

## **MODULE OVERVIEW**

This module introduces the trainees to the safety rules and regulations for E & I technicians, including the necessary precautions for avoiding the various hazards that exist on the job.

## **PREREQUISITES**

Prior to training with this module, it is recommended that the trainee shall have successfully completed *Core Curriculum* and *Industrial Maintenance E & I Technician Level One*.

## **OBJECTIVES**

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

1. Demonstrate safe working procedures in an industrial environment.
2. Explain the purposes of OSHA and *NFPA 70E* and how they promote safety on the job.
3. Recognize electrical/energy hazards and describe how to avoid or minimize them in the workplace.
4. Explain safety issues concerning lockout/tagout procedures, personal protection using assured grounding and isolation programs, confined space entry, respiratory protection, and fall protection systems.
5. Recognize and apply safe working practices.

## **PERFORMANCE TASKS**

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

1. Perform a visual inspection and an air test on rubber gloves.
2. Develop a task plan and deliver a task briefing:
  - Discuss the work to be performed and the hazards involved.
  - Locate the closest phone to the work site and ensure that the local emergency telephone numbers are either posted at the phone or known by you and your partner(s).
  - Plan an escape route from the location in the event of an accident.
3. Identify and describe the electrical hazards in your work site.

## **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 the latest edition of the *National Electrical Code*<sup>®</sup>  
OSHA Electrical Safety Guidelines (pocket guide)  
*NFPA 70E*  
GFCI device  
Access to eye wash station  
Company safety manual  
Company lockout/tagout procedures  
Lockout/tagout devices and labels  
Solvent MSDS

Various types of personal protective and safety equipment, including:  
Rubber gloves  
Insulating blankets  
Hot sticks  
Fuse pullers  
Shorting probes  
Safety glasses  
Face shields  
Step ladders  
Straight ladders  
Fall arrest system  
Safety harnesses  
TV/DVD/VCR player (optional)  
Safety videos (optional)  
Trade Terms 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 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.

*29 CFR Parts 1900–1910, Standards for General Industry.* Occupational Safety and Health Administration, U.S. Department of Labor.

*29 CFR Part 1926, Standards for the Construction Industry.* Occupational Safety and Health Administration, U.S. Department of Labor.

*National Electrical Code® Handbook,* Latest Edition. Quincy, MA: National Fire Protection Association.

*Standard for Electrical Safety in the Workplace,* Latest Edition. Quincy, MA: National Fire Protection 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 12½ hours are suggested to cover *Industrial Safety for E & I Technicians*. 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
<b>Session I. Introduction; Electrical Shock; Reducing the Risk of Electrical Shock</b>	
A. Introduction	_____
B. Electrical Shock	_____
1. The Effect of Current	_____
a. Body Resistance	_____
b. Burns	_____
C. Reducing the Risk of Electrical Shock	_____
1. Protective Equipment	_____
2. Verifying Circuits That are De-Energized	_____
3. Other Precautions	_____
4. <i>NFPA 70E</i>	_____
D. Laboratory	_____
Have the trainees practice performing a visual inspection and an air test on rubber gloves. This laboratory corresponds to Performance Task 1.	
<b>Session II. Energy Control</b>	
A. Energy Control	_____
1. Lockout/Tagout	_____
2. Lockout/Tagout Procedures	_____
3. Safeguards	_____

**Session III. Ladders and Scaffolds; Lifts, Hoists, and Cranes; Lifting; Basic Tool Safety; Confined Space Entry Procedures**

- A. Ladders and Scaffolds
- B. Lifts, Hoists, and Cranes
- C. Lifting
- D. Basic Tool Safety
- E. Confined Space Entry Procedures

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**Session IV. First Aid; Solvents and Toxic Vapors; Asbestos; Batteries; PCBs and Vapor Lamps; Fall Protection**

- A. First Aid
- B. Solvents and Toxic Vapors
- C. Asbestos
- D. Batteries
- E. PCBs and Vapor Lamps
- F. Fall Protection
- G. Laboratory

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Have the trainees practice developing a task plan and delivering a task briefing, including discussing the work to be performed and the hazards involved; locating the closest phone to the work site and ensuring that the local emergency phone numbers are either posted at the phone or are known by the trainees and their partners; and planning an escape route from the location in the event of an accident. This laboratory corresponds to Performance Task 2.

- H. Laboratory

Have the trainees practice identifying and describing the electrical hazards at their work site. This laboratory corresponds to Performance Task 3.

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**Session V. Review and Testing**

- A. Review
- B. Module Examination
  1. Trainees must score 70 percent 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 the NCCER.
  2. Record the training results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.

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## **MODULE OVERVIEW**

This module covers electrical shock and arc flash hazards and introduces the trainees to *NFPA 70E®*, *Standard for Electrical Safety in the Workplace*.

## **PREREQUISITES**

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

## **OBJECTIVES**

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

1. Identify types of electrical hazard types and locations, and explain related safety guidelines and terms.
2. Recognize and explain hazard boundaries.
3. Explain employer and employee responsibilities in recognizing and managing electrical hazards.
4. List common factors that lead to electrical incidents and explain the importance of using appropriate procedures and safe work practices.
5. Analyze the electrical hazards of a given task, plan the job, and complete an electrical work permit request.
6. Select, inspect, use, and care for personal protective equipment (PPE) and test equipment used for electrical work.
7. Explain how to create an electrically safe work condition.

## **PERFORMANCE TASKS**

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

1. Given a specific electrical task and circumstances, complete an energized electrical work permit request.

## **MATERIALS AND EQUIPMENT LIST**

Overhead projector and screen

Transparencies

Blank acetate sheets

Transparency pens

Whiteboard/chalkboard

Markers/chalk

Pencils and scratch paper

*NFPA 70E®*, *Standard for Electrical Safety in the Workplace*

Various types of protective equipment, including rubber gloves, leathers, rubber blankets, face shields, and arc flash suits

Various insulated/insulating and live-line tools

Temporary grounding jumpers

Insulated rescue hook

Blank energized electrical work request forms

Example job drawings

Time-current curves for various molded-case and low-voltage power circuit breakers (both thermal-magnetic operators and electronic trip units)

Molded-case and low-voltage circuit breakers

Insulation tester

Proximity detectors

Module Examinations\*

Performance Profile Sheets\*

\* 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.

*Arc Flash Hazard Incident Energy Calculations: A Historical Perspective and Comparative Study of the Standards IEEE 1584 and NFPA 70E® (2007)*. R.F. Ammerman, P.K. Sen, and J.P. Nelson: Calgary, Canada.

*IEEE C2-2007, National Electrical Safety Code*. Institute of Electrical and Electronics Engineers: New York, NY.

*IEEE 1584-2002, IEEE Guide for Performing Arc-Flash Hazard Calculations*. Institute of Electrical and Electronics Engineers: New York, NY.

