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®*
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**
Session I. Introduction; Electrical Shock; Reducing the Risk of Electrical Shock	
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. *NFPA 70E*	_____
D. Laboratory	_____
Have the trainees practice performing a visual inspection and an air test on rubber gloves. This laboratory corresponds to Performance Task 1.	
Session II. Energy Control	
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 _____

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 _____

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.

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.

Managing Electrical Hazards
Annotated Instructor's Guide

Module 26501-09

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.

Topic	**Planned Time**
Session I. Introduction to Electrical Hazards; Electrical Equipment; Getting Started With *NFPA 70E®*	
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	_____
Session II. Employer/Employee Responsibilities; Electrical Incidents and Prevention	
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.

Introduction to the *National Electrical Code®* Annotated Instructor's Guide

Module 40202-08

MODULE OVERVIEW

This module provides an introduction to the *National Electrical Code®*.

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®* (*NEC®*).
2. Describe the layout of the *NEC®*.
3. Explain how to navigate the *NEC®*.
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®*.
2. Look up the *NEC®* 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®*

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**

Session I. Introduction to the *NEC®*; Purpose and History of the *NEC®*; The Layout of the *NEC®*; Navigating the *NEC®*; Other Organizations

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 *feeder* 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®*

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**
Session I. Introduction; Atomic Theory; Electrical Power Generation and Distribution; Electric Charge and Current	
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	_____
Session II. Ohm's Law; Schematic Representation of Circuit Elements; Resistors	
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.

Alternating Current
Annotated Instructor's Guide

Module 40204-08

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**
Session I. Introduction; Sine Wave Generation; Sine Wave Terminology	
A. Introduction	_____
B. Sine Wave Generation	_____
C. Sine Wave Terminology	_____
Session II. AC Phase Relationships; Nonsinusoidal Waveforms	
A. AC Phase Relationships	_____
B. Nonsinusoidal Waveforms	_____
Session III. Resistance in AC Circuits; Inductance in AC Circuits	
A. Resistance in AC Circuits	_____
B. Inductance in AC Circuits	_____
Session IV. Capacitance	
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	_____
Sessions V and VI. LC and RLC Circuits; Power in AC Circuits	
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 _____

Session VIII. 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 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**
Session I. Introduction; Electrical Drawings	
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	_____
Session II. Instrumentation Drawings I	
A. Piping and Instrumentation Drawings	_____
1. Laboratory Have trainees read and interpret P&IDs. This laboratory corresponds to Performance Task 2.	_____
B. Loop Sheets	_____
Session III. Instrumentation Drawings II	
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 _____

B. Electrical Symbols _____

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.

C. Instrumentation Symbols _____

D. Module 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.

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 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®*

Samples of the following test equipment:

- Voltmeter
- Ohmmeter
- Ammeter
- Voltage tester
- Volt-ohm-milliammeter (VOM)
- Megohmmeter
- Motor rotation tester
- Phase rotation tester
- Handheld HART® communicator
- Fluke® 725 (or other) multifunction process calibrator
- Fluke® 744 documenting process calibrator
- Fluke® 789 ProcessMeter™
- 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**
Session I. Introduction; Electrical Meters	
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 _____

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.

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 _____

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.

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.

Conductors and Cables
Annotated Instructor's Guide

Module 40212-08

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*® 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*®

Aluminum conductors

Copper conductors

Samples of thermoplastic insulation materials, including:
- Polyvinyl chloride (PVC)
- Polyethylene (PE)
- Cross-linked polyethylene (XLP)
- Nylon
- Teflon®

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**

Session I. Introduction; Conductors and Insulation

A. Introduction _____
B. Conductors and Insulation _____
   1. Wire Size _____
   2. Ampacity _____
   3. Conductor Material _____
   4. Conductor Insulation _____

Session II. Conductors and Insulation (continued)

A. Conductors and Insulation _____
   1. Fixture Wires _____
   2. Cables _____
   3. Instrumentation Control Wiring _____

Session III. Installing Conductors in Conduit Systems

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.

