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.
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

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overhead projector and screen</td>
<td>Transparency pens</td>
</tr>
<tr>
<td>Transparencies</td>
<td>Pencils and scratch paper</td>
</tr>
<tr>
<td>Whiteboard/chalkboard</td>
<td>Appropriate personal protective equipment</td>
</tr>
<tr>
<td>Markers/chalk</td>
<td>Scientific calculator</td>
</tr>
<tr>
<td>Blank acetate sheets</td>
<td>Module Examinations*</td>
</tr>
</tbody>
</table>

* 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.


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.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Planned Time</th>
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<tbody>
<tr>
<td><strong>Session I. Introduction; Resistive Circuits</strong></td>
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<tr>
<td>A. Introduction</td>
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<tr>
<td>B. Resistive Circuits</td>
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</tr>
<tr>
<td>1. Resistances in Series</td>
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<tr>
<td>2. Resistances in Parallel</td>
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<tr>
<td>3. Series-Parallel Circuits</td>
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<tr>
<td><strong>Session II. Applying Ohm’s Law</strong></td>
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<tr>
<td>A. Applying Ohm’s Law in Series Circuits</td>
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<tr>
<td>B. Applying Ohm’s Law in Parallel Circuits</td>
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<tr>
<td>C. Applying Ohm’s Law in Series-Parallel Circuits</td>
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</tr>
<tr>
<td><strong>Session III. Kirchoff’s Laws</strong></td>
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<tr>
<td>A. Kirchoff’s Current Law</td>
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<tr>
<td>B. Kirchoff’s Voltage Law</td>
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<tr>
<td>C. Loop Equations</td>
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<tr>
<td><strong>Session IV. Introduction to Alternating Current</strong></td>
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<tr>
<td>A. Sine Wave Generation</td>
<td></td>
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<tr>
<td>B. Sine Wave Terminology</td>
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<tr>
<td><strong>Session V. AC Phase Relationships; Resistance in AC Circuits</strong></td>
<td></td>
</tr>
<tr>
<td>A. AC Phase Relationships</td>
<td></td>
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<tr>
<td>B. Resistance in AC Circuits</td>
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<tr>
<td><strong>Session VI. Inductance in AC Circuits; Capacitance</strong></td>
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<tr>
<td>A. Inductance in AC Circuits</td>
<td></td>
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<tr>
<td>B. Capacitance</td>
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<tr>
<td>1. Calculating Equivalent Capacitance</td>
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<tr>
<td>2. Voltage Rating</td>
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<tr>
<td>3. Leak Resistance</td>
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<tr>
<td>4. Capacitive Reactance</td>
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</tbody>
</table>
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.
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.


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.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Planned Time</th>
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</thead>
<tbody>
<tr>
<td><strong>Session I. Introduction; Metric Measurements</strong></td>
<td></td>
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<tr>
<td>A. Introduction</td>
<td></td>
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<tr>
<td>B. Metric Measurements</td>
<td></td>
</tr>
<tr>
<td>1. Converting Lengths</td>
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<td>2. Converting Areas</td>
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<tr>
<td>3. Converting Volumes</td>
<td></td>
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<tr>
<td>4. Wet Volume Measurements</td>
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<tr>
<td>C. Laboratory</td>
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</tr>
<tr>
<td>Have the trainees practice calculating the volume of a vessel. This laboratory corresponds to Performance Task 4.</td>
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<tr>
<td><strong>Session II. Metric Measurements (continued)</strong></td>
<td></td>
</tr>
<tr>
<td>A. Mass versus Weight</td>
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<tr>
<td>B. Pressure</td>
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<tr>
<td>1. Laboratory</td>
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<tr>
<td>Have the trainees practice calculating differential pressure. This laboratory corresponds to Performance Task 3.</td>
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<tr>
<td>C. Temperature</td>
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<tr>
<td>1. Laboratory</td>
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</tr>
<tr>
<td>Have the trainees practice finding the point where Fahrenheit equals Celsius. This laboratory corresponds to Performance Task 1.</td>
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<tr>
<td>D. Flow</td>
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</tr>
<tr>
<td><strong>Session III. Handheld Calculators; Instrumentation Applications</strong></td>
<td></td>
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<tr>
<td>A. Handheld Calculators and Instrumentation Applications</td>
<td></td>
</tr>
<tr>
<td>1. Squares and Square Roots</td>
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<tr>
<td>2. Auxiliary Functions</td>
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</tbody>
</table>
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.
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.


