriate heating and cooling equipment based on a load estimate and airflow requirements. This laboratory corresponds to Performance Task 4.

Sessions VII-VIII. Air Distribution System Duct Design

A. Duct System Basics _____

B. Air Distribution Duct Systems _____

C. Duct System Components _____

D. Duct System Design _____

1. Laboratory _____

   Have trainees calculate the total system friction loss (external static pressure) for a selected air distribution system. This laboratory corresponds to Performance Task 8.

2. Laboratory _____

   Have trainees determine the number, location, and sizes of supply outlets and return inlets needed in a building. This laboratory corresponds to Performance Task 5.

3. Laboratory _____

   Have trainees use a friction chart and/or standard duct sizing tables to size the trunk and branch ducts for a selected low-volume air distribution system. This laboratory corresponds to Performance Task 6.

4. Laboratory _____

   Have trainees use a duct design calculator to size the trunk and branch ducts for a selected low-volume air distribution system. This laboratory corresponds to Performance Task 7.

E. Other Duct System Design Considerations _____

Session IX. Support Systems; Load Estimating for Commercial Buildings

A. Support Systems _____

1. Refrigerant Piping _____
2. Condensate Piping _____
3. Electrical Service _____

B. Load Estimating for Commercial Buildings _____

Session X. Review and Testing

A. Review _____

B. Module Examination _____

1. Trainees must score 70% or higher to receive recognition from NCCER.
2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.

C. Performance Testing _____

1. Trainees must perform each task to the satisfaction of the instructor to receive recognition from NCCER. If applicable, proficiency noted during laboratory exercises can be used to satisfy the Performance Testing requirements.
2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.

MODULE OVERVIEW

This module expands on the refrigeration system coverage provided in the *HVAC Level Three* module *Retail Refrigeration Systems*. It covers large-scale refrigeration systems such as those found in supermarkets, cold storage facilities, packing houses, and food processing plants.

PREREQUISITES

Prior to training with this module, it is recommended that the trainee shall have successfully completed *Core Curriculum*; *HVAC Level One*; *HVAC Level Two*; *HVAC Level Three*; and *HVAC Level Four*, Modules 03401-09 through 03407-09.

OBJECTIVES

Upon completion of this module, the trainee will be able to do the following:

1. Identify different types of refrigerated coolers and display cases and describe each one's common application.
2. Compare the basic components used in commercial/industrial refrigeration systems with those used in retail refrigeration systems.
3. Identify single, multiple, and satellite compressor systems. Describe the applications, installation considerations, and advantages and disadvantages of each type.
4. Identify packaged condensing units and unit coolers. Describe their applications, operation, and installation considerations.
5. Identify two-stage compressors and explain their operation and applications.
6. Identify the various accessories used in commercial refrigeration systems. Explain why each is used and where it should be installed in the system.
7. Identify the various refrigeration control devices. Explain the purpose of each type and how it works.
8. Compare the components used in ammonia systems with those used in halocarbon-based refrigerant systems.

PERFORMANCE TASKS

Under the supervision of the instructor, the trainee should be able to do the following:

1. Install a packaged condensing unit and/or individual air-cooled condenser in a refrigeration system.
2. Install a packaged unit cooler and/or individual evaporator in a refrigeration system.
3. Install two to three selected refrigeration system accessories.
4. From a selection provided by the instructor, identify the following control devices commonly used in refrigeration systems:
   - Crankcase pressure regulator
   - Evaporator pressure regulator
   - Condenser head pressure regulator
   - Hot gas bypass regulator
   - Compressor cylinder unloader
   - Solenoid-controlled unloader

MATERIALS AND EQUIPMENT LIST

Overhead projector and screen

Transparencies

Blank acetate sheets

Transparency pens

Whiteboard/chalkboard

Markers/chalk

Pencils and scratch paper

Appropriate personal protective equipment

Refrigeration packaged condensing unit

Refrigeration evaporator or unit cooler

Refrigeration system control devices, including:
- Crankcase pressure regulator
- Evaporator pressure regulator
- Condenser head pressure regulator
- Hot gas bypass regulator
- Compressor cylinder unloader
- Solenoid-controlled unloader