Conductor Terminations and Splices
Annotated Instructor's Guide

Module 40213-08

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*® (*NEC*®) 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
Transparencies
Blank acetate sheets
Transparency pens
Whiteboard/chalkboard
Markers/chalk
Pencils and scratch paper
Prism
Copy of the latest edition of the *National Electrical Code*®
Wire strippers
Power cable strippers
Assorted sizes of wire/cables and connectors
Assorted sizes and types of crimp connectors
Assorted sizes and types of mechanical compression connectors
Heat-shrink insulators
Heat gun for shrink insulators
Assorted sizes and types of wire nuts
Hand crimping tools and dies
Hydraulic crimping tools and dies
Metal-clad cable
Type MC cable connectors
Ratchet cable bender
Heat-shrink and roll-on insulating tapes
Propane torch
Torque wrenches
Multimeter
Test circuit
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**

Session I. Introduction; Stripping and Cleaning Conductors; Wire Connections Under 600 Volts

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.

Session II. Control and Signal Cable; Low-Voltage Connectors and Terminals; Guidelines for Installing Connectors

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.

Session III. Bending Cable and Training Conductors; *NEC*® Termination Requirements; Taping Electrical Joints; Motor Connection Kits

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

Transparencies

Markers/chalk

Blank acetate sheets

Transparency pens

Pencils and scratch paper

Overhead projector and screen

Whiteboard/chalkboard

Appropriate personal protective equipment

Copy of the latest edition of the *National Electrical Code®*

Assorted wire and connectors necessary for making control circuit wiring connections

Assorted manufacturer's motor control device catalogs/data sheets

Examples of wiring diagrams

Examples of circuit schedules/wire lists

Examples of control ladder diagrams

Examples of logic diagrams

Open-frame electromechanical power relays

Miniature electromechanical plug-in relays

Assorted NEMA and IEC magnetic and manual contactors and motor starters

Melting-alloy thermal overload relays

Bimetallic overload relays

Magnetic overload relays

continued

Contactor/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 dissemble, 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.

Hydraulic Controls
Annotated Instructor's Guide

Module 40311-09

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

Transparencies

Blank acetate sheets

Transparency pens

Whiteboard/chalkboard

Markers/chalk

Pencils and scratch paper

Appropriate personal protective equipment

Full face shields

An operational hydraulic system with actuators

Applicable tools to remove, work on, and replace hydraulic system components

Samples of simple and complex hydraulic system drawings

Samples of hydraulic fluids with matching MSDSs

New and used hydraulic components, including:
- Filters
- Strainers
- Regulators
- Pumps
- Accumulators
- Hoses
- Fittings and quick disconnects
- Control valves
- Cylinders
- Motors

Solenoid valves

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

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

Hydraulic Fittings Company, for products and job aides.
www.discounthydraulichose.com

Viking Pump, Inc., for products and product information (literature, specifications, drawings)
www.vikingpump.com

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

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

Hosecraft USA, for products and product information (literature, specifications, drawings)
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**

Session I. Introduction; Hydraulic System Safety; Principles of Hydraulics; Hydraulic Fluids

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 _____

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 _____

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 _____

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.

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.

Pneumatic Controls
Annotated Instructor's Guide

Module 40312-09

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

Transparencies

Blank acetate sheets

Transparency pens

Whiteboard/chalkboard

Markers/chalk

Pencils and scratch paper

Appropriate personal protective equipment

Full-face shields

Portable air tank

An operational pneumatic system with actuators

Samples of simple and complex pneumatic system drawings

Vendor manuals on compressed air components and systems

New and used pneumatic system components, including:
- Compressor
- Filters
- Regulators
- Hoses
- Fittings and quick disconnects
- Control valves
- Cylinders
- Motors

Solenoid valves

Pressure regulators

Applicable tools to remove, work on, and replace pneumatic system components

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

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

SULLAIR Corporation, for training materials, products, and product information
(literature, specifications, drawings)
www.sullair.com

MFD Pneumatics, for pneumatic products and product information
(literature, specifications, drawings)
www.mfdpneumatics.com

Quincy Compressor, for training materials, products, and product information
(literature, specifications, drawings)
www.quincycompressor.com

Ingersoll-Rand Company, for hydraulic and pneumatic products and product information
(literature, specifications, drawings)
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**

Session I. Introduction; Pneumatic System Safety; Characteristics of Gases; Effects of Atmospheric Pressure; Compressing Gases; Transmission of Energy; Compressor Operation and Types

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 _____

Session II. Treatment of Compressed Air

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 _____

Session III. Pneumatic System Components; Troubleshooting Pneumatic Systems

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.

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.

Programmable Logic Controllers
Annotated Instructor's Guide

Module 40409-09

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**
Session I. Introduction; PLC Architecture; Number Systems Review	
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	_____
Session II. PLC Hardware; Processor Modules; Software; Hardware to Program Correlation; Installation	
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.