*Improved Models for Predicting Incident Thermal Energy Exposures Caused by High Energy Arcing Faults in Low- and Medium-Voltage Power Systems (2008)*. R.F. Ammerman, Colorado School of Mines: Golden, CO.

*NFPA 70B-2006, Recommended Practice for Electrical Equipment Maintenance*. National Fire Protection Association: Quincy, MA.

*NFPA 70E®-2008, Standard for Electrical Safety in the Workplace*. National Fire Protection Association: Quincy, MA.

## **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 *Managing Electrical Hazards*. 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.

<b>Topic</b>	<b>Planned Time</b>
<b>Session I. Introduction to Electrical Hazards; Electrical Equipment; Getting Started With NFPA 70E®</b>	
A. Introduction to Electrical Hazards	_____
1. Electrical Shock	_____
2. Arc Flash and Blast Hazards	_____
B. Electrical Equipment, Including Specific Hazards Associated with Each Type	_____
C. Getting Started with NFPA 70E®	_____
1. Navigating NFPA 70E®	_____
2. Recognizing Hazard Boundaries	_____
<b>Session II. Employer/Employee Responsibilities; Electrical Incidents and Prevention</b>	
A. Employer/Employee Responsibilities	_____
B. Electrical Incidents and Prevention	_____
1. Electrical Incidents	_____
2. Safety-Related Work Practices	_____
3. Personal Protective Equipment	_____
4. Other Tools and Protective Equipment	_____

### Session III. Energized Electrical Work Permit

- A. Completing Part I \_\_\_\_\_
- B. Completing Part II \_\_\_\_\_
- C. Completing Part III \_\_\_\_\_
- D. Laboratory \_\_\_\_\_

Have the trainees practice completing an energized electrical work permit request. This laboratory corresponds to Performance Task 1.

### Session IV. Analyzing Electrical Hazards; Electrical Test Equipment Selection and Use

- A. Analyzing Electrical Hazards
  - 1. Drawings and Documents \_\_\_\_\_
  - 2. Shock Hazard Analysis \_\_\_\_\_
  - 3. Arc Flash Hazard Analysis \_\_\_\_\_
  - 4. Identifying Flash Protection Boundaries and Selecting PPE \_\_\_\_\_
- B. Electrical Test Equipment Selection and Use
  - 1. Inspection \_\_\_\_\_
  - 2. Training \_\_\_\_\_
  - 3. Meter Use \_\_\_\_\_

### Session V. Establishing an Electrically Safe Work Condition; Emergency Response; Personal Safety Toolbox; Review and Testing

- A. Establishing an Electrically Safe Work Condition
  - 1. Electrical Lockout/Tagout \_\_\_\_\_
  - 2. Hazardous Energy Control Procedures \_\_\_\_\_
- B. Emergency Response
  - 1. Shock Victims \_\_\_\_\_
  - 2. Arc Flash Victims \_\_\_\_\_
  - 3. Teamwork \_\_\_\_\_
  - 4. Resuscitation \_\_\_\_\_
- C. Personal Safety Toolbox
  - 1. Communication \_\_\_\_\_
  - 2. Changes in Scope \_\_\_\_\_
  - 3. Administrative Controls \_\_\_\_\_
- D. Module Review \_\_\_\_\_
- E. Module Examination \_\_\_\_\_
  - 1. Trainees must score 70 percent 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.
- F. 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 provides an introduction to the *National Electrical Code*<sup>®</sup>.

## PREREQUISITES

Prior to training with this module, it is recommended that the trainee shall have successfully completed *Core Curriculum; Industrial Maintenance E & I Technician Level One; and Industrial Maintenance E & I Technician Level Two*, Module 40201-08.

## OBJECTIVES

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

1. Explain the purpose and history of the *National Electrical Code*<sup>®</sup> (NEC<sup>®</sup>).
2. Describe the layout of the NEC<sup>®</sup>.
3. Explain how to navigate the NEC<sup>®</sup>.
4. Describe the purpose of the National Electrical Manufacturers Association (NEMA) and the National Fire Protection Association (NFPA).
5. Explain the role of nationally recognized testing laboratories.

## PERFORMANCE TASKS

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

1. Find the definition of the term *feeder* in the NEC<sup>®</sup>.
2. Look up the NEC<sup>®</sup> requirements that you would need to follow if you were installing a receptacle in a cooling tower.
3. Find the minimum wire bending space required for two 1/0 AWG conductors installed in a junction box or cabinet and entering opposite the terminal.

## MATERIALS AND EQUIPMENT LIST

Overhead projector and screen

Transparencies

Blank acetate sheets

Transparency pens

Whiteboard/chalkboard

Markers/chalk

Pencils and scratch paper

Copy of the latest edition of the *National Electrical Code*<sup>®</sup>

Sample of a labeled device

Trade Terms 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.

## ADDITIONAL RESOURCES

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

*National Electrical Code® Handbook*, Latest Edition. Quincy, MA: National Fire Protection 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 5 hours are suggested to cover *Introduction to the National Electrical Code®*. 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
<b>Session I. Introduction to the NEC®; Purpose and History of the NEC®; The Layout of the NEC®; Navigating the NEC®; Other Organizations</b>	
A. Introduction	_____
B. Purpose and History of the NEC®	_____
C. The Layout of the NEC®	_____
1. Types of Rules	_____
2. NEC® Introduction	_____
3. The Body of the NEC®	_____
4. Text in the NEC®	_____
D. Navigating the NEC®	_____
1. Chapter 1 – General	_____
2. Chapter 2 – Wiring and Protection	_____
3. Chapter 3 – Wiring Methods and Materials	_____
4. Chapter 4 – Equipment for General Use	_____
5. Chapter 5 – Special Occupancies	_____
6. Chapter 6 – Special Equipment	_____
7. Chapter 7 – Special Conditions	_____
8. Chapter 8 – Communications Systems	_____
9. Examples of Navigating the NEC®	_____
E. Other Organizations	_____
F. Laboratory	_____
Have the trainees practice finding the definition of the term <i>feeder</i> in the NEC®. This laboratory corresponds to Performance Task 1.	
G. Laboratory	_____
Have the trainees practice looking up the NEC® requirements that you would need to follow if you were installing a receptacle in a cooling tower. This laboratory corresponds to Performance Task 2.	
H. Laboratory	_____
Have the trainees practice finding the minimum wire bending space required for two 1/0 AWG conductors installed in a junction box or cabinet and entering opposite the terminal. This laboratory corresponds to Performance Task 3.	



## Session II. Review and Testing

A. Review

B. Module Examination

1. Trainees must score 70 percent 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 the NCCER.
2. Record the training results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.

## **MODULE OVERVIEW**

This module introduces trainees to basic electrical theory and troubleshooting, using circuit calculations involving the application of Ohm's and Kirchhoff's laws.

## **PREREQUISITES**

Prior to training with this module, it is recommended that the trainee shall have successfully completed *Core Curriculum; Industrial Maintenance E & I Technician Level One*; and *Industrial Maintenance E & I Technician Level Two*, Modules 40201-08 and 40202-08.