Capacity control devices

Refrigeration system accessories, including:
- Filter-drier with replacement cartridge
- Sightglass/moisture-liquid indicator
- Suction line accumulator
- Crankcase heater
- Oil separator
- Receiver
- Service valves
- Fusible plug
- Relief valve
- Relief manifold
- Check valve
- Muffler
- Vibration isolator

Defrost devices

Defrost time clock / timer

Copies of the Quick Quiz*

Module Examination**

Performance Profile Sheets**

* Located in the back of this module

**Located in the Test Booklet

SAFETY CONSIDERATIONS

Ensure that the trainees are equipped with appropriate personal protective equipment and know how to use it properly. This module may require trainees to visit job sites. Ensure that trainees are briefed on site safety policies prior to any site visits.

ADDITIONAL RESOURCES

This module is intended to present thorough resources for task training. The following reference works are suggested for both instructors and motivated trainees interested in further study. These are optional materials for continued education rather than for task training.

ASHRAE Handbook, Refrigeration Systems and Applications, Latest Edition. Atlanta, GA: American Society of Heating, Refrigerating, and Air Conditioning Engineers.

ASHRAE Handbook, HVAC Systems and Equipment, Latest Edition. Atlanta, GA: American Society of Heating, Refrigerating, and Air Conditioning Engineers.

TEACHING TIME FOR THIS MODULE

An outline for use in developing your lesson plan is presented below. Note that each Roman numeral in the outline equates to one session of instruction. Each session has a suggested time period of 2½ hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 22½ hours are suggested to cover *Commercial and Industrial Refrigeration Systems*. You will need to adjust the time required for hands-on activity and testing based on your class size and resources. Because laboratories often correspond to Performance Tasks, the proficiency of the trainees may be noted during these exercises for Performance Testing purposes.

Topic **Planned Time**

Session I. Introduction; Refrigeration and the Preservation of Food Products; Refrigerated Transport Units

A. Introduction _____
B. Refrigeration and the Preservation of Food Products _____
   1. Cold Storage _____
   2. Commercial Freezing Methods _____
C. Refrigerated Transport Units _____
   1. Refrigerated Shipboard Containers _____
   2. Trailer and Truck Units _____
   3. Refrigerated Railcars _____

Sessions II–V. Refrigeration Systems and Components; Accessories

A. Refrigeration Systems and Components _____
   1. Compressors _____
   2. Condensers _____
      a. Laboratory _____

      Have trainees install a packaged condensing unit or individual air-cooled condenser in a refrigeration system. This laboratory corresponds to Performance Task 1.
   3. Evaporators _____
      a. Laboratory _____

      Have trainees install a packaged unit cooler or individual evaporator in a refrigeration system. This laboratory corresponds to Performance Task 2.
   4. Display Cases _____
   5. Accessories _____
      a. Laboratory _____

      Have trainees install two or three selected refrigeration system accessories. This laboratory corresponds to Performance Task 3.

Session VI. Refrigeration System Control Devices, Part I

A. Crankcase Pressure Regulating Valves _____
B. Evaporator Pressure Regulating Valves _____
C. Air-Cooled Condenser Pressure Regulator _____
D. Bypass Control Valves _____
E. Capacity Control Devices _____

Session VII. Refrigeration System Control Devices II

A. Pump-Down Control _____

B. Defrost Systems _____

C. Laboratory _____

Selecting items from the list below, have trainees identify control devices commonly used in refrigeration systems. This laboratory corresponds to Performance Task 4.

- Crankcase pressure regulator
- Evaporator pressure regulator
- Condenser head pressure regulator
- Hot gas bypass regulator
- Compressor cylinder unloader
- Solenoid-controlled unloader

Session VIII. Ammonia Refrigeration Systems; Secondary Coolants

A. Ammonia Refrigeration Systems _____

B. Secondary Coolants _____

Session IX. Review and Testing

A. Review _____

B. Module Examination _____

1. Trainees must score 70% or higher to receive recognition from NCCER.
2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.

