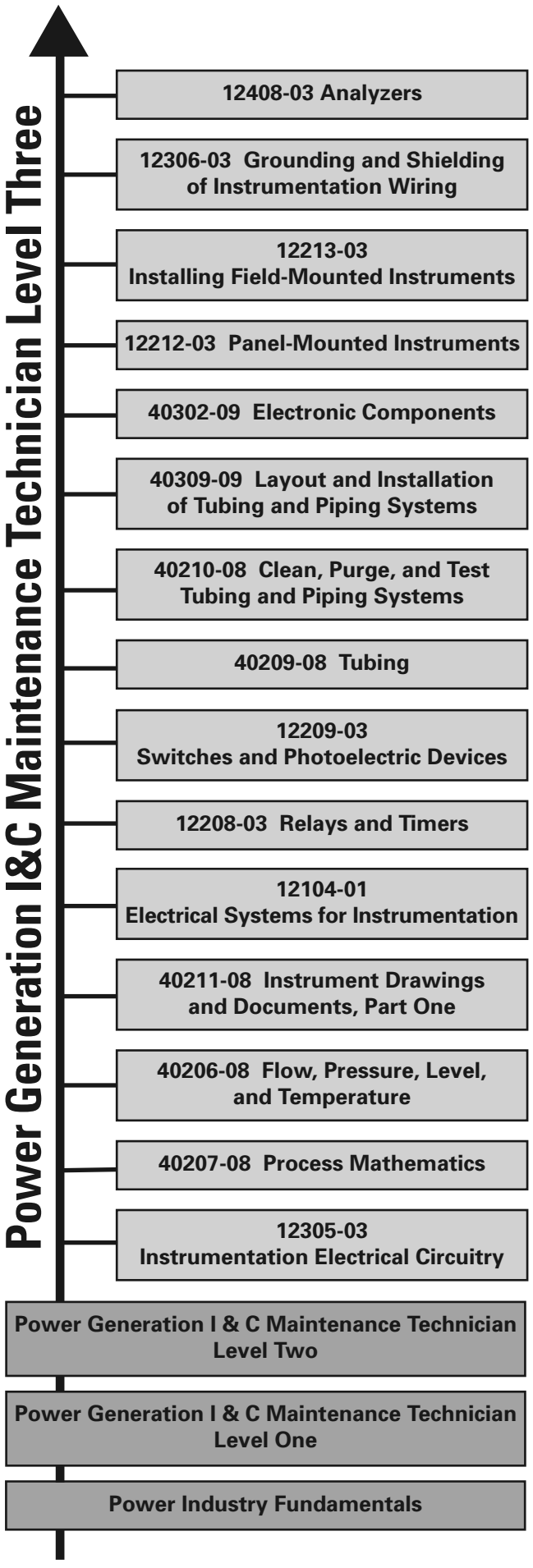
COMPTENCIES, OBJECTIVES, AND PERFORMANCE TASKS



MODULE OVERVIEW

This module covers the characteristics and terminology associated with various types of circuits. It also discusses the calculations required to determine voltage, current, and resistance.

PREREQUISITES

Please refer to the Course Map in the Trainee Module. Prior to training with this module, it is recommended that the trainee shall have successfully completed the following:

Core Curriculum; Instrumentation Levels One and Two; Instrumentation Level Three, Modules 12301-03 through 12304-03.

OBJECTIVES

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

1. Explain the basic characteristics of series circuits, parallel circuits, and series-parallel circuits.
2. Analyze series, parallel, and series-parallel circuits.
3. Find the total resistance in series, parallel, and series-parallel circuits.
4. Determine the frequency and period for a given AC sine wave.
5. Calculate the peak, effective (rms), and average voltage or current values for an AC sine wave.
6. Describe the voltage and current phase relationship in a resistive AC circuit.
7. Define inductive reactance and state how it is affected by frequency.
8. Define capacitive reactance and state how it is affected by frequency.
9. Explain the terms true power, apparent power, reactive power, and power factor.
10. Explain why a 4–20mA signal is typically transmitted in a loop instead of a 1–5V signal.
11. Describe the characteristics of a digital signal.
12. Calculate the unknown resistance value in a resistance temperature detector (RTD) bridge circuit.

PERFORMANCE TASKS

There are no Performance Tasks for this module.

MATERIALS AND EQUIPMENT LIST

Overhead projector and screen
Transparencies
Whiteboard/chalkboard
Markers/chalk
Blank acetate sheets
Transparency pens
Pencils and scratch paper
Appropriate personal protective equipment
Scientific calculator
Module Examinations*

* Located in the Test Booklet.

SAFETY CONSIDERATIONS

Ensure that the trainees are equipped with appropriate personal protective equipment.

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.

American Electricians' Handbook. New York, NY: McGraw-Hill.

Electronics Fundamentals. Thomas L. Floyd. New York, NY: Prentice Hall.

Introduction to Electric Circuits. Richard C. Dorf and James A. Sroboda. New York, NY: Prentice Hall.

Principles of Electric Circuits. Thomas L. Floyd. 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 25 hours are suggested to cover *Instrumentation Electrical Circuitry*. 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; Resistive Circuits	
A. Introduction	_____
B. Resistive Circuits	_____
1. Resistances in Series	_____
2. Resistances in Parallel	_____
3. Series-Parallel Circuits	_____
Session II. Applying Ohm's Law	
A. Applying Ohm's Law in Series Circuits	_____
B. Applying Ohm's Law in Parallel Circuits	_____
C. Applying Ohm's Law in Series-Parallel Circuits	_____
Session III. Kirchoff's Laws	
A. Kirchoff's Current Law	_____
B. Kirchoff's Voltage Law	_____
C. Loop Equations	_____
Session IV. Introduction to Alternating Current	
A. Sine Wave Generation	_____
B. Sine Wave Terminology	_____
Session V. AC Phase Relationships; Resistance in AC Circuits	
A. AC Phase Relationships	_____
B. Resistance in AC Circuits	_____
Session VI. Inductance in AC Circuits; Capacitance	
A. Inductance in AC Circuits	_____
B. Capacitance	_____
1. Calculating Equivalent Capacitance	_____
2. Voltage Rating	_____
3. Leak Resistance	_____
4. Capacitive Reactance	_____

Session VII. Power in AC Circuits; Electronic Instrumentation Signals

A. Power in AC Circuits _____

B. Electronic Instrumentation Signals _____

1. Analog Signals (4–20mA and 1–5V) _____
2. Digital Signals _____

Session VIII. Introduction to PLCs

A. Discrete Input/Output _____

B. Analog Input/Output _____

Session IX. Applications of Instrumentation Circuitry

A. Temperature (RTD Bridge) _____

B. Pressure (Strain Gauge Bridge) _____

C. Remote Level Indication _____

Session X. Review; Module Examination

A. Review _____

B. Module Examination _____

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

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.