## **OBJECTIVES**

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

1. Define voltage and identify the ways in which it can be produced.
2. Explain the difference between conductors and insulators.
3. Define the units of measurement that are used to measure the properties of electricity.
4. Identify the meters used to measure voltage, current, and resistance.
5. Explain the basic characteristics of series and parallel circuits.
6. Use Kirchhoff's current law to calculate the total and unknown currents in parallel and series-parallel circuits.
7. Use Kirchhoff's voltage law to calculate voltage drops in series, parallel, and series-parallel circuits.
8. Use the formula for Ohm's law to calculate voltage, current, and resistance.

## **PERFORMANCE TASKS**

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

1. Use the formula for Ohm's law to calculate voltage, current, and resistance.
2. Given different resistors, identify the correct resistance value and tolerance using the color code.
3. Use the power formula to calculate the amount of power used by a circuit.
4. Use a variation of the power formula to calculate the main current a resistor can carry based on the resistor's value and power rating.
5. Calculate the total resistance for selected series, parallel, and series-parallel circuits.
6. Use Kirchhoff's current law to calculate the total and unknown currents in parallel and series-parallel circuits.
7. Use Kirchhoff's voltage law to calculate voltage drops in series, parallel, and series-parallel circuits.

## **MATERIALS AND EQUIPMENT LIST**

Overhead projector and screen

Transparencies

Blank acetate sheets

Transparency pens

Whiteboard / chalkboard

Markers / chalk

Pencils and scratch paper

Multimeters, ammeters, voltmeters, and ohmmeters

Copy of the latest edition of the *National Electrical Code*<sup>®</sup>

Wire-wound and carbon composition electronic resistors

Trade Terms 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 work with electrical test equipment. Make sure that all trainees are briefed on appropriate safety procedures. Emphasize electrical safety.

## 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.

*Electronics Fundamentals: Circuits, Devices, and Applications*, Thomas L. Floyd. New York: Prentice Hall.

*Principles of Electric Circuits*, Thomas L. Floyd. New York: 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 15 hours are suggested to cover *Electrical Theory*. 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
<b>Session I. Introduction; Atomic Theory; Electrical Power Generation and Distribution; Electric Charge and Current</b>	
A. Introduction	_____
B. Atomic Theory	_____
1. The Atom	_____
2. Conductors and Insulators	_____
3. Magnetism	_____
C. Electrical Power Generation and Distribution	_____
D. Electric Charge and Current	_____
1. Current Flow	_____
2. Voltage	_____
3. Resistance	_____
<b>Session II. Ohm's Law; Schematic Representation of Circuit Elements; Resistors</b>	
A. Ohm's Law	_____
B. Laboratory	_____
Have the trainees practice using the formula for Ohm's law to calculate voltage, current, and resistance. This laboratory corresponds to Performance Task 1.	
C. Schematic Representation of Circuit Elements	_____
D. Laboratory	_____
Have the trainees practice drawing basic voltmeter and ohmmeter circuits and explain how they operate. This laboratory corresponds to Performance Task 3.	
E. Resistors	_____
F. Laboratory	_____
Have the trainees practice, given different resistors, identifying the correct resistance value and tolerance using the color code. This laboratory corresponds to Performance Task 2.	

### Session III. Electrical Circuits; Electrical Measuring Instruments; Electrical Power

- A. Electrical Circuits
  - 1. Series Circuits
  - 2. Parallel Circuits
  - 3. Series-Parallel Circuits
- B. Electrical Measuring Instruments
  - 1. Measuring Current
  - 2. Measuring Voltage
  - 3. Measuring Resistance
  - 4. Voltage Testers
- C. Electrical Power
  - 1. Power Equation
  - 2. Power Rating of Resistors
- D. Laboratory

Have the trainees practice using the power formula to calculate the amount of power used by a circuit. This laboratory corresponds to Performance Task 4.
- E. Laboratory

Have the trainees practice using a variation of the power formula to calculate the main current a resistor can carry based on the resistor's value and power rating. This laboratory corresponds to Performance Task 5.

### Sessions IV and V. DC Circuit Calculations

- A. DC Circuit Calculations
  - 1. Resistances in Series
  - 2. Resistances in Parallel
  - 3. Series-Parallel Circuits
- B. Laboratory

Have the trainees practice calculating the total resistance for selected series, parallel, and series-parallel circuits. This laboratory corresponds to Performance Task 6.
- C. Applying Ohm's Law
- D. Kirchhoff's Laws
- E. Laboratory

Have the trainees practice using Kirchhoff's current law to calculate the total and unknown currents in parallel and series-parallel circuits. This laboratory corresponds to Performance Task 7.
- F. Laboratory

Have the trainees practice using Kirchhoff's voltage law to calculate voltage drops in series, parallel, and series-parallel circuits. This laboratory corresponds to Performance Task 8.

### Session VI. Review and Testing

- A. Review
- B. Module Examination
  - 1. Trainees must score 70 percent 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 the NCCER.
  - 2. Record the training results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.

## **MODULE OVERVIEW**

This module introduces the principles of alternating current.

## **PREREQUISITES**

Prior to training with this module, it is recommended that the trainee shall have successfully completed *Core Curriculum; Industrial Maintenance E & I Technician Level One; and Industrial Maintenance E & I Technician Level Two*, Modules 40201-08 through 40203-08.

## **OBJECTIVES**

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

1. Calculate the peak and effective voltage or current values for an AC waveform.
2. Calculate the phase relationship between two AC waveforms.
3. Describe the voltage and current phase relationship in a resistive AC circuit.
4. Describe the voltage and current transients that occur in an inductive circuit.
5. Define inductive reactance and state how it is affected by frequency.
6. Describe the voltage and current transients that occur in a capacitive circuit.
7. Define capacitive reactance and state how it is affected by frequency.
8. Explain the relationship between voltage and current in the following types of AC circuits:
  - RL circuit
  - RC circuit
  - LC circuit
  - RLC circuit
9. Explain the following terms as they relate to AC circuits:
  - True power
  - Apparent power
  - Reactive power
  - Power factor
10. Explain basic transformer action.

## **PERFORMANCE TASKS**

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

1. Given the parameters of an inductive circuit with a low power factor, calculate the true and apparent power and identify methods that could be used to improve the efficiency of the circuit.
2. Solve for two values of a power triangle provided by your instructor.

## **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

Scientific calculator or trigonometric tables

Examples of capacitors

Trade Terms 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.

*Introduction to Electric Circuits*, Latest Edition, New York: Prentice Hall.