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.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Planned Time</th>
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<tbody>
<tr>
<td><strong>Session I. Introduction; Pressure</strong></td>
<td></td>
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<tr>
<td>A. Introduction</td>
<td></td>
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<tr>
<td>B. Pressure</td>
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</tr>
<tr>
<td>1. Units of Pressure Measurement</td>
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<tr>
<td>2. Pressure Measurement Devices</td>
<td></td>
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<tr>
<td>3. Conditions That Damage Pressure Elements</td>
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<tr>
<td>4. Pressure Element Protection Devices</td>
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<tr>
<td><strong>Session II. Flow</strong></td>
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<tr>
<td>A. Flow</td>
<td></td>
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<tr>
<td>1. Flow Measurement Units</td>
<td></td>
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<tr>
<td>2. Differential Pressure and Flow Relationship</td>
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<tr>
<td>3. Differential Pressure Flow Devices</td>
<td></td>
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<tr>
<td>4. Other Types of Flow Measurement Devices</td>
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<tr>
<td>5. Flow Device Installation Considerations</td>
<td></td>
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<tr>
<td><strong>Session III. Temperature</strong></td>
<td></td>
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<tr>
<td>A. Temperature</td>
<td></td>
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<tr>
<td>1. Temperature Scales</td>
<td></td>
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<tr>
<td>2. Temperature Measurement Devices</td>
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</tr>
</tbody>
</table>
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.
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*
- ISA 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.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Planned Time</th>
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<tbody>
<tr>
<td><strong>Session I. Introduction; Instrument Symbols and Identification</strong></td>
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<tr>
<td>A. Introduction</td>
<td></td>
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<tr>
<td>B. Instrument Symbols and Identification</td>
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<tr>
<td>1. Instrument Symbols</td>
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<tr>
<td>2. Instrument Tag Numbers and Identification Abbreviations</td>
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<tr>
<td>3. Graphic or Pictorial Instrument Symbols</td>
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<tr>
<td>4. Line Symbols</td>
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<tr>
<td><strong>Session II. Instrument Index</strong></td>
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<tr>
<td>A. Instrument Index</td>
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<tr>
<td><strong>Session III. General Instrument Specifications</strong></td>
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<tr>
<td>A. General Instrument Specifications</td>
<td></td>
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<tr>
<td><strong>Session IV. General Notes and Details; Installation Detail Drawings</strong></td>
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<tr>
<td>A. General Notes and Details</td>
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<tr>
<td>B. Installation Detail Drawings</td>
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<tr>
<td><strong>Session V. Location Drawings; Control Loops</strong></td>
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<tr>
<td>A. Location Drawings</td>
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<tr>
<td>B. Control Loops</td>
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<tr>
<td>C. Laboratory</td>
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<tr>
<td>Have the trainees practice locating and identifying drawing elements. This laboratory corresponds to Performance Task 1.</td>
<td></td>
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</tbody>
</table>
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

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

*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.


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 2 1⁄2 hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 22 1⁄2 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.

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

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.
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

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overhead projector and screen</td>
<td>Pencils and scratch paper</td>
</tr>
<tr>
<td>Transparencies</td>
<td>Appropriate personal protective equipment</td>
</tr>
<tr>
<td>Transparency pens</td>
<td>An assortment of relays, timers, and clocks</td>
</tr>
<tr>
<td>Blank acetate sheets</td>
<td>Hand tools for installing relays, timers, and clocks</td>
</tr>
<tr>
<td>Markers/chalk</td>
<td>Module Examinations*</td>
</tr>
<tr>
<td>Whiteboard/chalkboard</td>
<td>Performance Profile Sheets*</td>
</tr>
</tbody>
</table>

*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.

