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.

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. Draw basic voltmeter and ohmmeter circuits and explain how they operate.
4. Use the power formula to calculate the amount of power used by a circuit.
5. 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.
6. Calculate the total resistance for selected series, parallel, and series-parallel circuits.
7. Use Kirchhoff's current law to calculate the total and unknown currents in parallel and series-parallel circuits.
8. 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 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.

Flow, Pressure, Level, and Temperature Annotated Instructor's Guide

Module 40206-08

MODULE OVERVIEW

This module introduces devices used to measure flow, pressure, level, and temperature in instrument and control 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*; and *Industrial Maintenance E & I Technician Level Two*, Modules 40201-08 through 40205-08.

OBJECTIVES

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

1. Identify and describe methods of flow measurement.
2. Identify and describe methods of pressure measurement.
3. Identify and describe methods of temperature measurement.
4. Identify and describe methods of level measurement.

PERFORMANCE TASKS

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

MATERIALS AND EQUIPMENT LIST

Overhead projector and screen

Transparencies

Blank acetate sheets

Transparency pens

Whiteboard/chalkboard

Markers/chalk

Pencils and scratch paper

Appropriate personal protective equipment

Samples of pressure measurement devices, including:
- Various types of manometers
- Bellows-type pressure sensors
- Various types of Bourdon tubes
- Pneumatic and electronic transmitters

Samples of pressure element protection devices, including:
- Isolation diaphragms
- Snubbers

Samples of flow measurement devices, including:
- Orifice plates
- Flow nozzles
- Venturi tubes
- Pitot tubes
- Target flowmeters
- Electromagnetic flowmeters
- Turbine flowmeters
- Various types of vortex flowmeters
- Variable area flowmeters (rotameters)
- Coriolis meters

Samples of temperature measurement devices, including:
- Fluid thermometers
- Bimetallic thermometers
- Various types of thermocouples
- Resistance temperature detectors (RTDs)
- Thermistors
- Non-contact thermometers (pyrometers)

Samples of level measurement devices, including:
- Dipsticks and lead lines
- Sight glasses (gauge glasses)
- Float and cable arrangements
- Displacers
- Hydrostatic head devices
- Bubbler systems
- Magnetic float devices
- Conductance devices
- Various types of capacitance devices
- Ultrasonic level measurement system
- Electric load cells

Trade Terms Quiz*

Module Examinations**

* 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.

Industrial Pressure, Level & Density Measurement, 1995. Donald R. Gillum. Research Triangle Park, NC: Instrument Society of America.

Instrument Engineers' Handbook, Volume 1: Process Measurement, 1995. Bela G. Liptak, Boca Raton, FL: CRC Press.

Instrument Engineers' Handbook, Volume 2: Process Control, 1995. Bela G. Liptak. Boca Raton, FL: CRC Press.

Purdy's Instrument Handbook. 1996. Ralph G. Dewey. Deer Park, TX: Good News Balloons.

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 *Flow, Pressure, Level, and Temperature*. 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; Pressure	
A. Introduction	_____
B. Pressure	_____
1. Units of Pressure Measurement	_____
2. Pressure Measurement Devices	_____
3. Conditions That Damage Pressure Elements	_____
4. Pressure Element Protection Devices	_____
Session II. Flow	
A. Flow	_____
1. Flow Measurement Units	_____
2. Differential Pressure and Flow Relationship	_____
3. Differential Pressure Flow Devices	_____
4. Other Types of Flow Measurement Devices	_____
5. Flow Device Installation Considerations	_____
Session III. Temperature	
A. Temperature	_____
1. Temperature Scales	_____
2. Temperature Measurement Devices	_____

Sessions IV and V. Level

A. Level _____

1. Level Measurement and Pressure _____
2. Direct Level Measurement Devices _____
3. Indirect Level Measurement Devices _____
4. Special Level Measurement Instruments _____

B. Laboratory _____

Have the trainees practice measuring pressure, flow, temperature, and level using various methods.

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.

Process Mathematics
Annotated Instructor's Guide

Module 40207-08

MODULE OVERVIEW

This module covers the metric and English systems in depth, along with conversions from one system to the other. It also covers the calculation of squares and square roots.

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 40206-08.

OBJECTIVES

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

1. Identify different units of pressure measurement.
2. Convert measured values in the English system, using common conversion factor tables, to equivalent SI values.
3. Perform the basic mathematical operations necessary in instrumentation.
4. Square numbers and find the square root of numbers.
5. Perform the mathematical conversions necessary for instrumentation measurements.

PERFORMANCE TASKS

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

1. Find the point where Fahrenheit equals Celsius.
2. Do three temperature conversions.
3. Calculate differential pressure.
4. Calculate the volume of a vessel.

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
Calculators
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.