*Principles of Electric Circuits*, Latest Edition, New York: 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 20 hours are suggested to cover *Alternating Current*. 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
<b>Session I. Introduction; Sine Wave Generation; Sine Wave Terminology</b>	
A. Introduction	_____
B. Sine Wave Generation	_____
C. Sine Wave Terminology	_____
<b>Session II. AC Phase Relationships; Nonsinusoidal Waveforms</b>	
A. AC Phase Relationships	_____
B. Nonsinusoidal Waveforms	_____
<b>Session III. Resistance in AC Circuits; Inductance in AC Circuits</b>	
A. Resistance in AC Circuits	_____
B. Inductance in AC Circuits	_____
<b>Session IV. Capacitance</b>	
A. Capacitance	_____
1. Factors Affecting Capacitance	_____
2. Calculating Equivalent Capacitance	_____
3. Capacitor Specifications	_____
4. Voltage and Current in a Capacitive AC Circuit	_____
5. Capacitive Resistance	_____
<b>Sessions V and VI. LC and RLC Circuits; Power in AC Circuits</b>	
A. LC and RLC Circuits	_____
B. Power in AC Circuits	_____
C. Laboratory	_____
Given the parameters of an inductive circuit with a low power factor, have the trainees practice calculating the true and apparent power and identify methods that could be used to improve the efficiency of the circuit. This laboratory corresponds to Performance Task 1.	
D. Laboratory	_____
Have the trainees practice solving for two values of a power triangle provided by the instructor. This laboratory corresponds to Performance Task 2.	

**Session VII. Transformers**

A. Transformers

1. Transformer Construction
2. Operating Characteristics
3. Turns and Voltage Ratio
4. Types of Transformers

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**Session VIII. Review and Testing**

A. Review

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B. Module Examination

1. Trainees must score 70 percent 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.

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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.

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## **MODULE OVERVIEW**

This module covers the interpretation of electrical and instrumentation drawings. It also provides an overview of common drawing methods, notes, and symbols.

## **PREREQUISITES**

Prior to training with this module, it is recommended that the trainee shall have successfully completed *Core Curriculum; Industrial Maintenance E & I Technician Level One; Industrial Maintenance E & I Technician Level Two; and Industrial Maintenance E & I Technician Level Three, Modules 40301-09 and 40302-09.*

## **OBJECTIVES**

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

1. Identify common types of electrical and instrumentation diagrams and drawings.
2. Read and interpret electrical diagrams used in instrumentation work:
  - Wiring diagrams
  - Ladder diagrams
  - One-line diagrams
  - Motor controller diagrams
3. Read and interpret instrumentation diagrams:
  - P&ID diagrams
  - Loop diagrams
  - Raceway diagrams
4. Draw a loop diagram for a given instrumentation loop.

## **PERFORMANCE TASKS**

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

1. Trace the circuit flow on a one-line diagram.
2. Read and interpret an electrical raceway drawing.
3. Read and interpret a piping and instrumentation drawing (P&ID).
4. Read and interpret a loop sheet.
5. Interpret component symbols on an electronic schematic diagram.

## **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

Sample one-line diagrams, electrical raceway drawings, P&IDs, loop sheets, and electronic schematic diagrams

Module Examinations\*

Performance Profile Sheets\*

\*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 material for continued education rather than for task training.

*Instrumentation*, 1975. F.W. Kirk and N.R. Rimboi, American Technical Society.

*ANI/ISA-5.1, Instrumentation Symbols and Identification*, July 1992.

## 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 *E & I Drawings*. 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
<b>Session I. Introduction; Electrical Drawings</b>	
A. Introduction	_____
B. Electrical Drawings	_____
1. Block Diagrams	_____
2. Single- and Three-Line Diagrams	_____
a. Laboratory	_____
Have trainees trace the circuit flow on a one-line diagram. This laboratory corresponds to Performance Task 1.	
3. Wiring Diagrams	_____
4. Raceway Drawings	_____
a. Laboratory	_____
Have trainees read and interpret a raceway drawing.	
5. Schematic Diagrams	_____
<b>Session II. Instrumentation Drawings I</b>	
A. Piping and Instrumentation Drawings	_____
1. Laboratory	_____
Have trainees read and interpret P&IDs. This laboratory corresponds to Performance Task 2.	
B. Loop Sheets	_____
<b>Session III. Instrumentation Drawings II</b>	
A. Logic/Ladder Diagrams	_____
B. Equipment Location Drawings	_____
C. Installation Detail Drawings	_____
D. Flow Drawings	_____
E. Instrument Data Sheets	_____

## Session IV. Standardized Design Methods; Review and Testing

A. Standardized Design Methods

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B. Electrical Symbols

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1. Laboratory

Have trainees read and interpret symbols on an electronic schematic diagram. Note the proficiency of each trainee. This laboratory corresponds to Performance Task 5.

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C. Instrumentation Symbols

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D. Module Review

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E. Module Examination

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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.

F. Performance Testing

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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 the use of various test instruments for testing and performing troubleshooting on electrical equipment.

## **PREREQUISITES**

Prior to training with this module, it is recommended that the trainee shall have successfully completed *Core Curriculum; Industrial Maintenance E & I Technician Level One; and Industrial Maintenance E & I Technician Level Two*, Modules 40201-08 through 40204-08.

## **OBJECTIVES**

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

1. Identify and explain the purposes of test instruments commonly used to test and troubleshoot E & I equipment.
2. Explain how to read and convert from one scale to another using the above test equipment.
3. Explain the importance of proper meter polarity.
4. Define frequency and explain the use of a frequency meter.
5. Explain the difference between digital and analog meters.

## **PERFORMANCE TASKS**

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

1. Under instructor supervision, measure the voltage in your classroom (hot to neutral and neutral to ground).
2. Under instructor supervision, use an ohmmeter to measure the values of various resistors.
3. Use a continuity tester to verify whether a lamp is burned out.
4. Using a pressure source, measure pressure with the appropriate device.
5. Use a field communicator.
6. Use a manometer or a deadweight tester.

## **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 the latest edition of the *National Electrical Code*<sup>®</sup>

Samples of the following test equipment:

Voltmeter

Ohmmeter

Ammeter

Voltage tester

Volt-ohm-milliammeter (VOM)

Megohmmeter

Motor rotation tester

Phase rotation tester

Handheld HART<sup>®</sup> communicator

Fluke<sup>®</sup> 725 (or other) multifunction process calibrator

Fluke<sup>®</sup> 744 documenting process calibrator

Fluke<sup>®</sup> 789 ProcessMeter<sup>™</sup>

Various process control test and calibration meters

Manometers (U-tube, well, inclined, and electronic)

Deadweight tester

Module Examinations\*

Performance Profile Sheets\*

\* 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.

*ABCs of Multimeter Safety*, Everett, WA: Fluke Corporation.

*ABCs of DMMs Multimeter Features and Functions Explained*, Everett, WA: Fluke Corporation.

*Clamp Meter ABCs*, Everett, WA: Fluke Corporation.

*Electronics Fundamentals: Circuits, Devices, and Applications*, Thomas L. Floyd. New York: Prentice Hall.

*Power Quality Analyzer Uses for Electricians*, Everett, WA: Fluke Corporation.