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.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Planned Time</th>
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</thead>
<tbody>
<tr>
<td><strong>Session I. Introduction; Electrical Relays; Laboratory</strong></td>
<td></td>
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<tr>
<td>A. Introduction</td>
<td></td>
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<tr>
<td>B. Electrical Relays</td>
<td></td>
</tr>
<tr>
<td>1. Electromechanical Relays</td>
<td></td>
</tr>
<tr>
<td>a. Reed Relays and Switches</td>
<td></td>
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<tr>
<td>b. General Purpose Relays</td>
<td></td>
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<tr>
<td>c. Control Relays in Instrumentation</td>
<td></td>
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<tr>
<td>2. Solid-State Relays</td>
<td></td>
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<tr>
<td>a. Comparison of Electromechanical Relays to Solid-State Relays</td>
<td></td>
</tr>
<tr>
<td>C. Laboratory</td>
<td></td>
</tr>
<tr>
<td>Under your supervision, have the trainees select and install various electric relays. Note the proficiency of each trainee.</td>
<td></td>
</tr>
<tr>
<td><strong>Session II. Pneumatic Relays, Repeaters, and Boosters; Laboratory; Timers and Time Clocks</strong></td>
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</tr>
<tr>
<td>A. Pneumatic Relays, Repeaters, and Boosters</td>
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</tr>
<tr>
<td>1. Force-Balance Transmitter Relays</td>
<td></td>
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<tr>
<td>2. Computing Relays</td>
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<tr>
<td>a. Pneumatic Multiplying and Dividing Relays</td>
<td></td>
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<tr>
<td>b. Pneumatic Adding, Subtracting, and Inverting Relays</td>
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<tr>
<td>c. Pneumatic Scaling and Proportioning Relays</td>
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<tr>
<td>d. High- and Low-Pressure Selector and High-Pressure Limiter Relays</td>
<td></td>
</tr>
<tr>
<td>e. Booster Relays</td>
<td></td>
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<tr>
<td>B. Laboratory</td>
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</tr>
<tr>
<td>Under your supervision, have the trainees select and install various pneumatic relays. Note the proficiency of each trainee.</td>
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</tr>
<tr>
<td>C. Timers and Time Clocks</td>
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<tr>
<td>1. Dashpot Timer Relays</td>
<td></td>
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<tr>
<td>2. Pneumatic Timers</td>
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<tr>
<td>3. Synchronous Time Switches</td>
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<tr>
<td>4. Solid State Timers</td>
<td></td>
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<tr>
<td><strong>Session III. Laboratory; Review; Module Examination and Performance Testing</strong></td>
<td></td>
</tr>
<tr>
<td>A. Laboratory</td>
<td></td>
</tr>
<tr>
<td>Under your supervision, have the trainees select and install various clocks and timers. Note the proficiency of each trainee.</td>
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<tr>
<td>B. Summary</td>
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<tr>
<td>1. Summarize module</td>
<td></td>
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<tr>
<td>2. Answer questions</td>
<td></td>
</tr>
<tr>
<td>C. Module Examination</td>
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</tbody>
</table>
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.

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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.

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.