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.

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.

MODULE OVERVIEW

This module introduces the trainee to the basic electrical concepts and skills needed to test electrical circuits.

PREREQUISITES

Please refer to the Course Map in the Trainee Module. Prior to training with this module, it is recommended that the trainee shall have successfully completed the following:

Core Curriculum; Instrumentation Level One, Modules 12101 through 12103

OBJECTIVES

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

1. Define the following terms:
   - Alternating current (AC)
   - Capacitance
   - Conductor
   - Current
   - Direct current (DC)
   - Electrical circuit
   - Inductance
   - Insulator
   - Ohm's law
   - Resistance
   - Voltage
2. State the two requirements for current flow in a circuit.
3. Use a multimeter and clamp-on ammeter to measure voltage, current, and resistance in a circuit.
4. State Ohm's law in equation form.
5. Use Ohm's law to calculate individual component values and total values for I, E, R, and P in a simple DC series circuit, given any two of the following properties: resistance, current, and voltage.
6. Demonstrate a knowledge of safety considerations when working with electricity.
7. Calculate the value and determine the tolerance of a resistor.
8. Identify correct wire sizes used for different instrumentation applications.
9. Identify various types of electrical fittings used for different instrumentation applications.

PERFORMANCE TASKS

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

1. Measure and record the current, voltage, and resistance in a DC circuit.
2. Calculate the power consumed by the circuit, using any two of the measured values.

NCCER STANDARDIZED CRAFT TRAINING PROGRAM

The National Center for Construction Education and Research (NCCER) provides a standardized national program of accredited craft training. Key features of the program include instructor certification, competency-based training, and performance testing. The program provides trainees, instructors, and companies with a standard form of recognition through a National Craft Training Registry. The program is described in full in the *Guidelines for Accreditation*, published by the NCCER. For more information on standardized craft training, contact the NCCER by writing us at P.O. Box 141104, Gainesville, FL 32614-1104; calling 352-334-0911; or e-mailing info@nccer.org. More information may be found at our Web site, www.nccer.org.

HOW TO USE THIS ANNOTATED INSTRUCTOR'S GUIDE

Each page presents two sections of information. The larger section displays each page exactly as it appears in the Trainee Module. The narrow column ties suggested trainee and instructor actions to each page and provides icons to call your attention to material, safety, audiovisual, or testing requirements. The bottom of each page includes space for your notes.

If you see the Teaching Tip icon, that means there is a teaching tip associated with this section. Also refer to any suggested teaching tips at the end of the module.

SAFETY CONSIDERATIONS

Ensure that the trainees are equipped with appropriate personal protective equipment.

PREPARATION

Before teaching this module, you should review the Module Outline, Objectives, Performance Tasks, and the Materials and Equipment List. Be sure to allow ample time to prepare your own training or lesson plan and gather all required equipment and materials.

MATERIALS AND EQUIPMENT LIST

Overhead projector and screen
Transparencies
Whiteboard/chalkboard
Markers/chalk
Latest edition of the *National Electrical Code*
Module Examinations*
Performance Profile Sheets*
Analog multimeters
Digital multimeters
Clamp-on ammeters
Various types and sizes of capacitors
Capacitor color chart
Various types and sizes of resistors
Wire gauge
Various types and sizes of wire
Various types and sizes of thermocouples
Various types and sizes of conduit couplings
Various types and sizes of coaxial cable connectors
Various types and sizes of insulating bushings
Various types and sizes of flex connectors
Various types and sizes of explosion-proof housings

*Located in the Test Booklet packaged with this Annotated Instructor's Guide.

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, 2000. Thomas L. Floyd. Upper Saddle River, NJ: Prentice Hall.

Cooper Crouse-Hinds Catalog of Fittings. Syracuse, NY: Crouse-Hinds.

General Training – Electricity, Syracuse. NY: Carrier Corporation.

NOTES

The designations "National Electrical Code," "NE Code," and "NEC," where used in this document, refer to the *National Electrical Code*®, which is a registered trademark of the National Fire Protection Association, Quincy, MA. All National Electrical Code (NEC) references in this module refer to the 1999 edition of the NEC.

If you feel that additional math instruction would be helpful, Prentice Hall offers a basic math textbook entitled *Fundamentals of Electrical and Mechanical Mathematics*. It covers the basic math requirements for electrical trainees and may be ordered by contacting Prentice Hall Customer Service at 1-800-922-0579.

TEACHING TIME FOR THIS MODULE

An outline for use in developing your lesson plan is presented below. Note that each Roman numeral in the outline equates to one session of instruction. Each session has a suggested time period of 2½ hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 22½ hours are suggested to cover *Electrical Systems for Instrumentation*. You will need to adjust the time required for hands-on activity and testing based on your class size and resources.

Topic	**Planned Time**
Session I. Introduction to Electrical Systems	
A. Introduction	_____
B. Terms and Definitions	_____
C. Simple Circuit	_____
Session II. Ohm's Law and Series DC Circuits	
A. Ohm's Law	_____
B. Series DC Circuits	_____
1. Current, Voltage, and Resistance	_____
2. Power	_____
C. Laboratory / Performance Testing – Calculating Power	_____
Session III. Methods of Measuring Electrical Properties	
A. Measuring Voltage with a Multimeter	_____
B. Measuring Resistance with a Multimeter	_____
C. Measuring Current with a Multimeter	_____
D. Measuring Current with a Clamp-on Ammeter	_____
Session IV. Laboratory/Performance Testing – Current Measurement	_____
Session V. Laboratory/Performance Testing – Voltage Measurement	_____
Session VI. Laboratory/Performance Testing – Resistance Measurement	_____
Session VII. Resistors, Capacitors, and Instrumentation Control Wiring	
A. Resistors and Color Codes	_____
B. Capacitors and Color Codes	_____
C. Instrumentation Control Wiring	_____
1. Shields	_____
2. Grounding	_____
3. Jackets	_____
4. Wire Sizes	_____
5. Wire Ratings	_____
Session VIII. Thermocouples, Electrical Fittings, and Explosion-Proof Housings	
A. Thermocouples	_____
B. Electrical Fittings	_____
C. Explosion-Proof Housings	_____

Session IX. Summary, Module Examination, and Performance Testing

A. Summary
   1. Summarize module _____
   2. Answer questions _____

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

C. Performance Testing _____
   1. Trainees must perform each task to the satisfaction of the instructor to receive recognition from the NCCER
   2. Record the testing results on Craft Training Report Form 200 and submit the results to the training program sponsor.