*Principles of Electric Circuits*, Thomas L. Floyd. New York: 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 10 hours are suggested to cover *E & I Test 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
<b>Session I. Introduction; Electrical Meters</b>	
A. Introduction	_____
B. Electrical Meters	_____
1. Voltmeter	_____
2. Ohmmeter	_____
3. Ammeter	_____
4. Multimeter	_____
5. Megohmmeter	_____
6. Motor and Phase Rotation Testers	_____
7. Recording Instruments	_____
C. Laboratory	_____
Under instructor supervision, have the trainees practice measuring the voltage in your classroom (hot to neutral and neutral to ground). This laboratory corresponds to Performance Task 1.	
D. Laboratory	_____
Under instructor supervision, have the trainees practice using an ohmmeter to measure the values of various resistors. This laboratory corresponds to Performance Task 2.	

**Session II. Electrical Category Ratings; Electrical Safety; Calibration**

- A. Electrical Category Ratings
- B. Electrical Safety
- C. Calibration
- D. Laboratory

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Have the trainees practice using a continuity tester to verify whether a lamp is burned out. This laboratory corresponds to Performance Task 3.

- E. Laboratory

Using a pressure source, have the trainees practice measuring pressure with the appropriate device. This laboratory corresponds to Performance Task 4.

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**Session III. Instrumentation Test Equipment**

- A. Instrumentation Test Equipment
  - 1. HART® Communication and Communicator
  - 2. Process Calibrators
  - 3. Fluke 789 ProcessMeter™
  - 4. Manometer
  - 5. Deadweight Tester
- B. Laboratory

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Have the trainees practice using a field communicator. This laboratory corresponds to Performance Task 5.

- C. Laboratory

Have the trainees practice using a manometer or a deadweight tester. This laboratory corresponds to Performance Task 6.

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**Session IV. Review and Testing**

- A. Review
- B. Module Examination
  - 1. Trainees must score 70 percent 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 the NCCER.
  - 2. Record the training results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.

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## **MODULE OVERVIEW**

This module provides information for selecting and installing conductors and cables, including how to pull conductors through conduit runs.

## **PREREQUISITES**

Prior to training with this module, it is recommended that the trainee shall have successfully completed *Core Curriculum; Industrial Maintenance E & I Technician Level One*; and *Industrial Maintenance E & I Technician Level Two*, Modules 40201-08 through 40211-08.

## **OBJECTIVES**

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

1. From the cable markings, describe the insulation and jacket material, conductor size and type, number of conductors, temperature rating, voltage rating, and permitted uses.
2. Determine the allowable ampacity of a conductor for a given application.
3. Identify the *NEC*<sup>®</sup> requirements for color coding of conductors.
4. Install conductors in a raceway system.

## **PERFORMANCE TASKS**

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

1. Install conductors in a raceway 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

Copy of the latest edition of the *National Electrical Code*<sup>®</sup>

Aluminum conductors

Copper conductors

Samples of thermoplastic insulation materials, including:

Polyvinyl chloride (PVC)

Polyethylene (PE)

Cross-linked polyethylene (XLP)

Nylon

Teflon<sup>®</sup>

Color-coded wires

Samples of various types of cable, including:

NM

NMC

UF

NMS

MV

MC

AC

FC

FCC

TC

SE

USE

Shields for instrumentation control wiring

Shield drain

Jackets

Fish tape

Rodder

Wire grips

Module Examinations\*

Performance Profile Sheets\*

\* 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 work is suggested for both instructors and motivated trainees interested in further study. This is optional material for continued education rather than for task training.

*National Electrical Code® Handbook*, Latest Edition. Quincy, MA: National Fire Protection 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 10 hours are suggested to cover *Conductors and Cables*. 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
<b>Session I. Introduction; Conductors and Insulation</b>	
A. Introduction	_____
B. Conductors and Insulation	_____
1. Wire Size	_____
2. Ampacity	_____
3. Conductor Material	_____
4. Conductor Insulation	_____
<b>Session II. Conductors and Insulation (continued)</b>	
A. Conductors and Insulation	_____
1. Fixture Wires	_____
2. Cables	_____
3. Instrumentation Control Wiring	_____
<b>Session III. Installing Conductors in Conduit Systems</b>	
A. Installing Conductors in Conduit Systems	_____
1. Fish Tape	_____
2. Wire Grips	_____
3. Pull Lines	_____
4. Safety Precautions	_____
5. Pulling Equipment	_____
6. Feeding Conductors into Conduit	_____
7. Conductor Lubrication	_____
8. Conductor Termination	_____
B. Laboratory	_____
Have the trainees practice installing conductors in a raceway system. This laboratory corresponds to Performance Task 1.	

**Session IV. Review and Testing**

A. Review

B. Module Examination

1. Trainees must score 70 percent 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 the NCCER.
2. Record the training results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.

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## **MODULE OVERVIEW**

This module introduces the methods and procedures for making conductor terminations and splices.

## **PREREQUISITES**

Prior to training with this module, it is recommended that the trainee shall have successfully completed *Core Curriculum; Industrial Maintenance E & I Technician Level One*; and *Industrial Maintenance E & I Technician Level Two*, Modules 40201-08 through 40212-08.

## **OBJECTIVES**

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

1. Describe how to make a sound conductor termination.
2. Prepare cable ends for terminations and splices and connect the ends using lugs or connectors.
3. Train cable at termination points.
4. Describe the *National Electrical Code*<sup>®</sup> (NEC<sup>®</sup>) requirements for making cable terminations and splices.
5. Demonstrate crimping techniques.
6. Select the proper lug or connector for the job.

## **PERFORMANCE TASKS**

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

1. Terminate conductors using selected crimp-type and mechanical-type terminals and connectors.
2. Terminate conductors on a terminal strip.
3. Insulate selected types of wire splices and/or install a motor connection kit.

## **MATERIALS AND EQUIPMENT LIST**

Overhead projector and screen	Heat-shrink insulators
Transparencies	Heat gun for shrink insulators
Blank acetate sheets	Assorted sizes and types of wire nuts
Transparency pens	Hand crimping tools and dies
Whiteboard/chalkboard	Hydraulic crimping tools and dies
Markers/chalk	Metal-clad cable
Pencils and scratch paper	Type MC cable connectors
Prism	Ratchet cable bender
Copy of the latest edition of the <i>National Electrical Code</i> <sup>®</sup>	Heat-shrink and roll-on insulating tapes
Wire strippers	Propane torch
Power cable strippers	Torque wrenches
Assorted sizes of wire/cables and connectors	Multimeter
Assorted sizes and types of crimp connectors	Test circuit
Assorted sizes and types of mechanical compression connectors	Trade Terms 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 requires that trainees terminate cable. Make sure that all trainees are briefed on appropriate safety procedures. Emphasize electrical safety. This module may require that trainees visit job sites. Ensure all trainees are properly briefed on site safety.