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.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Planned Time</th>
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<tbody>
<tr>
<td><strong>Session I. Introduction; Switch Definition, Properties, and Description</strong></td>
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<tr>
<td>A. Introduction</td>
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<tr>
<td>B. Switch Definition, Properties, and Description</td>
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</tr>
<tr>
<td>1. Switch Definition</td>
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<tr>
<td>2. Switch Classifications</td>
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<tr>
<td>a. Switch Contacts</td>
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<tr>
<td>b. Pole of a Switch</td>
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<tr>
<td>c. Closed Positions or Throws of a Switch</td>
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<tr>
<td>d. Typical Switch Wiring</td>
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<tr>
<td>3. Switch Descriptions</td>
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<tr>
<td>a. Panel-Mounted Switches</td>
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<td>b. Float Level Switches</td>
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<td>c. Pressure Switches</td>
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<tr>
<td>d. Limit Switches</td>
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<tr>
<td>e. Electronic Switches (SCRs)</td>
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<tr>
<td>4. Laboratory</td>
<td></td>
</tr>
<tr>
<td>Under your supervision, have the trainees select and install various switches. Note the proficiency of each trainee.</td>
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</tr>
<tr>
<td><strong>Session II. Photoelectric Devices; Proximity Sensors; Summary; Module Examination and Performance Testing</strong></td>
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<tr>
<td>A. Photoelectric Devices</td>
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<tr>
<td>1. Photocell Switches</td>
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<tr>
<td>2. Solar Cells</td>
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<td>3. Infrared Devices</td>
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<tr>
<td>a. Motion Detectors</td>
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<td>b. Industrial Process IR Sensors</td>
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<tr>
<td>4. Fiber Optics</td>
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<tr>
<td>5. Laboratory</td>
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</tr>
<tr>
<td>Under your supervision, have the trainees select and install various photoelectric devices. Note the proficiency of each trainee.</td>
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<tr>
<td>B. Proximity Sensors</td>
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<tr>
<td>C. Summary</td>
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</tr>
<tr>
<td>1. Summarize module</td>
<td></td>
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<tr>
<td>2. Answer questions</td>
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<tr>
<td>D. Module Examination</td>
<td></td>
</tr>
<tr>
<td>1. Trainees must score 70% or higher to receive recognition from the NCCER.</td>
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<tr>
<td>2. Record the testing results on Craft Training Report Form 200 and submit the results to the Training Program Sponsor.</td>
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<tr>
<td>E. Performance Testing</td>
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</tr>
<tr>
<td>1. Trainees must perform each task to the satisfaction of the instructor to receive recognition from the NCCER.</td>
<td></td>
</tr>
<tr>
<td>2. Record the testing results on Craft Training Report Form 200 and submit the results to the Training Program Sponsor.</td>
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</tbody>
</table>
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
- 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
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.


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.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Planned Time</th>
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<tbody>
<tr>
<td>Session I. Introduction; Sizes and Types of Tubing</td>
<td></td>
</tr>
<tr>
<td>A. Introduction</td>
<td></td>
</tr>
<tr>
<td>B. Sizes and Types of Tubing</td>
<td></td>
</tr>
<tr>
<td>1. General Sizing Measurements for Tubing</td>
<td></td>
</tr>
<tr>
<td>2. Tubing Materials</td>
<td></td>
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<tr>
<td>3. Tubing Standards and Specifications</td>
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</tbody>
</table>

* Located in the back of this module
**Located in the Test Booklet

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**
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.
MODULAR 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

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overhead projector and screen</td>
<td>1</td>
</tr>
<tr>
<td>Transparencies</td>
<td>1</td>
</tr>
<tr>
<td>Blank acetate sheets</td>
<td>1</td>
</tr>
<tr>
<td>Transparency pens</td>
<td>1</td>
</tr>
<tr>
<td>Whiteboard/chalkboard</td>
<td>1</td>
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<tr>
<td>Markers/chalk</td>
<td>1</td>
</tr>
<tr>
<td>Pencils and scratch paper</td>
<td>1</td>
</tr>
<tr>
<td>Appropriate personal protective equipment</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Item</th>
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<tbody>
<tr>
<td>Bubbler leak tester</td>
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<tr>
<td>Liquid bubble test fluid</td>
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</tr>
<tr>
<td>Access to a system to perform blowdown/purge and pressure leak tests</td>
<td>1</td>
</tr>
<tr>
<td>Trade Terms Quiz*</td>
<td>1</td>
</tr>
<tr>
<td>Module Examinations**</td>
<td>1</td>
</tr>
<tr>
<td>Performance Profile Sheets**</td>
<td>1</td>
</tr>
</tbody>
</table>

* 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.


