Air Quality Equipment
Annotated Instructor's Guide

Module 03204-07

MODULE OVERVIEW

This module covers common accessories used to control air quality, including dehumidifiers, humidifiers, and filters. It also covers energy conservation equipment.

PREREQUISITES

Prior to training with this module, it is recommended that the trainee shall have successfully completed *Core Curriculum*; *HVAC Level One*; and *HVAC Level Two*, Modules 03201-07 through 03203-07.

OBJECTIVES

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

1. Explain why it is important to control humidity in a building.
2. Recognize the various kinds of humidifiers used with HVAC systems and explain why each is used.
3. Demonstrate how to install and service the humidifiers used in HVAC systems.
4. Recognize the kinds of air filters used with HVAC systems and explain why each is used.
5. Demonstrate how to install and service the filters used in HVAC systems.
6. Use a manometer or differential pressure gauge to measure the friction loss of an air filter.
7. Identify accessories commonly used with air conditioning systems to improve indoor air quality and reduce energy cost, and explain the function of each, including:
   - Humidity control devices
   - Air filtration devices
   - Energy conservation devices
8. Demonstrate or describe how to clean an electronic air cleaner.

PERFORMANCE TASKS

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

1. Demonstrate how to inspect, clean, and replace humidifiers.
2. Inspect disposable/permanent air filters for mechanical damage and cleanliness.
3. Clean permanent-type air filters.
4. Measure the differential pressure drop across an air filter with a manometer.

MATERIALS AND EQUIPMENT LIST

Overhead projector and screen
Transparencies
Blank acetate sheets
Transparency pens
Whiteboard/chalkboard
Markers/chalk
Pencils and scratch paper
Humidifiers
Disposable air filters
Electronic air cleaner
Various types of air filters
Tools for removing and cleaning air filters
Manometer
Operating air filtration system
Manufacturers' literature on energy and heat recovery ventilators
Ultraviolet light purification system
Carbon monoxide and carbon dioxide monitors
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. The module requires that trainees work with air filters and testing equipment. Ensure all trainees 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.

Air Conditioning Systems, Principles, Equipment, and Service. 2000. Prentice Hall.

Refrigeration and Air Conditioning: An Introduction to HVAC. 2003. Prentice Hall.

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 5 hours are suggested to cover *Air Quality 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, Humidity Control, and Indoor Air Quality	
A. Introduction	_____
B. Process and Comfort Air Conditioning	_____
C. Humidity Control	_____
D. Laboratory Trainees practice inspecting, cleaning, and replacing humidifiers. This laboratory corresponds to Performance Task 1.	_____
E. Mechanical Air Filters	_____
F. Laboratory Trainees practice inspecting disposable/permanent air filters. This laboratory corresponds to Performance Task 2.	_____
G. Laboratory Trainees practice cleaning permanent air filters. This laboratory corresponds to Performance Task 3.	_____
Session II. Indoor Air Quality II, Review, and Testing	
A. Laboratory Trainees practice measuring the differential pressure drop across an air filter with a manometer. This laboratory corresponds to Performance Task 4.	_____
B. Air Conditioning Energy Conservation Equipment	_____
C. Ultraviolet Light Air Purification Systems	_____
D. Carbon Monoxide and Carbon Dioxide Monitors	_____
E. Review	_____

F. 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.

G. 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.

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.