## ADDITIONAL RESOURCES

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

*National Electrical Code® Handbook*, Latest Edition. Quincy, MA: National Fire Protection 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 10 hours are suggested to cover *Conductor Terminations and Splices*. 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
<b>Session I. Introduction; Stripping and Cleaning Conductors; Wire Connections Under 600 Volts</b>	
A. Introduction	_____
B. Stripping and Cleaning Conductors	_____
C. Wire Connections under 600V	_____
D. Laboratory	_____
Have the trainees practice stripping insulation from the end of a cable.	
<b>Session II. Control and Signal Cable; Low-Voltage Connectors and Terminals; Guidelines for Installing Connectors</b>	
A. Control and Signal Cable	_____
B. Low-Voltage Connectors and Terminals	_____
C. Guidelines for Installing Connectors	_____
D. Laboratory	_____
Have the trainees practice terminating conductors on a terminal strip. This laboratory corresponds to Performance Task 2.	
<b>Session III. Bending Cable and Training Conductors; NEC® Termination Requirements; Taping Electrical Joints; Motor Connection Kits</b>	
A. Bending Cable and Training Conductors	_____
B. NEC® Termination Requirements	_____
C. Taping Electrical Joints	_____
D. Motor Connection Kits	_____
E. Laboratory	_____
Have the trainees practice terminating conductors using selected crimp-type and mechanical-type terminals and connectors. This laboratory corresponds to Performance Task 1.	
F. Laboratory	_____
Have the trainees practice insulating selected types of wire splices and/or install a motor connection kit. This laboratory corresponds to Performance Task 3.	

## Session IV. Review and Testing

### A. Review

### B. Module Examination

1. Trainees must score 70 percent 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 introduces the trainee to the methods and procedures used in selecting and wiring motor controls.

## **PREREQUISITES**

Prior to training with this module, it is recommended that the trainee shall have successfully completed *Core Curriculum; Industrial Maintenance E & I Technician Level One; Industrial Maintenance E & I Technician Level Two; and Industrial Maintenance E & I Technician Level Three*, Modules 40301-09 through 40303-09.

## **OBJECTIVES**

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

1. Identify contactors and relays both physically and schematically and describe their operating principles.
2. Identify pilot devices both physically and schematically and describe their operating principles.
3. Interpret motor control wiring, connection, and ladder diagrams.
4. Select and size contactors and relays for use in specific electrical motor control systems.
5. Select and size pilot devices for use in specific electrical motor control systems.
6. Connect motor controllers for specific applications according to *National Electrical Code® (NEC®)* requirements.

## **PERFORMANCE TASK**

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

1. Make all connections for a magnetic motor controller controlled by two pushbutton stations, including the connections for the holding circuit interlock.
2. Disassemble, inspect, and reassemble a motor starter.

## **MATERIALS AND EQUIPMENT LIST**

Overhead projector and screen	Assorted manufacturer's motor control device catalogs/data sheets
Transparencies	Examples of wiring diagrams
Markers/chalk	Examples of circuit schedules/wire lists
Blank acetate sheets	Examples of control ladder diagrams
Transparency pens	Examples of logic diagrams
Pencils and scratch paper	Open-frame electromechanical power relays
Overhead projector and screen	Miniature electromechanical plug-in relays
Whiteboard/chalkboard	Assorted NEMA and IEC magnetic and manual contactors and motor starters
Appropriate personal protective equipment	Melting-alloy thermal overload relays
Copy of the latest edition of the <i>National Electrical Code®</i>	Bimetallic overload relays
Assorted wire and connectors necessary for making control circuit wiring connections	Magnetic overload relays

*continued*

Contactors/motor starter accessories including:

- Power-pole adder kit
- Timer attachment
- Fuse kit
- Transient suppression module
- Internal auxiliary contacts
- Control transformers
- Pushbutton switches
- Push-pull pushbutton switches
- Selector switches
- Pilot lights
- Assorted pushbutton stations
- Temperature switches
- Pressure switches

- Mechanical limit switches
- Flow switches
- Float switches
- Foot switches
- Jogging and plugging switches
- Inductive and capacitive proximity sensors
- Photoelectric switches/sensors
- Drum switches
- Assorted NEMA enclosures
- 240V motor
- Tools necessary for making wiring connections
- Module Examinations\*
- Performance Profile Sheets\*

\*Located in the Test Booklet

## SAFETY CONSIDERATIONS

Ensure that the trainees are equipped with appropriate personal protective equipment. This module requires trainees to work with motor controls. Brief the trainees on the proper safety procedures for working with motor controls.

## 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.

*Electrical Motor Controls*, Gary Rockis and Glen Mazur. Homewood, IL: American Technical Publishers, Inc., 1997.

*National Electrical Code® Handbook*, Latest Edition. Quincy, MA: National Fire Protection Association.

*NFPA 70E Recommended Practice for Electrical Equipment Maintenance*. Quincy, MA: National Fire Protection Association, 2004.

## NOTE

*NFPA 70®*, *National Electrical Code®*, and *NEC®* are registered trademarks of the National Fire Protection Association, Inc., Quincy, MA 02269. All *National Electrical Code®* and *NEC®* references in this module refer to the 2008 edition of the *National Electrical Code®*.

## 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 *Motor Controls*. 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, Electromechanical Relays; Magnetic Contactors; Overload Protection

A. Introduction

\_\_\_\_\_

B. Electromechanical Relays

\_\_\_\_\_

C. Magnetic Contactors

\_\_\_\_\_

D. Overload Protection

\_\_\_\_\_

**Session II. Magnetic and Manual Motor Starters; Control Transformers and Pilot Devices**

A. Magnetic and Manual Motor Starters

- 1. Nonreversing and Reversing Magnetic Motor Starters
- 2. NEMA Magnetic Contactors/Motor Starters
- 3. IEC Magnetic Contactors/Motor Starters
- 4. Manual Motor Starters
- 5. Accessories

B. Control Transformers and Pilot Devices

- 1. Pushbutton and Selector Switches; Pilot Devices
- 2. Temperature and Pressure Switches
- 3. Mechanical Limit Switches
- 4. Flow, Float, and Foot Switches
- 5. Jogging and Plugging Switches
- 6. Proximity and Photoelectric Switches/Sensors

C. Laboratory

Under your supervision, have the trainees disassemble, inspect, and reassemble a motor starter. This laboratory corresponds to Performance Task 2.

**Session III. Drum Switches; Enclosures; Diagrams**

A. Drum Switches

B. Enclosures

C. Diagrams

- 1. Relating Diagrams to Equipment Wiring and Operation

**Session IV. NEC® Regulations for the Installation of Motor Control Circuits and Connecting Motor Controllers for Specific Applications**

A. NEC® Regulations for the Installation of Motor Control Circuits

B. Connecting Motor Controllers for Specific Applications

**Session V. Motor Controller Laboratory**

A. Laboratory

Under your supervision, have the trainees make all connections for a magnetic motor controller controlled by two pushbutton stations, including the connections for the holding circuit interlock. This laboratory corresponds with Performance Task 1.