Thirty Days to Metric Mastery: For People Who Hate Math, D.C. Steinke, House of Charles, 1981.

Thinking Metric, Second Edition, T.F. Gilbert and M.B. Gilbert, John Wiley & Sons, 1978.

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 *Process Mathematics*. 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; Metric Measurements	
A. Introduction	_____
B. Metric Measurements	_____
1. Converting Lengths	_____
2. Converting Areas	_____
3. Converting Volumes	_____
4. Wet Volume Measurements	_____
C. Laboratory	_____
Have the trainees practice calculating the volume of a vessel. This laboratory corresponds to Performance Task 4.	
Session II. Metric Measurements (continued)	
A. Mass versus Weight	_____
B. Pressure	_____
1. Laboratory	_____
Have the trainees practice calculating differential pressure. This laboratory corresponds to Performance Task 3.	
C. Temperature	_____
1. Laboratory	_____
Have the trainees practice finding the point where Fahrenheit equals Celsius. This laboratory corresponds to Performance Task 1.	
D. Flow	_____
Session III. Handheld Calculators; Instrumentation Applications	
A. Handheld Calculators and Instrumentation Applications	_____
1. Squares and Square Roots	_____
2. Auxiliary Functions	_____

Sessions IV and V. Technical Applications

A. Technical Applications _____

1. Converting to a Metric Rule Dipstick _____
2. Sight Glass Level Measurement _____
3. Conductance Probe Settings _____
4. Open Tank Measurement Conversions _____
5. Pressurized Tank Measurement Conversions _____
6. Temperature Measurement Conversion _____

C. Laboratory _____

Have the trainees practice doing three temperature conversions. This laboratory corresponds to Performance Task 2.

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

Hand Bending
Annotated Instructor's Guide

Module 40208-08

MODULE OVERVIEW

This module introduces trainees to the methods and procedures used in cutting, hand bending, reaming, and threading conduit.

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 40207-08.

OBJECTIVES

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

1. Identify the methods for hand bending and installing conduit.
2. Calculate conduit bends.
3. Make 90-degree bends, back-to-back bends, offsets, kicks, and saddle bends using a hand bender.
4. Cut, ream, and thread conduit.

PERFORMANCE TASKS

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

1. Make 90-degree bends, back-to-back bends, offsets, kicks, and saddle bends using a hand bender.
2. Cut, ream, and thread conduit.

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 edition)
Hand bender and manufacturer's instructions
Various pieces of conduit
Hickey
Manufacturers' gain tables
No. 10 or No. 12 solid wire
Tape measure
Calculator
Hacksaw
Pipe vise
Pipe cutter
Reamer
Cutting oil
Shop towels
Hand-operated threader
Sandbox or drip pan
Torpedo level
PVC pieces
PVC cements
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 trainees to cut, bend, ream, and thread pipe. Make sure that all trainees are briefed on appropriate safety procedures. Emphasize hand tool 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.

Benfield Conduit Bending Manual, 2nd Edition. Overland Park, KS: EC&M Books.

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

Tom Henry's Conduit Bending Package (includes video, book, and bending chart). Winter Park, FL: Code Electrical Classes, Inc.

TEACHING TIME FOR THIS MODULE

An outline for use in developing your lesson plan is presented below. Note that each Roman numeral in the outline equates to one session of instruction. Each session has a suggested time period of 2½ hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 10 hours are suggested to cover *Hand Bending*. 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; Hand Bending	
A. Introduction	_____
B. Hand Bending Equipment	_____
1. Geometry Required to Make a Bend	_____
2. Making a 90-Degree Bend	_____
C. Laboratory	_____
Have the trainees practice making 90-degree bends. This laboratory corresponds to Performance Task 1.	_____
D. Gain	_____
E. Back-to-Back 90-Degree Bends	_____
F. Laboratory	_____
Have the trainees practice making back-to-back bends. This laboratory corresponds to Performance Task 1.	
Session II. Offsets; Saddle Bends	
A. Making an Offset	_____
B. Laboratory	_____
Have the trainees practice making kicks. This laboratory corresponds to Performance Task 1.	
C. Parallel Offsets	_____
D. Laboratory	_____
Have the trainees practice making offset bends. This laboratory corresponds to Performance Task 1.	
E. Saddle Bends	_____
F. Laboratory	_____
Have the trainees practice making saddle bends. This laboratory corresponds to Performance Task 1.	
G. Four-Bend Saddles	_____

Session III. Cutting, Reaming, and Threading Conduit; Cutting and Joining PVC Conduit

A. Cutting, Reaming, and Threading Conduit _____

1. Hacksaw Method of Cutting Conduit _____
2. Pipe Cutter Method _____
3. Reaming Conduit _____
4. Threading Conduit _____

B. Laboratory _____

Have the trainees practice cutting, reaming, and threading conduit. This laboratory corresponds to Performance Task 2.