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.

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


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.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Planned Time</th>
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</thead>
<tbody>
<tr>
<td><strong>Session I. Introduction to Layout</strong></td>
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<tr>
<td>A. Introduction</td>
<td>____________</td>
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<tr>
<td>B. Layout</td>
<td>____________</td>
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<tr>
<td>1. Layout Preparation</td>
<td>____________</td>
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<tr>
<td>2. Piping System Layout Considerations</td>
<td>____________</td>
</tr>
<tr>
<td>3. Developing an Isometric Sketch</td>
<td>____________</td>
</tr>
<tr>
<td>C. Laboratory</td>
<td>____________</td>
</tr>
<tr>
<td>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.</td>
<td></td>
</tr>
<tr>
<td><strong>Session II. Measuring and Bending Tubing and Piping</strong></td>
<td></td>
</tr>
<tr>
<td>A. Determining Initial Bend Position and Angle</td>
<td>____________</td>
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<tr>
<td>B. Locating the Bend Position on Tubing</td>
<td>____________</td>
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<tr>
<td>C. Pipe and Tube Cutting Tools</td>
<td>____________</td>
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<tr>
<td>D. Bender Selection</td>
<td>____________</td>
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<tr>
<td>E. Using a Compression Tube Bender</td>
<td>____________</td>
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<tr>
<td>F. Adjustment (Gain) Calculations</td>
<td>____________</td>
</tr>
</tbody>
</table>

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*
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.
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.


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.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Planned Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Session I. Introduction; Semiconductor Fundamentals; Diodes</td>
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</tr>
<tr>
<td>A. Introduction</td>
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<tr>
<td>B. Semiconductor Fundamentals</td>
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<tr>
<td>C. Diodes</td>
<td></td>
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<tr>
<td>D. Laboratory</td>
<td>Have trainees practice building a simple bridge rectifier circuit and viewing the results. This laboratory corresponds to Performance Task 2.</td>
</tr>
<tr>
<td>E. Light-Emitting Diodes</td>
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<tr>
<td>F. Photo Diodes</td>
<td></td>
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<tr>
<td>G. Zener Diodes</td>
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<tr>
<td>H. Laboratory</td>
<td>Have trainees check diodes for proper operation. This laboratory corresponds to Performance Task 3.</td>
</tr>
<tr>
<td>Session II. Transistors and SCRs</td>
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<tr>
<td>A. Transistors</td>
<td></td>
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<tr>
<td>B. Silicon-Controlled Rectifiers</td>
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<tr>
<td>Session III. Diacs; Triacs; Printed Circuit Boards</td>
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<tr>
<td>A. Diacs</td>
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<tr>
<td>B. Triacs</td>
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<tr>
<td>C. Printed Circuit Boards</td>
<td></td>
</tr>
<tr>
<td>D. Laboratory</td>
<td>Have trainees practice identifying a substitute for an electronic component. This laboratory corresponds to Performance Task 1.</td>
</tr>
</tbody>
</table>
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.