**Session VI. 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.

C. Performance Testing

- 1. Trainees must perform each task to the satisfaction of the instructor 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.

## **MODULE OVERVIEW**

This module introduces the trainee to the basics of hydraulics and hydraulic system safety. It covers system components and methods of inspecting and troubleshooting hydraulic systems.

## **PREREQUISITES**

Prior to training with this module, it is recommended that the trainee shall have successfully completed *Core Curriculum; Industrial Maintenance E & I Technician Level One; Industrial Maintenance E & I Technician Level Two; and Industrial Maintenance E & I Technician Level Three, Modules 40301-09 through 40310-09.*

## **OBJECTIVES**

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

1. Explain hydraulic system safety.
2. Explain the principles of hydraulics.
3. Identify hydraulic devices and symbols and explain their functions.
4. Explain a hydraulic system in a process application.

## **PERFORMANCE TASKS**

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

1. Repair a solenoid valve.
2. Bleed down a system.
3. Clean and inspect a pressure regulator.

## **MATERIALS AND EQUIPMENT LIST**

Overhead projector and screen	New and used hydraulic components, including:
Transparencies	Filters
Blank acetate sheets	Strainers
Transparency pens	Regulators
Whiteboard/chalkboard	Pumps
Markers/chalk	Accumulators
Pencils and scratch paper	Hoses
Appropriate personal protective equipment	Fittings and quick disconnects
Full face shields	Control valves
An operational hydraulic system with actuators	Cylinders
Applicable tools to remove, work on, and replace hydraulic system components	Motors
Samples of simple and complex hydraulic system drawings	Solenoid valves
Samples of hydraulic fluids with matching MSDSs	Pressure regulators
	Vendor manuals on both a hydraulic system and hydraulic components such as pumps and actuators
	Module Examinations*
	Performance Profile Sheets*

\* 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. Ensure that trainees are briefed on shop safety procedures. Emphasize any special safety precautions associated with working on or near hydraulic fluids and system components. Stress the fact that hydraulic fluid and components become very hot in operation. In addition, hydraulic fluid is usually under very high pressures; lines may rupture, and line connectors and component seals may leak. Warn trainees of high-pressure leaks, especially when the fluid is hot.

## 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 are for continued education rather than for task training.

*Industrial Fluid Power*, Womack and Hedges, Womack Educational Publications;  
Dallas, TX 75235, 2005, for training materials.  
[www.womack-machine.com](http://www.womack-machine.com)

*Industrial Hydraulic Technology*, Second Edition, Bulletin 0232-B1, Parker Hannifin Corporation;  
Cleveland, OH 44124, 1997.

Parker Hannifin Corporation, for training materials, products, and product information  
(literature, specifications, drawings)  
[www.parker.com](http://www.parker.com)

Hydraulic Fittings Company, for products and job aides.  
[www.discounthydraulicchase.com](http://www.discounthydraulicchase.com)

Viking Pump, Inc., for products and product information (literature, specifications, drawings)  
[www.vikingpump.com](http://www.vikingpump.com)

Bosch Rexroth Corporation, for training materials, products, and product information (literature,  
specifications, drawings)  
[www.boschrexroth-us.com](http://www.boschrexroth-us.com)

Eaton Hydraulics, for training materials, products, and product information (literature, specifications,  
drawings) [http://hydraulics.eaton.com/products/menu\\_main.htm](http://hydraulics.eaton.com/products/menu_main.htm)

Hosecraft USA, for products and product information (literature, specifications, drawings)  
[www.hosecraftusa.com](http://www.hosecraftusa.com)

## 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 *Hydraulic Controls*. You will need to adjust the time required for 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	Time
<b>Session I. Introduction; Hydraulic System Safety; Principles of Hydraulics; Hydraulic Fluids</b>	
A. Introduction	_____
B. Hydraulic System Safety	_____
C. Principles of Hydraulics	_____
1. Fluid Power	_____
a. Laboratory	_____
Have trainees practice calculating the area of pistons inside of cylinders with different diameters.	
D. Hydraulic Fluids	_____



**Session II. Hydraulic System Parts**

- A. Strainers and Filters
- B. Reservoirs
- C. Accumulators
- D. Piping, Tubing, and Fittings
- E. Directional-Control Valves
- F. Pressure-Control Valves
- G. Cylinders
- H. Hydraulic Pumps
- I. Hydraulic Motors

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**Session III. Inspecting and Troubleshooting Hydraulic System Components**

- A. Inspecting Hydraulic System Components
- B. Troubleshooting Hydraulic System Components
  - 1. Reading Hydraulic Schematic Diagrams
  - 2. Troubleshooting Hydraulic Systems

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**Session IV. Removing, Replacing, and Repairing Hydraulic System Components; Applications**

- A. Preparing Systems for Shutdown and Repair
- B. Removing and Replacing Directional Control Valve Solenoids
- C. Applications

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**Session V. Laboratory**

- A. Laboratory  
Have trainees practice repairing solenoid valves, bleeding down a system, and cleaning and inspecting a pressure regulator. This laboratory corresponds to Performance Tasks 1, 2, and 3.

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**Session VI. 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.
- 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.

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## **MODULE OVERVIEW**

This module covers the basics of pneumatic (compressed air) systems and components. It includes information on pneumatic system safety and ways to treat compressed air. Methods for inspecting and troubleshooting pneumatic systems are also discussed.

## **PREREQUISITES**

Prior to training with this module, it is recommended that the trainee shall have successfully completed *Core Curriculum; Industrial Maintenance E & I Technician Level One; Industrial Maintenance E & I Technician Level Two; and Industrial Maintenance E & I Technician Level Three, Modules 40301-09 through 40311-09.*

## **OBJECTIVES**

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

1. Explain pneumatic system safety.
2. Explain the physical characteristics of gases.
3. Explain compressing gases.
4. Explain the pneumatic transmission of energy.
5. Explain the principles of compressor operation.
6. Identify and explain types of compressors.
7. Explain compressed-air treatment.
8. Identify and explain pneumatic system components and symbols.

## **PERFORMANCE TASKS**

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

## **MATERIALS AND EQUIPMENT LIST**

Overhead projector and screen	New and used pneumatic system components, including:
Transparencies	Compressor
Blank acetate sheets	Filters
Transparency pens	Regulators
Whiteboard/chalkboard	Hoses
Markers/chalk	Fittings and quick disconnects
Pencils and scratch paper	Control valves
Appropriate personal protective equipment	Cylinders
Full-face shields	Motors
Portable air tank	Solenoid valves
An operational pneumatic system with actuators	Pressure regulators
Samples of simple and complex pneumatic system drawings	Applicable tools to remove, work on, and replace pneumatic system components
Vendor manuals on compressed air components and systems	Module Examinations*

\* 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. Ensure that trainees are briefed on shop safety procedures. Emphasize any special safety precautions associated with working on or near pneumatic system components. Stress the fact that pneumatic system components can become very hot and that compressed air can penetrate human skin.