MODULE OVERVIEW

This module presents the principles of operation and applications of various instrumentation relays and timers. It also covers the selection of devices in a loop using specification sheets or samples.

PREREQUISITES

Please refer to the Course Map in the Trainee Module. Prior to training with this module, it is recommended that the trainee shall have successfully completed the following modules:

Core Curriculum; Instrumentation Level One; Instrumentation Level Two, Modules 12201-03 through 12204-03

OBJECTIVES

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

1. Describe the basic functions of relays.
2. Describe and identify electromechanical relays and explain how they operate.
3. Install and connect relays in sockets.
4. Describe and identify solid state relays and explain how they operate.
5. Describe and identify pneumatic relays and repeaters. Explain how these operate.
6. Describe and identify hydraulic relays and explain how they operate.
7. Describe and identify timers and time delay relays, including:
   - Dashpot
   - Synchronous time clock
   - Solid state
8. Describe the operation of a volume booster.
9. Install various types of timers.

PERFORMANCE TASKS

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

1. Select and install various types of relays.
2. Select and install various types of timers.

NCCER STANDARDIZED CRAFT TRAINING PROGRAM

The National Center for Construction Education and Research (NCCER) provides a standardized national program of accredited craft training. Key features of the program include instructor certification, competency-based training, and performance testing. The program provides trainees, instructors, and companies with a standard form of recognition through a National Craft Training Registry. The program is described in full in the *Guidelines for Accreditation*, published by the NCCER. For more information on standardized craft training, contact the NCCER at P.O. Box 141104, Gainesville, FL 32614-1104, 352-334-0911, visit our Web site at www.nccer.org, or e-mail info@nccer.org.

HOW TO USE THIS ANNOTATED INSTRUCTOR'S GUIDE

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If you see the Teaching Tip icon, that means there is a teaching tip associated with this section. Also refer to any suggested teaching tips at the end of the module.

SAFETY CONSIDERATIONS

Ensure that the trainees are equipped with appropriate personal protective equipment. Emphasize the safety precautions required when working around energized circuits and electrical components.

PREPARATION

Before teaching this module, you should review the Module Outline, Objectives, Performance Tasks, and the Materials and Equipment List. Be sure to allow ample time to prepare your own training or lesson plan and gather all required equipment and materials.

MATERIALS AND EQUIPMENT LIST

Overhead projector and screen
Transparencies
Transparency pens
Blank acetate sheets
Markers/chalk
Whiteboard/chalkboard
Pencils and scratch paper
Appropriate personal protective equipment
An assortment of relays, timers, and clocks
Hand tools for installing relays, timers, and clocks
Module Examinations*
Performance Profile Sheets*

*Located in the Test Booklet.

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 Instruments and Controls Handbook, Second Edition. D. M. Considine. McGraw-Hill Book Company.

Instrument Engineers Handbook, Volume II, Process Control. Bela Liptak. Chilton Book Company.

Electric Motor Controls Automated Industrial Systems, Second Edition. Gary Rockis and Glen Mazur. American Technical Publishers.

Instrumentation, Third Edition. Franklyn W. Kirk and Nicholas R. Rimboi. American Technical Society.

Standards and Practices for Instrumentation, Instrumentation Society of America.

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 *Relays and Timers*. You will need to adjust the time required for hands-on activity and testing based on your class size and resources.

Topic **Planned Time**

Session I. Introduction; Electrical Relays; Laboratory

A. Introduction _____
B. Electrical Relays _____
   1. Electromechanical Relays _____
      a. Reed Relays and Switches _____
      b. General Purpose Relays _____
      c. Control Relays in Instrumentation _____
   2. Solid-State Relays _____
      a. Comparison of Electromechanical Relays to Solid-State Relays _____
C. Laboratory _____

   Under your supervision, have the trainees select and install various electric relays. Note the proficiency of each trainee

Session II. Pneumatic Relays, Repeaters, and Boosters; Laboratory; Timers and Time Clocks

A. Pneumatic Relays, Repeaters, and Boosters _____
   1. Force-Balance Transmitter Relays _____
   2. Computing Relays _____
      a. Pneumatic Multiplying and Dividing Relays _____
      b. Pneumatic Adding, Subtracting, and Inverting Relays _____
      c. Pneumatic Scaling and Proportioning Relays _____
      d. High- and Low-Pressure Selector and High-Pressure Limiter Relays _____
      e. Booster Relays _____
B. Laboratory _____

   Under your supervision, have the trainees select and install various pneumatic relays. Note the proficiency of each trainee.

C. Timers and Time Clocks _____
   1. Dashpot Timer Relays _____
   2. Pneumatic Timers _____
   3. Synchronous Time Switches _____
   4. Solid State Timers _____

Session III. Laboratory; Review; Module Examination and Performance Testing

A. Laboratory _____

   Under your supervision, have the trainees select and install various clocks and timers. Note the proficiency of each trainee.

B. Summary
   1. Summarize module _____
   2. Answer questions _____
C. Module Examination _____

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

D. Performance Testing

1. Trainees must perform each task to the satisfaction of the instructor to receive recognition from the NCCER.
2. Record the testing results on Craft Training Report Form 200 and submit the results to the Training Program Sponsor.

MODULE OVERVIEW

This module covers the operation and applications of switches and photoelectric devices. It also covers the selection and installation of these devices.

PREREQUISITES

Please refer to the Course Map in the Trainee Module. Prior to training with this module, it is recommended that the trainee shall have successfully completed the following modules:

Core Curriculum; Instrumentation Level One; Instrumentation Level Two, Modules 12201-03 through 12204-03

OBJECTIVES

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

1. State the purpose of a switch.
2. Identify commonly used switches.
3. Describe the operation of various types of switches.
4. Classify switches, using wiring symbols, according to the number of poles and the number of throws.
5. State the purpose of an SCR.
6. Describe the operation of photoelectric devices.
7. Identify commonly used photoelectric devices.
8. State the electrical characteristics of a solar cell.