C. Performance Testing _____

1. Trainees must perform each task to the satisfaction of the instructor to receive recognition from NCCER. If applicable, proficiency noted during laboratory exercises can be used to satisfy the Performance Testing requirements.
2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.

Alternative Heating and Cooling Systems
Annotated Instructor's Guide

Module 03409-09

MODULE OVERVIEW

Alternative heating and cooling systems are being employed for the purpose of reducing energy consumption and its associated impact on the environment. This module introduces several of these alternative systems.

PREREQUISITES

Prior to training with this module, it is recommended that the trainee shall have successfully completed *Core Curriculum*, *HVAC Level One*; *HVAC Level Two*; *HVAC Level Three*; and *HVAC Level Four*, Modules 03401-09 through 03408-09.

OBJECTIVES

Upon completion of this module, the trainee will be able to do the following:

1. Describe alternative technologies for heating, including:
   - In-floor
   - Direct-fired makeup unit (DFMU)
   - Solar
   - Air turnover
   - Corn or wood pellet burners
   - Waste oil/multi-fuel
   - Fireplace inserts
2. Describe alternative technologies for cooling, including:
   - Ductless system (DX/hydronic)
   - Computer room
   - Chilled beams
   - Multi-zone

PERFORMANCE TASKS

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

MATERIALS AND EQUIPMENT LIST

Overhead projector and screen
Transparencies
Blank acetate sheets
Transparency pens
Whiteboard/chalkboard
Markers/chalk
Pencils and scratch paper
Appropriate personal protective equipment
Samples of wood pellets and shelled corn
Section of Type HT vent
Examples of brushes used to clean wood-burning appliances
Copies of the Quick Quiz*
Module Examination**

* Located in the back of this module

**Located in the Test Booklet

SAFETY CONSIDERATIONS

Ensure that the trainees are equipped with appropriate personal protective equipment and know how to use it properly. This module may require that the trainees visit job sites. Ensure that trainees are briefed on site safety policies prior to any site visits.

ADDITIONAL RESOURCES

This module is intended to present thorough resources for task training. The following reference works are suggested for both instructors and motivated trainees interested in further study. These are optional materials for continued education rather than for task training.

http://warmair.net

http://www.servicemagic.com/article.show.Think-Green-when-it-Comes-to-Residential-Heating.15397.html

TEACHING TIME FOR THIS MODULE

An outline for use in developing your lesson plan is presented below. Note that each Roman numeral in the outline equates to one session of instruction. Each session has a suggested time period of 2½ hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 10 hours are suggested to cover *Alternative Heating and Cooling Systems*. You will need to adjust the time required for hands-on activity and testing based on your class size and resources.

Topic	**Planned Time**
Session I. Introduction; Alternative Heating Methods and Systems; Solid Fuel Appliances	
A. Introduction	_____
B. Alternative Heating Methods and Systems	_____
C. Solid Fuel Appliances	_____
1. Wood-Burning Stoves	_____
2. Wood-Burning Furnaces	_____
3. Wood-Burning Boilers	_____
4. Installation and Maintenance	_____
Session II. Waste Oil Heaters; Geothermal and Water-Source Heat Pumps; Solar Heating Systems; In-Floor Radiant Heating Systems; Direct-Fired Makeup Units	
A. Waste Oil Heaters	_____
1. Waste Oil Heating Issues	_____
B. Geothermal and Water-Source Heat Pumps	_____
1. Ground-Source Heat Pumps	_____
2. Water-Source Heat Pumps	_____
C. Solar Heating Systems	_____
1. Passive Solar Heating Systems	_____
2. Active Solar Heating Systems	_____
D. In-Floor Radiant Heating Systems	_____
1. Electric Radiant Heating Systems	_____
2. Radiant Hydronic Heating Systems	_____
E. Direct-Fired Makeup Units	_____

Session III. Alternative Cooling Methods and Systems; Ductless Split Systems; Computer Rack Cooling Systems; Valance Cooling Systems; Chilled-Beam Cooling Systems