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.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Planned Time</th>
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<tbody>
<tr>
<td><strong>Session I. Introduction; P&amp;IDs Relating to Panel-Mounted Instruments; Laying Out Panel-Mounted Instruments</strong></td>
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<tr>
<td>A. Introduction</td>
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<tr>
<td>B. P&amp;IDs Relating to Panel-Mounted Instruments</td>
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<tr>
<td>1. P&amp;ID Symbology</td>
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<tr>
<td>C. Laying Out Panel-Mounted Instruments</td>
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<tr>
<td>1. Accessibility</td>
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<td>2. Safety</td>
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<tr>
<td>3. Developing a Layout Template</td>
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<tr>
<td>4. Selecting the Proper Layout Tools</td>
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<tr>
<td>a. Scribers</td>
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<tr>
<td>b. Steel Rules</td>
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<td>c. Steel Squares</td>
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<tr>
<td>d. Combination Sets</td>
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<tr>
<td>e. Dividers</td>
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<td>f. Prick Punches</td>
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<td>g. Center Punches</td>
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<tr>
<td>h. Toolmakers’ Hammers</td>
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<tr>
<td>i. Straightedges</td>
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<tr>
<td>j. Layout Dye (Blueing)</td>
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<tr>
<td>5. Completing the Layout</td>
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<tr>
<td>a. Manufacturers’ Templates</td>
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<tr>
<td>b. Creating a Template</td>
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<tr>
<td><strong>Session II. Selecting the Proper Installation Tools; Making the Panel Cutout and Installing the Instrument</strong></td>
<td></td>
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<tr>
<td>A. Selecting the Proper Installation Tools</td>
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<tr>
<td>1. Hydraulic Knockout Punches</td>
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<tr>
<td>2. Power Shears and Nibblers</td>
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<tr>
<td>B. Making the Panel Cutout and Installing the Instrument</td>
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<tr>
<td><strong>Session III. Laboratory; Summary; Module Examination and Performance Testing</strong></td>
<td></td>
</tr>
<tr>
<td>A. Laboratory</td>
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<tr>
<td>Under your supervision, have the trainees lay out an instrument panel and install an instrument on the panel. Note the proficiency of each trainee.</td>
<td></td>
</tr>
<tr>
<td>B. Summary</td>
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</tr>
<tr>
<td>1. Summarize module</td>
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<tr>
<td>2. Answer questions</td>
<td></td>
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<tr>
<td>C. Module Examination</td>
<td></td>
</tr>
<tr>
<td>1. Trainees must score 70% or higher to receive recognition from the NCCER.</td>
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</tr>
<tr>
<td>2. Record the testing results on Craft Training Report Form 200 and submit the results to the Training Program Sponsor.</td>
<td></td>
</tr>
</tbody>
</table>
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 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.

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 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
- ½" 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.


### 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.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Planned Time</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Session I. Introduction; Stand-Mounted Instruments</strong></td>
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<tr>
<td>A. Introduction</td>
<td></td>
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<tr>
<td>B. Stand-Mounted Instruments</td>
<td></td>
</tr>
<tr>
<td>1. Floor-Mounted Stands</td>
<td></td>
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<tr>
<td>2. Wall-Mounted Stands</td>
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<tr>
<td>3. Fabricating the Stand</td>
<td></td>
</tr>
<tr>
<td>a. Tools and Materials Required</td>
<td></td>
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<tr>
<td>b. Measuring, Cutting, and Assembling the Pipe and Plate</td>
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<tr>
<td>4. Securing the Stand</td>
<td></td>
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<tr>
<td>a. Securing to Concrete Floors</td>
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<tr>
<td>b. Securing to Metal Grating Floors</td>
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<tr>
<td>5. Mounting Instruments on Stands</td>
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<tr>
<td>a. Instrument Locations</td>
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<tr>
<td><strong>Session II. Laboratory</strong></td>
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<tr>
<td>A. Laboratory</td>
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<tr>
<td>Under your supervision, have the trainees fabricate a floor-mounted instrument stand. Note the proficiency of each trainee.</td>
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<tr>
<td><strong>Session III. Laboratory, Continued</strong></td>
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<tr>
<td>A. Laboratory</td>
<td></td>
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<tr>
<td>Under your supervision, have the trainees continue to fabricate a floor-mounted instrument stand. Note the proficiency of each trainee.</td>
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<tr>
<td><strong>Session IV. In-Line Mounted Instruments</strong></td>
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<tr>
<td>A. In-Line Mounted Instruments</td>
<td></td>
</tr>
<tr>
<td>1. Differential Pressure Flowmeters</td>
<td></td>
</tr>
<tr>
<td>a. Orifice Plates, Flow Nozzles, and Venturi Tubes</td>
<td></td>
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<tr>
<td>b. Laboratory</td>
<td></td>
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<tr>
<td>Under your supervision, have the trainees install an orifice plate between two flanges. Note the proficiency of each trainee.</td>
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</tbody>
</table>
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.
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 | Latest edition of the National Electrical Code® |
| Transparencies               | Pencils and scratch paper                      |
| Whiteboard/chalkboard       | Sample drawings                                |
| Markers/chalk               | Appropriate personal protective equipment      |
| Blank acetate sheets         | Module Examinations*                           |
| Transparency pens           | 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.