PERFORMANCE TASKS

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

1. Select and install various switches.
2. Select and install various photoelectric devices.

NCCER STANDARDIZED CRAFT TRAINING PROGRAM

The National Center for Construction Education and Research (NCCER) provides a standardized national program of accredited craft training. Key features of the program include instructor certification, competency-based training, and performance testing. The program provides trainees, instructors, and companies with a standard form of recognition through a National Craft Training Registry. The program is described in full in the *Guidelines for Accreditation*, published by the NCCER. For more information on standardized craft training, contact the NCCER at P.O. Box 141104, Gainesville, FL 32614-1104, 352-334-0911, visit our Web site at www.nccer.org, or e-mail info@nccer.org.

HOW TO USE THIS ANNOTATED INSTRUCTOR'S GUIDE

Each page presents two sections of information. The larger section displays each page exactly as it appears in the Trainee Module. The narrow column ties suggested trainee and instructor actions to each page and provides icons to call your attention to material, safety, audiovisual, or testing requirements. The bottom of each page includes space for your notes.

If you see the Teaching Tip icon, that means there is a teaching tip associated with this section. Also refer to any suggested teaching tips at the end of the module.

SAFETY CONSIDERATIONS

Ensure that the trainees are equipped with appropriate personal protective equipment.

PREPARATION

Before teaching this module, you should review the Module Outline, Objectives, Performance Tasks, and the Materials and Equipment List. Be sure to allow ample time to prepare your own training or lesson plan and gather all required equipment and materials.

MATERIALS AND EQUIPMENT LIST

Overhead projector and screen
Transparencies
Transparency pens
Blank acetate sheets
Markers/chalk
Whiteboard/chalkboard
Pencils and scratch paper
Appropriate personal protective equipment
Various switches, photoelectric devices, and proximity sensors
Hand tools necessary to install switches and photoelectric devices
Module Examinations*
Performance Profile Sheets*

*Located in the Test Booklet.

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.

American Electricians' Handbook, Twelfth Edition. Terrell Croft and Wilford I. Summers. NY; McGraw-Hill.

National Electrical Code Handbook, 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 *Switches and Photoelectric Devices*. You will need to adjust the time required for hands-on activity and testing based on your class size and resources.

Topic **Planned Time**

Session I. Introduction; Switch Definition, Properties, and Description

A. Introduction _____
B. Switch Definition, Properties, and Description _____
   1. Switch Definition _____
   2. Switch Classifications _____
      a. Switch Contacts _____
      b. Pole of a Switch _____
      c. Closed Positions or Throws of a Switch _____
      d. Typical Switch Wiring _____
   3. Switch Descriptions _____
      a. Panel-Mounted Switches _____
      b. Float Level Switches _____
      c. Pressure Switches _____
      d. Limit Switches _____
      e. Electronic Switches (SCRs) _____
   4. Laboratory _____

      Under your supervision, have the trainees select and install various switches. Note the proficiency of each trainee.

Session II. Photoelectric Devices; Proximity Sensors; Summary; Module Examination and Performance Testing

A. Photoelectric Devices _____
   1. Photocell Switches _____
   2. Solar Cells _____
   3. Infrared Devices _____
      a. Motion Detectors _____
      b. Industrial Process IR Sensors _____
   4. Fiber Optics _____
   5. Laboratory _____

      Under your supervision, have the trainees select and install various photoelectric devices. Note the proficiency of each trainee.

B. Proximity Sensors _____
C. Summary
   1. Summarize module _____
   2. Answer questions _____
D. Module Examination _____
   1. Trainees must score 70% or higher to receive recognition from the NCCER.
   2. Record the testing results on Craft Training Report Form 200 and submit the results to the Training Program Sponsor.
E. 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.

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.

Layout and Installation of Tubing and Piping Systems Annotated Instructor's Guide

Module 40309-09

MODULE OVERVIEW

This module describes the procedure for laying out tubing and piping using the job drawings and/or specifications, and includes the calculations required to complete bends. It also covers the installation of tubing, piping, hangers, and supports.

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 40308-09.

OBJECTIVES

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

1. Using prints, specifications, and visual inspections, determine the scope of the layout procedure.
2. Determine the proper methods for routing piping or tubing.
3. Apply fitter's math to measure and bend piping or tubing.
4. Cut piping or tubing.
5. Apply the appropriate calculations and bender to accurately bend piping or tubing to the proper angle in an offset.
6. Identify and state the usage of various piping and tubing supports.
7. Install various piping and tubing supports.
8. Identify and state the usage of various piping and tubing fittings, including:
   - Flare tube fittings
   - Compression tubing fittings
   - Threaded pipe fittings
   - Pipe flanges

PERFORMANCE TASKS

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

1. Given a partial system equipment location diagram (one loop) and observing all considerations covered in this module, create an isometric drawing of the given loop.
2. Measure and bend the tubing sections in the loop and select the fittings needed to install the layout shown in the isometric drawing in Performance Task 1.
3. Indicate the types and locations of minimal support needed for the tubing installation.
4. Make up compression fittings on tubing.

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 drawings for a piping layout
Sample loop drawings and specifications
Graph paper
Protractor
Straightedge
45-degree triangle
Scientific calculator
Copper tubing and fittings
Assorted piping and tubing cutting tools
Reamers

continued

Hand benders
Various hangers and supports
Snubber
Flanges and flange bolts
Torque wrenches
Compression fittings
Flared fittings and flaring tool
Cardboard boxes
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. Emphasize the importance of wearing safety glasses when cutting tubing or piping.

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.

Tube Fitter's Manual, Swagelok Inc., MS 13-03.
Instrument Tube Fitter's Manual, Parker Fluid Connectors.

TEACHING TIME FOR THIS MODULE

An outline for use in developing your lesson plan is presented below. Note that each Roman numeral in the outline equates to one session of instruction. Each session has a suggested time period of 2½ hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 22½ hours are suggested to cover *Layout and Installation of Piping and 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 to Layout	
A. Introduction	_____
B. Layout	_____
1. Layout Preparation	_____
2. Piping System Layout Considerations	_____
3. Developing an Isometric Sketch	_____
C. Laboratory Provide the trainees with a partial system equipment location diagram and have them create an isometric drawing of one loop. This laboratory corresponds to Performance Task 1.	_____
Session II. Measuring and Bending Tubing and Piping	
A. Determining Initial Bend Position and Angle	_____
B. Locating the Bend Position on Tubing	_____
C. Pipe and Tube Cutting Tools	_____
D. Bender Selection	_____
E. Using a Compression Tube Bender	_____
F. Adjustment (Gain) Calculations	_____

Sessions III–VI. Laboratory

A. Laboratory _____
Have trainees measure and bend the tubing sections for a loop as they follow an isometric drawing. This laboratory corresponds to Performance Task 2.