## **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.

*Industrial Fluid Power, Vol. 1, 2, and 3*, 2005. Womack and Hedges. Dallas, TX:  
Womack Educational Publications (for training materials)  
[www.womack-machine.com](http://www.womack-machine.com)

*Industrial Pneumatic Technology, Bulletin 0275-B1*. 1980. Cleveland, OH: Parker Hannifin Corporation.  
Parker Hannifin Corporation, for training materials, products, and product information  
(literature, specifications, drawings)  
[www.parker.com](http://www.parker.com)

SULLAIR Corporation, for training materials, products, and product information  
(literature, specifications, drawings)  
[www.sullair.com](http://www.sullair.com)

MFD Pneumatics, for pneumatic products and product information  
(literature, specifications, drawings)  
[www.mfdpneumatics.com](http://www.mfdpneumatics.com)

Quincy Compressor, for training materials, products, and product information  
(literature, specifications, drawings)  
[www.quincycompressor.com](http://www.quincycompressor.com)

Ingersoll-Rand Company, for hydraulic and pneumatic products and product information  
(literature, specifications, drawings)  
[www.fluids.ingersollrand.com](http://www.fluids.ingersollrand.com)

## 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 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 *Pneumatic Controls*. You will need to adjust the time required for testing based on your class size and resources.

Topic	Planned Time
<b>Session I. Introduction; Pneumatic System Safety; Characteristics of Gases; Effects of Atmospheric Pressure; Compressing Gases; Transmission of Energy; Compressor Operation and Types</b>	
A. Introduction	_____
B. Pneumatic System Safety	_____
C. Physical Characteristics of Gases	_____
D. Effects of Atmospheric Pressure	_____
E. Compressing Gases	_____
1. Intermittent-Flow Class	_____
2. Continuous-Flow Class	_____
F. Pneumatic Transmission of Energy	_____
G. Compressor Operation and Types	_____
1. Compressor Basics	_____
2. Positive-Displacement Compressors	_____
3. Continuous-Flow Compressors	_____
4. Compressor Controls	_____
<b>Session II. Treatment of Compressed Air</b>	
A. Intake Filters	_____
B. Intercoolers and Aftercoolers	_____
C. Oil and Water Separators	_____
D. Chemical Dryers	_____
E. Receivers	_____
F. In-line Filters	_____
G. Pressure Regulators	_____
H. Lubricators and Filter-Regulator-Lubricators	_____
I. Air Treatment Controls	_____
<b>Session III. Pneumatic System Components; Troubleshooting Pneumatic Systems</b>	
A. Valves	_____
B. Actuators	_____
C. Mufflers	_____
D. Pneumatic Symbols	_____
1. Laboratory	_____
Have trainees draw simple pneumatic circuits using pneumatic symbols.	
E. Troubleshooting Pneumatic Systems	_____

**Session IV and V. Laboratory**

A. Laboratory

Have trainees practice identifying components; checking compressor motor current; inspecting, cleaning, and adjusting pneumatic pressure regulators; adjusting system components to change actuator actions; and troubleshooting a pneumatic system with at least two malfunctions.

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**Session VI. 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.

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## **MODULE OVERVIEW**

This module provides information on the operating principles, uses, and programming methods for PLCs used in industrial environments.

## **PREREQUISITES**

Prior to training with this module, it is recommended that the trainee shall have successfully completed *Core Curriculum; Industrial Maintenance E & I Technician Level One; Industrial Maintenance E & I Technician Level Two; Industrial Maintenance E & I Technician Level Three; and Industrial Maintenance E & I Technician Level Four*, Modules 40401-09 through 40408-09.

## **OBJECTIVES**

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

1. Describe the function and purpose of a programmable logic controller (PLC).
2. Compare hardwired and PLC systems.
3. Explain number systems.
4. Explain the general function of an input/output (I/O) module, including the following types:
  - Discrete
  - Numerical and analog data
  - Special
  - Remote
5. Explain the power supply and ground connections to I/O modules.
6. Explain PLC architecture.
7. Explain the purpose of PLC software and firmware.
8. Describe the features and the differences between PLC programming languages.
9. Describe the features of relay ladder logic instruction categories.
10. Explain the principles used to correlate PLC hardware components to software instructions.

## **PERFORMANCE TASKS**

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

1. Locate the specific I/O point associated with a given software address.
2. Connect to a PLC and turn on an output device.

## **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

Ladder diagrams

Functional diagrams

An operating PLC-controlled system or simulator

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 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

*Process Control Instrumentation Technology*, 2007. Curtis D. Johnson. New York, NY: Prentice Hall.

*Programmable Logic Controllers*, 2/E, 2008. James A Rehg, Glenn J. Sartori. New York, NY: Prentice Hall.

*Fundamentals of Programmable Logic Controllers, Sensors, and Communications*, 3/E, 2004. Jon Stenerson. New York, NY: 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 17½ hours are suggested to cover *Programmable Logic Controllers*. 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
<b>Session I. Introduction; PLC Architecture; Number Systems Review</b>	
A. Introduction	_____
B. PLC Architecture	_____
1. Hardwired and PLC Systems	_____
2. Comparison of Hardwired and PLC Systems	_____
C. Number Systems Review	_____
1. Binary Numbers	_____
2. Octal	_____
3. Hexadecimal	_____
4. Binary Codes	_____
<b>Session II. PLC Hardware; Processor Modules; Software; Hardware to Program Correlation; Installation</b>	
A. PLC Hardware	_____
1. Power Supplies and Grounds	_____
2. Addressing Modules	_____
3. Input/Output Modules	_____
B. Processor Modules	_____
1. Scans	_____
2. PLC Memory	_____
C. Software	_____
1. Ladder Logic	_____
2. Boolean	_____
3. English Statement	_____
4. Functional Block	_____
5. Machine Stage	_____

D. Hardware to Program Correlation \_\_\_\_\_

E. Guidelines for Programming and Installation \_\_\_\_\_

1. Programming \_\_\_\_\_

2. Installation \_\_\_\_\_

3. I/O Wiring \_\_\_\_\_

4. Dynamic System Checkout \_\_\_\_\_

**Sessions III–VI. PLC Testing, Installation, and Programming Laboratory**

A. Laboratory \_\_\_\_\_

Have trainees practice locating a specific I/O point associated with a given software address. This laboratory corresponds with Performance Task 1.

B. Laboratory \_\_\_\_\_

Have trainees practice connecting to a PLC to turn on an output device. This laboratory corresponds with Performance Task 2.

**Session VII. 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.

C. Performance Testing \_\_\_\_\_

1. Trainees must perform each task to the satisfaction of the instructor to receive recognition from the NCCER.

2. Record the training results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.