*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.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Planned Time</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Session I. Introduction; Overview of Electrical System Grounding</strong></td>
<td></td>
</tr>
<tr>
<td>A. Introduction</td>
<td></td>
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<tr>
<td>B. Overview of Electrical System Grounding</td>
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</tr>
<tr>
<td>1. Grounding System Terminology</td>
<td>____________</td>
</tr>
<tr>
<td>2. General NEC Grounding Requirements</td>
<td>____________</td>
</tr>
<tr>
<td>3. System and Equipment Grounding</td>
<td>____________</td>
</tr>
<tr>
<td>4. Laboratory – Trainees identify and explain the function of an equipment ground in a given drawing. This laboratory corresponds to Performance Task 1.</td>
<td>____________</td>
</tr>
<tr>
<td><strong>Session II. Direct Current Power; Noise/Electromagnetic Interference</strong></td>
<td></td>
</tr>
<tr>
<td>A. Direct Current Power</td>
<td>____________</td>
</tr>
<tr>
<td>1. DC Power Supplies</td>
<td></td>
</tr>
<tr>
<td>B. Noise/Electromagnetic Interference</td>
<td>____________</td>
</tr>
<tr>
<td>1. Capacitive-Coupled Noise</td>
<td>____________</td>
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<tr>
<td>2. Inductive-Coupled Noise</td>
<td>____________</td>
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<tr>
<td>3. Directly Coupled Noise</td>
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</tr>
<tr>
<td><strong>Session III. Cable Shielding and Grounding Techniques Used to Minimize EMI; Practical Instrument Shielding</strong></td>
<td></td>
</tr>
<tr>
<td>A. Cable Shielding and Grounding Techniques Used to Minimize EMI</td>
<td>____________</td>
</tr>
<tr>
<td>1. Cable Shields</td>
<td>____________</td>
</tr>
<tr>
<td>2. Preventing Ground Loops</td>
<td>____________</td>
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<tr>
<td>3. Laboratory – Trainees draw an example of a ground loop. This laboratory corresponds to Performance Task 2.</td>
<td>____________</td>
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<tr>
<td>4. Shield Termination</td>
<td>____________</td>
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<tr>
<td>5. Use of Multiple Shields</td>
<td>____________</td>
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<tr>
<td>6. Signal Cable Types</td>
<td>____________</td>
</tr>
</tbody>
</table>
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 (O₂)
   - Carbon monoxide (CO)
   - Carbon dioxide (CO₂)
   - Hydrogen sulfide (H₂S)
   - 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

<table>
<thead>
<tr>
<th>Material/Equipment</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overhead projector and screen</td>
<td>Safety equipment</td>
</tr>
<tr>
<td>Transparencies</td>
<td>Viscosity test equipment</td>
</tr>
<tr>
<td>Blank acetate sheets</td>
<td>Fluids of various viscosities</td>
</tr>
<tr>
<td>Transparency pens</td>
<td>Flash tester</td>
</tr>
<tr>
<td>Whiteboard/chalkboard</td>
<td>Fluids with different flash points</td>
</tr>
<tr>
<td>Markers/chalk</td>
<td>pH probe</td>
</tr>
<tr>
<td>Pencils and scratch paper</td>
<td>Oxidation-reduction potential (ORP) probe</td>
</tr>
<tr>
<td>Appropriate personal protective equipment</td>
<td>Material safety data sheets (MSDSs)</td>
</tr>
</tbody>
</table>
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.


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.

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

*Located in the Test Booklet.
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.