Session VII. Supporting Tubing and Piping

A. Support Spacing _____
B. Variable Spring Hangers _____
C. Constant Supports _____
D. Rigid Hangers and Supports _____
E. Snubbers _____
F. Supporting Tubing _____
G. Laboratory _____
Have trainees identify the types and locations of support devices required for an example tubing installation. This laboratory corresponds to Performance Task 3.

Session VIII. Fittings and Connectors

A. Flanged Connections _____
B. Compression Tubing Fittings _____
C. Laboratory _____
Have trainees install compression fittings on tubing. This laboratory corresponds to Performance Task 4.
D. Flared Connectors _____

Session IX. 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.

Electronic Components
Annotated Instructor's Guide

Module 40302-09

MODULE OVERVIEW

This module covers electronic components and their applications, and provides an introduction to the principles of electronics and semiconductor theory.

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*, Module 40301-09.

OBJECTIVES

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

1. Identify electronic components.
2. Describe the electrical characteristics of solid-state devices.
3. Describe the basic materials that make up solid-state devices.
4. Describe and identify the various types of transistors and explain how they operate.
5. Describe and connect diodes, including light-emitting diodes (LEDs) and silicon-controlled rectifiers (SCRs).
6. Use a cross-reference manual to find substitutes for electronic components.
7. Identify fuses used in electronic devices.
8. Identify the leads of various solid-state devices.
9. Describe integrated circuits.
10. Identify applicable pin numbers of integrated circuit chips.
11. Explain the purpose of logic gates.
12. Check diodes.

PERFORMANCE TASKS

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

1. Using a cross reference manual, identify a substitute for a selected electronic component.
2. Build a simple bridge rectifier circuit and view the results.
3. Check diodes.

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

24V transformer with a plug and power cord

Filter capacitor

Oscilloscope

DC load resistance

Selection of diodes, LEDs, transistors, and SCRs

Multimeter

IC removal and insertion tools

Grounding strap

Selection of schematic and logic diagrams

Selection of printed circuit boards, sealed components, integrated circuits, and microprocessors

Pushbutton

Components and wire to connect basic test circuits

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 materials for continued education rather than for task training.

Electronic Devices (Electron Flow Version), 8/E. 2007. Thomas L. Floyd. Prentice Hall.

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

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 10 hours are suggested to cover *Electronic Components*. 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; Semiconductor Fundamentals; Diodes	
A. Introduction	_____
B. Semiconductor Fundamentals	_____
C. Diodes	_____
D. Laboratory	_____
Have trainees practice building a simple bridge rectifier circuit and viewing the results. This laboratory corresponds to Performance Task 2.	
E. Light-Emitting Diodes	_____
F. Photo Diodes	_____
G. Zener Diodes	_____
H. Laboratory	_____
Have trainees check diodes for proper operation. This laboratory corresponds to Performance Task 3.	
Session II. Transistors and SCRs	
A. Transistors	_____
B. Silicon-Controlled Rectifiers	_____
Session III. Diacs; Triacs; Printed Circuit Boards	
A. Diacs	_____
B. Triacs	_____
C. Printed Circuit Boards	_____
D. Laboratory	_____
Have trainees practice identifying a substitute for an electronic component. This laboratory corresponds to Performance Task 1.	

Session IV. Operational Amplifiers; Digital Gates; Review and Testing

A. Operational Amplifiers _____

B. Basic Digital Gates _____

C. Module Review _____

D. Module Examination _____

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

E. Performance Testing _____

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

MODULE OVERVIEW

This module covers the piping and instrumentation drawings related panel-mounted instruments. It also describes the layout and installation of instruments on an instrument panel.

PREREQUISITES

Please refer to the Course Map in the Trainee Module. Prior to training with this module, it is recommended that the trainee shall have successfully completed the following modules:

Core Curriculum; Instrumentation Level One; Instrumentation Level Two, Modules 12201-03 through 12204-03

OBJECTIVES

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

1. Identify panel-mounted instruments from piping and instrumentation drawings.
2. Lay out panel-mounted devices for installation.
3. Install various panel-mounted instruments.

PERFORMANCE TASKS

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

1. Lay out an instrument panel.
2. Install an instrument in a panel.

NCCER STANDARDIZED CRAFT TRAINING PROGRAM

The National Center for Construction Education and Research (NCCER) provides a standardized national program of accredited craft training. Key features of the program include instructor certification, competency-based training, and performance testing. The program provides trainees, instructors, and companies with a standard form of recognition through a National Craft Training Registry. The program is described in full in the *Guidelines for Accreditation*, published by the NCCER. For more information on standardized craft training, contact the NCCER at P.O. Box 141104, Gainesville, FL 32614-1104, 352-334-0911, visit our Web site at www.nccer.org, or e-mail info@nccer.org.

HOW TO USE THIS ANNOTATED INSTRUCTOR'S GUIDE

Each page presents two sections of information. The larger section displays each page exactly as it appears in the Trainee Module. The narrow column ties suggested trainee and instructor actions to each page and provides icons to call your attention to material, safety, audiovisual, or testing requirements. The bottom of each page includes space for your notes.

If you see the Teaching Tip icon, that means there is a teaching tip associated with this section. Also refer to any suggested teaching tips at the end of the module.

SAFETY CONSIDERATIONS

Ensure that the trainees are equipped with appropriate personal protective equipment. Review the procedures for safely using power shears, nibblers, and hydraulic punches.

PREPARATION

Before teaching this module, you should review the Module Outline, Objectives, Performance Tasks, and the Materials and Equipment List. Be sure to allow ample time to prepare your own training or lesson plan and gather all required equipment and materials.

MATERIALS AND EQUIPMENT LIST

Overhead projector and screen
Transparencies
Transparency pens
Blank acetate sheets
Markers/chalk Whiteboard/chalkboard
Pencils and scratch paper
Appropriate personal protective equipment
Blue dye
Scrap metal plate 1/16" to 1/8" thick
Cardboard
Basic hand tools
Scribers
Steel rules
Steel squares
Combination set
Dividers
Prick punches
Center punches
Protractor
Toolmaker's hammers
Straightedges
Manufacturer's installation instructions and templates
Drill and bits
Reciprocating saw
Power shears
Nibblers
Hydraulic knockout punch
Hole saw
Mandrel
Various instruments for mounting on example panel
Module Examinations*
Performance Profile Sheets*

*Located in the Test Booklet.