A. Alternative Cooling Methods and Systems _____
B. Ductless Split Systems _____
   1. Condensing Units _____
   2. Air Handlers _____
   3. Multiple Ductless Split Systems _____
   4. Installation and Service _____
   5. Chilled-Water Ductless Split Systems _____
C. Computer Room Cooling Systems _____
   1. Raised-Floor Cooling Systems _____
   2. Free-Standing Air Handlers _____
   3. Liquid Chillers _____
   4. Cooled Equipment Enclosures _____
   5. Spot Coolers _____
D. Valance Cooling Systems _____
E. Chilled-Beam Cooling Systems _____
   1. Passive Chilled-Beam Systems _____
   2. Active Chilled-Beam Systems _____

Session IV. Evaporative Coolers; Alternative Energy-Saving Systems and Devices; Air Turnover Systems; Review and Testing

A. Evaporative Coolers _____
B. Alternative Energy-Saving Systems and Devices _____
   1. Heat Pump Water Heaters _____
   2. Waste Heat Water Heaters _____
   3. Evaporative Pre-Coolers _____
C. Air Turnover Systems _____
D. Review _____
E. Module Examination _____
   1. Trainees must score 70% or higher to receive recognition from NCCER.
   2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.

Introduction to Supervisory Skills
Annotated Instructor's Guide

Module 03410-09

MODULE OVERVIEW

This module explains many of the skills needed to become an effective supervisor. Issues covered include those related to leadership, gender and culture, problem solving/decision making, and safety.

PREREQUISITES

Prior to training with this module, it is recommended that the trainee shall have successfully completed *Core Curriculum*; *HVAC Level One*; *HVAC Level Two*; *HVAC Level Three*; and *HVAC Level Four*, Modules 03401-09 through 03409-09.

OBJECTIVES

Upon completion of this module, the trainee will be able to do the following:

1. Describe the skills necessary to be a supervisor.
2. List the characteristics and behavior of effective leaders, as well as the different leadership styles.
3. Explain the difference between problem solving and decision making.
4. Describe ways to deal with common leadership problems, such as absenteeism and turnover.
5. Identify a supervisor's safety responsibilities.
6. Describe the signals of substance abuse.
7. List the essential parts of an accident investigation.

PERFORMANCE TASKS

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

MATERIALS AND EQUIPMENT LIST

Overhead projector and screen
Transparencies
Blank acetate sheets
Transparency pens
Whiteboard/chalkboard
Markers/chalk
Pencils and scratch paper
Module Examination*

*Located in the Test Booklet

TEACHING TIME FOR THIS MODULE

An outline for use in developing your lesson plan is presented below. Note that each Roman numeral in the outline equates to one session of instruction. Each session has a suggested time period of 2½ hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 12½ hours are suggested to cover *Introduction to Supervisory Skills*. You will need to adjust the time required for hands-on activity and testing based on your class size and resources.

Topic	**Planned Time**
Session I. Introduction to Supervision; Becoming a Leader	
A. Introduction to Supervision	_____
B. Becoming a Leader	_____
1. Characteristics of Effective Leaders	_____
2. Leadership Behavior	_____
3. Functions of a Leader	_____
4. Leadership Styles	_____
5. Ethics in Leadership	_____
Session II. Gender and Cultural Issues	
A. Communication Styles of Men and Women	_____
B. Language Barriers	_____
C. Cultural Differences	_____
D. Sexual Harassment	_____
E. Gender and Minority Discrimination	_____
Session III. Problem Solving and Decision Making	
A. Types of Decisions	_____
B. Formal Problem-Solving Techniques	_____
C. Dealing with Leadership Problems	_____
Session IV. Supervisors and Safety; Supervisor Involvement in Safety	
A. Supervisors and Safety	_____
1. Safety Responsibilities, Programs, and Policies/Procedures	_____
2. Hazard Identification and Safety Training	_____
B. Supervisor Involvement in Safety	_____
1. Safety Meetings and Inspections	_____
2. Substance Abuse	_____
3. Accident Investigation	_____
Session V. Review and Testing	
A. Module Review	_____
B. Module Examination	_____
1. Trainees must score 70% or higher to receive recognition from NCCER.	
2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.	