C. Cutting and Joining PVC Conduit _____

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.

Tubing
Annotated Instructor's Guide

Module 40209-08

MODULE OVERVIEW

This module introduces the trainees to materials, tools, and methods used to measure, cut, bend, and join tubing.

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 40208-08.

OBJECTIVES

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

1. Identify the different kinds of tubing and describe the properties and common uses for each kind.
2. Explain the purpose for tubing standards and specifications.
3. Describe the proper handling and storage of tubing.
4. Cut tubing using the proper tools, cutting methods, and safety procedures.
5. Bend tubing using the proper tools, bending methods, and safety procedures.
6. Identify and select proper tubing fittings for selected instrumentation applications.
7. Flare tubing using the proper tools, flaring methods, and safety procedures.
8. Make and remake a compression fitting.

PERFORMANCE TASKS

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

1. Bend copper tubing at 45-degree and 90-degree angles using a compression-type bender.
2. Cut and deburr copper tubing using a hacksaw or tubing cutter.
3. Cut and deburr stainless steel tubing.
4. Install a flare fitting on a section of copper tubing.
5. Properly make up an instrument tubing connection with a compression fitting, then loosen and re-tighten it.

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

Outside or inside vernier caliper

Rule

Samples of various types of tubing, including:
- Copper
- Steel
- Stainless steel
- Aluminum
- Monel®
- Inconel®
- Hastelloy®
- Poly (plastic)
- PVC (PE, polypropylene, Teflon®, Tygon®, and nylon)

Samples of various tools for cutting, including:
- Handheld, internal, and soft tubing cutters
- Hacksaw
- Bandsaw
- Ratchet shears
- Pipe cutters
- Tubing shear
- Reamer, spiral reamer, and other deburring tools
- Sharp knife
- Sandpaper
- Flare nut wrench

continued

Samples of various tubing benders, including:
- Spring tube bender
- Compression-type hand bender
- Table- and/or bench-mounted tubing benders
- Hydraulic tubing bender

Samples of various types of fittings, including:
- Flare
- Compression
- Socket-welded
- Butt-weld
- Male and female connectors and adapters
- Tee
- Elbow
- Coupling
- Union
- Cross
- Tubing caps and plugs
- Reducer
- Bulkhead
- Thermocouple

Manual flaring tool

Hydraulic flaring tool

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.

Standards and Specifications for Tubing. Washington, DC: American National Standards Institute (ANSI).

Standards and Specifications for Tubing. New York, NY: American Society of Mechanical Engineers (ASME).

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 *Tubing*. 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; Sizes and Types of Tubing	
A. Introduction	_____
B. Sizes and Types of Tubing	_____
1. General Sizing Measurements for Tubing	_____
2. Tubing Materials	_____
3. Tubing Standards and Specifications	_____

Session II. Proper and Safe Methods for Storing and Handling Tubing; Cutting Tubing

A. Proper and Safe Methods for Storing Tubing _____
B. Proper and Safe Methods for Handling Tubing _____
C. Cutting Tubing _____
   1. Types and Sizes of Tubing Cutters _____
   2. Cutting Tubing with a Tube Cutter _____
   3. Cutting Tubing with a Hacksaw _____
   4. Cutting Tubing with a Bandsaw _____
   5. Cutting Poly Tubing _____
   6. Deburring Tubing _____
D. Laboratory _____

   Have the trainees practice cutting and deburring copper tubing using a hacksaw or tubing cutter. This laboratory corresponds to Performance Task 2.

E. Laboratory _____

   Have the trainees practice cutting and deburring stainless steel tubing. This laboratory corresponds to Performance Task 3.

Session III. Bending Tubing

A. Bending Tubing _____
   1. Standard Tubing Bends _____
   2. Tubing Bending Methods _____
   3. Types of Tubing Benders _____
B. Laboratory _____

   Have the trainees practice bending copper tubing at 45-degree and 90-degree angles using a compression-type bender. This laboratory corresponds to Performance Task 1.

Sessions IV and V. Tubing Fittings; Flaring Tubing

A. Flare Fittings _____
B. Compression Fittings _____
   1. Laboratory _____

      Have the trainees practice properly making up an instrument tubing connection with a compression fitting, then loosen and re-tighten it. This laboratory corresponds to Performance Task 5.

C. Socket-Welded Fittings _____
D. Butt-Weld Fittings _____
E. Types of Tubing Fittings _____
F. Flaring Tubing _____
   1. Laboratory _____

      Have the trainees practice installing a flare on a section of copper tubing. This laboratory corresponds to Performance Task 4.

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.

Clean, Purge, and Test Tubing and Piping Systems Annotated Instructor's Guide

Module 40210-08

MODULE OVERVIEW

This module introduces the trainees to the procedures for safely and effectively cleaning, purging, and testing piping, tubing, and hoses.