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.

Instrument Engineers Handbook, 1982. Pennsylvania: Chilton Book Company.

TEACHING TIME FOR THIS MODULE

An outline for use in developing your lesson plan is presented below. Note that each Roman numeral in the outline equates to one session of instruction. Each session has a suggested time period of 2½ hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 7½ hours are suggested to cover *Panel-Mounted Instruments*. You will need to adjust the time required for hands-on activity and testing based on your class size and resources.

Topic **Planned Time**

Session I. Introduction; P&IDs Relating to Panel-Mounted Instruments; Laying Out Panel-Mounted Instruments

A. Introduction _____
B. P&IDs Relating to Panel-Mounted Instruments _____
   1. P&ID Symbology _____
C. Laying Out Panel-Mounted Instruments _____
   1. Accessibility _____
   2. Safety _____
   3. Developing a Layout Template _____
   4. Selecting the Proper Layout Tools _____
      a. Scribers _____
      b. Steel Rules _____
      c. Steel Squares _____
      d. Combination Sets _____
      e. Dividers _____
      f. Prick Punches _____
      g. Center Punches _____
      h. Toolmakers' Hammers _____
      i. Straightedges _____
      j. Layout Dye (Blueing) _____
   5. Completing the Layout _____
      a. Manufacturers' Templates _____
      b. Creating a Template _____

Session II. Selecting the Proper Installation Tools; Making the Panel Cutout and Installing the Instrument

A. Selecting the Proper Installation Tools _____
   1. Hydraulic Knockout Punches _____
   2. Power Shears and Nibblers _____
B. Making the Panel Cutout and Installing the Instrument _____

Session III. Laboratory; Summary; Module Examination and Performance Testing

A. Laboratory _____

   Under your supervision, have the trainees lay out an instrument panel and install an instrument on the panel. Note the proficiency of each trainee.

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

D. 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.

Installing Field-Mounted Instruments
Annotated Instructor's Guide

Module 12213-03

MODULE OVERVIEW

This module covers the installation of instrumentation in a variety of field applications, including stand mounting, in-line mounting, vessel mounting, strap mounting, and insertion mounting. It also describes the function and installation of flanges and manifolds.

PREREQUISITES

Please refer to the Course Map in the Trainee Module. Prior to training with this module, it is recommended that the trainee shall have successfully completed the following modules:

Core Curriculum; Instrumentation Level One; Instrumentation Level Two, Modules 12201-03 through 12212-03

OBJECTIVES

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

1. Identify and describe various methods used in installing instruments in the field, including the following:
   - Stand mounted
   - In-line mounted
   - Structure mounted
   - Strap mounted
   - Insertion mounted
2. Determine and select the proper method of installation and location based on the instrument, environment and situation.
3. Plan and prepare support components for field-mounted instruments.
4. Install and describe the purpose of various valve manifold assemblies associated with the installation of field-mounted instruments.

PERFORMANCE TASKS

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

1. Fabricate a floor-mounted instrument stand.
2. Install an orifice plate between two flanges.
3. Assemble and install a thermowell assembly on a section of 4-inch process piping.
4. Identify selected pipe flange facings.
5. Identify selected pipe flange gaskets.
6. Install a three-valve manifold on a differential pressure transmitter using futbols.

NCCER STANDARDIZED CRAFT TRAINING PROGRAM

The National Center for Construction Education and Research (NCCER) provides a standardized national program of accredited craft training. Key features of the program include instructor certification, competency-based training, and performance testing. The program provides trainees, instructors, and companies with a standard form of recognition through a National Craft Training Registry. The program is described in full in the *Guidelines for Accreditation*, published by the NCCER. For more information on standardized craft training, contact the NCCER at P.O. Box 141104, Gainesville, FL 32614-1104, 352-334-0911, visit our Web site at www.nccer.org, or e-mail info@nccer.org.

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If you see the Teaching Tip icon, that means there is a teaching tip associated with this section. Also refer to any suggested teaching tips at the end of the module.

SAFETY CONSIDERATIONS

Ensure that the trainees are equipped with appropriate personal protective equipment. Review the safety procedures associated with welding. Make sure the trainees understand the importance of wearing eye protection and other protective equipment/clothing when working around any welding process.

PREPARATION

Before teaching this module, you should review the Module Outline, Objectives, Performance Tasks, and the Materials and Equipment List. Be sure to allow ample time to prepare your own training or lesson plan and gather all required equipment and materials.

MATERIALS AND EQUIPMENT LIST

Overhead projector and screen
Transparencies
Transparency pens
Blank acetate sheets
Markers/chalk
Whiteboard/chalkboard
Pencils and scratch paper
Appropriate personal protective equipment
Scribe
Dividers
Center punch
Hammer
Layout dye (optional)
Electric hacksaw or metal chop saw
Pipe cutter
Acetylene cutting torch
Hand grinder
Soapstone marker
Measuring tape
Try square or framing square
Pipe wraparound
2" carbon steel pipe
⅜" mild steel plate
SMAW welding machine or stick welder
Files
Deburring tool
Selection of concrete anchors
Drill
Drill bits
Fender washers
Orifice plate
Hydrometer
Capacitance probe
pH probe
Cable-mounted instrument support
Thermostat
Thermowell
4" carbon steel pipe
Various flange facings
Various flange gaskets
Futbols
Rod-out tool
Three-valve manifold
Wrenches
Module Examinations*
Performance Profile Sheets*

*Located in the Test Booklet.

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.

The Condensed Handbook of Measurement and Control, 1997. N.E. Battikha. Research Triangle Park, NC: The Instrumentation Society of America.

TEACHING TIME FOR THIS MODULE

An outline for use in developing your lesson plan is presented below. Note that each Roman numeral in the outline equates to one session of instruction. Each session has a suggested time period of 2½ hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 25 hours are suggested to cover *Installing Field-Mounted Instruments*. You will need to adjust the time required for hands-on activity and testing based on your class size and resources.

Topic	**Planned Time**
Session I. Introduction; Stand-Mounted Instruments	
A. Introduction	_____
B. Stand-Mounted Instruments	_____
1. Floor-Mounted Stands	_____
2. Wall-Mounted Stands	_____
3. Fabricating the Stand	_____
a. Tools and Materials Required	_____
b. Measuring, Cutting, and Assembling the Pipe and Plate	_____
4. Securing the Stand	_____
a. Securing to Concrete Floors	_____
b. Securing to Metal Grating Floors	_____
5. Mounting Instruments on Stands	_____
a. Instrument Locations	_____
Session II. Laboratory	
A. Laboratory	_____
Under your supervision, have the trainees fabricate a floor-mounted instrument stand. Note the proficiency of each trainee.	
Session III. Laboratory, Continued	
A. Laboratory	_____
Under your supervision, have the trainees continue to fabricate a floor-mounted instrument stand. Note the proficiency of each trainee.	
Session IV. In-Line Mounted Instruments	
A. In-Line Mounted Instruments	_____
1. Differential Pressure Flowmeters	_____
a. Orifice Plates, Flow Nozzles, and Venturi Tubes	_____
b. Laboratory	_____
Under your supervision, have the trainees install an orifice plate between two flanges. Note the proficiency of each trainee.	

Session V. In-Line Mounted Instruments, Continued _____

A. In-Line Mounted Instruments _____
   1. Velocity Flowmeters _____
      a. Turbine Flowmeters _____
      b. Vortex-Shedding Flowmeters _____
      c. Magnetic Flowmeters _____
      d. Ultrasonic Flowmeters _____
   2. Volumetric Flowmeters _____
      a. Rotary Vane
      b. Oval Gear _____
      c. Nutating Disc _____
   3. Mass Flowmeters _____
      a. Coriolis Mass Flowmeter _____
   4. Variable-Area Flowmeter (Rotameter) _____
      a. Rotameter Installation _____
   5. Density Meters _____
      a. Angular Position _____
      b. Hydrometers _____
      c. Sound Velocity _____
      d. Vibrating Plate _____
      e. Vibrating Tube _____

Session VI. Vessel-Mounted Instruments; Strap-Mounted Instruments; Insertion-Mounted Instruments _____

A. Vessel-Mounted Instruments _____
   1. Probe-Type Level Instruments _____
      a. Capacitance Probe (RF Probe) _____
      b. pH Probes _____
   2. Displacer-Type Level Instruments _____
      a. Chamber-Installed Displacers _____

B. Strap-Mounted Instruments _____
   1. Types of Supports _____
      a. Cable-Mounted Instrument Supports _____
   2 Thermostats and Heat Tracing _____
      a. Thermostatically Controlled Tracing _____
   3. Strapping _____
   4. Radiation Meters _____

C. Insertion-Mounted Instruments _____
   1. Thermowells _____
      a. Material _____
      b. Accuracy _____
      c. Tapered or Straight Shank _____
      d. Velocity Ratings _____
      e. Thermowell Insertion _____
   2. Connector Heads _____
   3. Installation _____
   4. Thermocouple Extension Wire _____
      a. Thermocouple Insulation _____
   5. Resistance Temperature Detectors _____

Session VII. Laboratory

A. Laboratory _____

Under your supervision, have the trainees assemble and install a thermowell on a section of 4-inch process piping. Note the proficiency of each trainee.

Session VIII. Flanges; Manifold Valve Assemblies

A. Flanges _____

1. Flange Sizes _____
2. Flange Pressure Rating _____
3. Flange Facings _____
4. Flange Gaskets _____
5. Methods of Joining Flanges _____
   a. Socket-Welded Flanges _____
   b. Screwed-Joint Flanges _____
   c. Butt-Welded Flanges _____
6. Laboratory _____

   Under your supervision, have the trainees identify selected pipe flange facings and gaskets. Note the proficiency of each trainee.

B. Manifold Valve Assemblies _____

1. Single-Valve Manifold _____
2. Two-Valve Manifold _____
3. Three-Valve Equalizer _____
4. Five-Valve Equalizer _____
5. Five-Valve Blowdown _____
6. Manifold Installation _____

Session IX. Laboratory

A. Laboratory _____

Under your supervision, have the trainees install a three-valve manifold on a differential pressure transmitter using futbols. Note the proficiency of each trainee.

Session X. Review; Module Examination and Performance Testing

A. Summary

1. Summarize module _____
2. Answer questions _____

B. Module Examination _____

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

C. Performance Testing _____

1. Trainees must perform each task to the satisfaction of the instructor to receive recognition from the NCCER.
2. Record the testing results on Craft Training Report Form 200 and submit the results to the Training Program Sponsor.

Grounding and Shielding of Instrumentation Wiring
Annotated Instructor's Guide

Module 12306-03

MODULE OVERVIEW

This module provides an overview of the grounding requirements for electrical systems. It also discusses the methods used to identify and minimize electrical noise in instrumentation systems.

PREREQUISITES

Please refer to the Course Map in the Trainee Module. Prior to training with this module, it is recommended that the trainee shall have successfully completed the following: Core Curriculum; Instrumentation Levels One and Two; Instrumentation Level Three, Modules 12301-03 through 12305-03.

OBJECTIVES

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

1. Define electrical system grounding.
2. List the reasons electrical systems are grounded.
3. Describe methods used to ground electrical systems.
4. Define noise in instrumentation systems.
5. Describe types of noise in instrumentation systems.
6. Identify sources of noise in instrumentation systems.
7. Apply shielding methods to reduce noise.

PERFORMANCE TASKS

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

1. Identify and explain the function of an equipment ground in a given drawing.
2. Draw an example of a ground loop.
3. Identify and explain the function of an equipment shield in a given drawing.

MATERIALS AND EQUIPMENT LIST

Overhead projector and screen
Transparencies
Whiteboard/chalkboard
Markers/chalk
Blank acetate sheets
Transparency pens
Latest edition of the *National Electrical Code®*
Pencils and scratch paper
Sample drawings
Appropriate personal protective equipment
Module Examinations*
Performance Profile Sheets*

* Located in the Test Booklet.

SAFETY CONSIDERATIONS

Ensure that the trainees are equipped with appropriate personal protective equipment.

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.

Grounding and Shielding in Instrumentation. Ralph Morrison. New York: John Wiley & Sons.

Grounding and Shielding in Facilities. Ralph Morrison. New York: John Wiley & Sons.