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 40209-08.

OBJECTIVES

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

1. Identify cleaning, flushing, and purging procedures.
2. Describe the general cleaning and purging requirements for piping and tubing.
3. Perform the appropriate cleaning and flushing methods until required cleanliness has been achieved.
4. Describe and select pressure and leak testing methods for piping/tubing systems.
5. Identify precautions associated with testing piping/tubing systems.
6. Perform pressure leak tests per approved procedures.
7. Prepare required test documentation.

PERFORMANCE TASKS

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

1. Set up and perform a pressure leak test.
2. Inspect the system to verify there is no leakage.
3. Perform a blowdown/purge.
4. Document the test results and restore the system to be service-ready.

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
Bubbler leak tester
Liquid bubble test fluid
Access to a system to perform blowdown/purge and pressure leak tests
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.

CFR (Code of Federal Regulations) 29 Subparts H and Z, Hazardous and Toxic Substances.

ASTM International/ANSI B31.1: Power Piping.

ASTM International/ANSI B31.3: Process Piping.

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 7½ hours are suggested to cover *Clean, Purge, and Test Tubing and Piping Systems*. You will need to adjust the time required for hands-on activity and testing based on your class size and resources. Because laboratories often correspond to Performance Tasks, the proficiency of the trainees may be noted during these exercises for Performance Testing purposes.

Topic	**Planned Time**
Session I. Introduction; Cleaning and Purging; Pressure and Leak Testing	
A. Introduction	_____
B. Cleaning and Purging	_____
1. General Cleaning Requirements for Tubing and Piping	_____
2. Cleaning, Flushing, and Purging Methods	_____
3. Applicable Records and Documentation	_____
C. Laboratory	_____
Have the trainees practice performing a blowdown/purge. This laboratory corresponds to Performance Task 3.	
D. Pressure and Leak Testing	_____
1. Selection Criteria for Testing Methods	_____
2. Description of Testing Methods	_____
Session II. Pressure and Leak Testing (continued)	
A. Pressure and Leak Testing	_____
1. Testing Precautions	_____
2. General Test Procedures	_____
3. Test Documentation	_____
B. Laboratory	_____
Have the trainees practice setting up and performing a pressure leak test. This laboratory corresponds to Performance Task 1.	
C. Laboratory	_____
Have the trainees practice inspecting the system to verify there is no leakage. This laboratory corresponds to Performance Task 2.	
D. Laboratory	_____
Have the trainees practice documenting the test results and restoring the system to be service-ready. This laboratory corresponds to Performance Task 4.	

Session III. 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.

Instrument Drawings and Documents, Part One
Annotated Instructor's Guide

Module 40211-08

MODULE OVERVIEW

This module introduces drawings for instrumentation systems and explains the symbols and other elements found in these drawings.

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 40210-08.

OBJECTIVES

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

1. Identify and describe standard Instrument Society of America (ISA) instrument symbols and abbreviations.
2. Read and interpret instrument indexes.
3. Read and interpret general instrument specifications.
4. Read and interpret general notes and details included on instrument drawings and documents.
5. Read and interpret installation detail drawings.
6. Read and interpret location drawings.

PERFORMANCE TASKS

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

1. Locate and identify drawing elements.

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

ISA Standard S5.1, Instrumentation Symbols and Identification

Samples of instrument indexes

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.

ISA Standards. Research Triangle Park, NC: Instrument Society of America.

- *ISA Standard S5.1, Instrumentation Symbols and Identification*
- I*SA Standard S5.2, Binary Logic Diagrams for Process Operations*
- *ISA Standard S5.3, Graphic Symbols for Distributed Control/Shared Display Instrumentation, Logic, and Computer Systems*
- *ISA Standard S5.4, Instrument Loop Diagrams*
- *ISA Standard S5.5, Graphical Symbols for Process Displays*
- *ISA Standard S51.1, Process Instrumentation Terminology*

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 *Instrument Drawings and Documents, Part One*. 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; Instrument Symbols and Identification	
A. Introduction	_____
B. Instrument Symbols and Identification	_____
1. Instrument Symbols	_____
2. Instrument Tag Numbers and Identification Abbreviations	_____
3. Graphic or Pictorial Instrument Symbols	_____
4. Line Symbols	_____
Session II. Instrument Index	
A. Instrument Index	_____
Session III. General Instrument Specifications	
A. General Instrument Specifications	_____
Session IV. General Notes and Details; Installation Detail Drawings	
A. General Notes and Details	_____
B. Installation Detail Drawings	_____
Session V. Location Drawings; Control Loops	
A. Location Drawings	_____
B. Control Loops	_____
C. Laboratory	_____
Have the trainees practice locating and identifying drawing elements. This laboratory corresponds to Performance Task 1.	

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.

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.