National Electrical Code®, 2002. 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 10 hours are suggested to cover *Grounding and Shielding of Instrumentation Wiring*. You will need to adjust the time required for hands-on activity and testing based on your class size and resources. Because laboratories often correspond to Performance Tasks, the proficiency of the trainees may be noted during these exercises for Performance Testing purposes.

Topic	**Planned Time**
Session I. Introduction; Overview of Electrical System Grounding	
A. Introduction	_____
B. Overview of Electrical System Grounding	_____
1. Grounding System Terminology	_____
2. General NEC Grounding Requirements	_____
3. System and Equipment Grounding	_____
4. Laboratory – Trainees identify and explain the function of an equipment ground in a given drawing. This laboratory corresponds to Performance Task 1.	
Session II. Direct Current Power; Noise/Electromagnetic Interference	
A. Direct Current Power	_____
1. DC Power Supplies	_____
B. Noise/Electromagnetic Interference	_____
1. Capacitive-Coupled Noise	_____
2. Inductive-Coupled Noise	_____
3. Directly Coupled Noise	_____
Session III. Cable Shielding and Grounding Techniques Used to Minimize EMI; Practical Instrument Shielding	
A. Cable Shielding and Grounding Techniques Used to Minimize EMI	_____
1. Cable Shields	_____
2. Preventing Ground Loops	_____
3. Laboratory – Trainees draw an example of a ground loop. This laboratory corresponds to Performance Task 2.	
4. Shield Termination	_____
5. Use of Multiple Shields	_____
6. Signal Cable Types	_____

B. Practical Instrument Shielding _____

1. Reducing Noise by Shielding _____
2. Laboratory – Trainees identify and explain the function of an equipment shield in a given drawing. This laboratory corresponds to Performance Task 3. _____
3. Installing Twisted Pair Shielded Wire _____

Session IV. Review; Module Examination; Performance Testing

A. Review _____

B. Module Examination _____

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

C. Performance Testing _____

1. Trainees must perform each task to the satisfaction of the instructor to receive recognition from the 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 defines the key properties of chemicals involved in instrumentation and identifies types of analyzers used at most industrial facilities to measure them. It includes chromatography and ultraviolet and infrared analyzers.

PREREQUISITES

Please refer to the Course Map in the Trainee Module. Prior to training with this module, it is recommended that the trainee shall have successfully completed the following:

Core Curriculum; Instrumentation Levels One through Three; Instrumentation Level Four Modules 12401-03 through 12407-03

OBJECTIVES

When you have completed this module, you will be able to do the following:

1. Define the following properties in a process or environment, and identify methods used to analyze them:
   - Density
   - Specific gravity
   - Viscosity
   - Turbidity
   - Flash point
   - Oxidation-reduction potential (ORP)
   - pH
   - Conductivity of a liquid
   - Oxygen (O_2)
   - Carbon monoxide (CO)
   - Carbon dioxide (CO_2)
   - Hydrogen sulfide (H_2S)
   - Total hydrocarbon content
   - Particulates in a clean room
2. Describe chromatography and its uses.
3. Describe ultraviolet analyzers and their uses.
4. Describe infrared analyzers and their uses.

PERFORMANCE TASKS

There are no performance tasks for this module.

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
Safety equipment
Viscosity test equipment
Fluids of various viscosities
Flash tester
Fluids with different flash points
pH probe
Oxidation-reduction potential (ORP) probe
Material safety data sheets (MSDSs)

Carbon monoxide detector
Hydrogen sulfide indicator
Analyzers
Sample gases
Hand tools
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. Emphasize good laboratory practices and proper disposal of waste.

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.

www.isa.org. The website of the Instrument Society of America.

The Condensed Handbook of Measurement and Control, 1997. N.E. Battikha. Research Triangle Park, NC: Instrument Society of America.

Industrial Pressure, Level & Density Measurement, 1995. Bela G. Liptak. Boca Raton, FL: CRC Press.

Instrumentation Reference Book, 2002. Walter Boyes. 3rd ed. Research Triangle Park, NC: Instrument Society of America.

Measurement & Instrumentation Principles, 2001. Alan S. Morris. Boston: Butterworth-Heinemann.

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 *Analyzers*. You will need to adjust the time required for hands-on activity and testing based on your class size and resources.

Topic	**Planned Time**
Session I. Introduction, Density, Specific Gravity, and Viscosity	
A. Introduction	_____
1. Classification	_____
2. Calibration	_____
B. Density and Specific Gravity	_____
1. Air Bubble Measurement	_____
2. Displacement Measurement	_____
3. Densitometer	_____
4. Nuclear Detectors	_____
C. Viscosity and Viscometers	_____
Session II. Turbidity and Flash Point	
A. Turbidity	_____
1. Jackson Turbidimeter	_____
2. Transmission Analyzer	_____
3. Reflection Analyzer	_____
4. Ratio Analyzer	_____
B. Flash Point	_____
1. Standardized Systems	_____
2. *OSHA 1910.106(a)*	_____

Session III. Oxidation-Reduction Potential and pH

A. Oxidation-Reduction Potential _____
   1. Probe Calibration _____
   2. Probe Maintenance _____
B. pH _____
   1. pH-Sensitive Electrodes _____
   2. Reference Electrodes _____

Session IV. Conductivity (of a Liquid) and Oxygen

A. Conductivity of a Liquid _____
   1. Electrodes _____
   2. Inductive Probes _____
B. Oxygen _____
   1. High-Temperature Electrochemical Sensors _____
   2. Paramagnetic Analyzers _____
   3. Galvanic Sensors _____

Session V. Carbon Monoxide, Carbon Dioxide, and Hydrogen Sulfide

A. Carbon Monoxide _____
B. Carbon Dioxide _____
   1. Emissions _____
   2. Monitoring _____
C. Hydrogen Sulfide _____
   1. Personnel Protection Indicators _____
   2. Semiconductor Sensors _____
   3. Electrochemical Sensors _____

Session VI. Total Hydrocarbon, Particulates, and Chemical Components

A. Total Hydrocarbon _____
B. Particulates _____
   1. Optical Microscopy _____
   2. Discrete Particle Counters _____
C. Chemical Components _____

Session VII. Infrared Radiation

A. Basic Theory _____
B. Affecting Factors _____
C. Sensing Equipment _____
D. Spectrometry _____

Session VIII. Ultraviolet Light Wave Absorption, Review, and Module Examination

A. Ultraviolet Light Wave Absorption _____
   1. Analysis _____
   2. Flame Detectors _____
B. Review _____
C. 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.