MODULE OVERVIEW

This module covers common systems of measurement, unit conversions, and the use of calculators.

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

OBJECTIVES

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

1. Identify similar units of measurement in both the English and metric systems and identify which units are larger.
2. Convert measured values in the English system, using common conversion factor tables, to equivalent metric values.
3. Use a handheld calculator to perform the basic mathematical operations necessary in instrumentation.
4. Use a handheld calculator to square numbers and find the square root of numbers.
5. Perform the mathematical conversions necessary for instrumentation measurements.

PERFORMANCE TASKS

There are no performance tasks for this module

NCCER STANDARDIZED CRAFT TRAINING PROGRAM

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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
English ruler (12")
Metric rule (20 cm or larger)
Water level (optional)
Barometer
Thermometer with Celsius and Fahrenheit scales
Calculator
Module Examinations*
Performance Profile Sheets*

* Single-module AIG purchases include the printed exam and performance task sheet. If you have purchased the perfect-bound version of this title, download these materials from the IRC using your access code.

ADDITIONAL RESOURCES

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

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

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

TEACHING TIME FOR THIS MODULE

An outline for use in developing your lesson plan is presented below. Note that each Roman numeral in the outline equates to one session of instruction. Each session has a suggested time period of 2½ hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 15 hours are suggested to cover *Craft-Related Mathematics*. You will need to adjust the time required for hands-on activity and testing based on your class size and resources.

Topic	**Planned Time**
Session I. Introduction; Metric Measurements	
A. Introduction	_____
B. Metric Measurements	_____
1. Converting Lengths	_____
2. Converting Areas	_____
3. Converting Volumes	_____
4. Wet Volume Measurements	_____
Session II. Mass versus Weight; Pressure	
A. Mass versus Weight	_____
1. Mass	_____
2. Weight (Force)	_____
B. Pressure	_____
1. The Pascal	_____
2. Hydrostatic Pressures	_____
3. Units of Hydrostatic Pressure	_____
Session III. Temperature; Flow	
A. Temperature	_____
1. Temperature Scales	_____
2. Temperature Conversions	_____
B. Flow	_____
1. Units of Flow	_____
2. Flow Characteristics	_____
Session IV. Hand-Held Calculators and Instrumentation Applications	
A. Hand-Held Calculators and Instrumentation Applications	_____
1. Squares and Square Roots	_____
2. Auxiliary Functions	_____
a. Polarity Conversion	_____
b. Memory	_____
Session 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	_____

Session VI. Temperature Measurement Conversions; Review; Module Examination

A. Temperature Measurement Conversions _____

B. Summary

1. Summarize module _____
2. Answer Questions _____

C. Module Examination _____

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

MODULE OVERVIEW

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

PREREQUISITES

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, Module 12201-03

OBJECTIVES

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

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

PERFORMANCE TASKS

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

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

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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
Sample one-line diagrams, electrical raceway drawings, P&IDs, and loop sheets
Module Examinations*
Performance Profile Sheets*

* Single-module AIG purchases include the printed exam and performance task sheet. If you have purchased the perfect-bound version of this title, download these materials from the IRC using your access 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 20 hours are suggested to cover *Instrumentation Drawings and Documentations, Part Two*. You will need to adjust the time required for hands-on activity and testing based on your class size and resources.

Topic **Planned Time**

Session I. Introduction; Electrical Drawings

A. Introduction _____

B. Electrical Drawings _____

1. Block Diagrams _____
2. Single- and Three-Line Diagrams
   a. Laboratory _____
      Under your supervision, have the trainees trace the circuit flow on a one-line diagram. Note the proficiency of each trainee.
3. Wiring Diagrams _____
   a. Point-to-Point Method _____
   b. Cable Method _____
   c. Baseline Method _____
   d. Lineless (Wireless) Method _____

Session II. Raceway Drawings; Schematic Diagrams

A. Raceway Drawings _____

1. Laboratory _____
   Under your supervision, have the trainees read and interpret a raceway drawing. Note the proficiency of each trainee.

B. Schematic Diagrams _____

Session III. Piping and Instrumentation Drawings (P&IDs)

A. Piping and Instrumentation Drawings (P&IDs) _____

1. Laboratory _____
   Under your supervision, have the trainees read and interpret a piping and instrumentation drawing (P&ID).

Session IV. Loop Sheets

A. Loop Sheets _____

1. Instrument Tag Numbers _____
2. Location and Connection Section _____
3. Calibration and Specification Section _____
4. Field Checklist _____
5. Laboratory _____

   Under your supervision, have the trainees read and interpret a loop sheet. Note the proficiency of each trainee.

Session V. Logic/Ladder Diagrams; Equipment Location Drawings; Installation Detail Drawings

A. Logic/Ladder Diagrams _____

B. Equipment Location Drawings _____

C. Installation Detail Drawings _____

Session VI. Flow Drawings; Instrument Data Sheets; Applying the Diagrams

A. Flow Drawings _____

B. Instrument Data Sheets _____

C. Applying the Diagrams _____

Session VII. Standardized Design Methods

A. Standardized Design Methods _____
   1. Electrical Symbols _____
   2. Instrumentation Symbols _____
   3. Number Systems _____
   4. Notes _____
   5. Graphic Styles _____

Session VIII. 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 safety precautions and procedures associated with various welding processes. It covers shielded metal arc welding, orbital welding, gas tungsten arc welding, gas metal arc welding, and oxyacetylene welding. It also introduces basic types of welded fittings and describes welding applications for instrumentation.

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 and 12202-03

OBJECTIVES

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

1. Define stick and orbital tube welding principles, procedures and applications.
2. Identify TIG and MIG welding principles, procedures, and applications.
3. Identify brazing principles, procedures, and applications.
4. Identify types of fittings that are welded.
5. Identify and demonstrate proper use of personal protective equipment.

PERFORMANCE TASKS

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

1. Select and apply the safety equipment required for welding.
2. Safely transport and set up welding equipment.
3. Attach equipment to cylinders.
4. Open cylinder valves and adjust the pressure.
5. Properly shut down and secure welding equipment.

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SAFETY CONSIDERATIONS

Ensure that the trainees are equipped with appropriate personal protective equipment. Emphasize that special training and equipment are required when using welding 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, including:
- Leather apron, sleeves, jacket, and chaps
- Leather welding gloves
- Goggles, helmets, and face shields
- Earmuffs and earplugs
- Welding shield
- Welding blanket

Electrode holders
Work leads
Workpiece clamps
Welding electrodes
Oxyacetylene welding equipment and accessories
Module Examinations*
Performance Profile Sheets*

* Single-module AIG purchases include the printed exam and performance task sheet. If you have purchased the perfect-bound version of this title, download these materials from the IRC using your access code.

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.

Metals and How to Weld Them, 1976. Cleveland, Ohio: James F. Lincoln Arc Welding Foundation.
Modern Welding, 1980. South Holland, IL: The Goodheart-Willcox Company, Inc.
Technical Guide for Gas Tungsten Arc Welding, EW-740, ITW/Hobart Welders, Troy, OH

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

Topic **Planned Time**

Session I. Introduction; Welding Safety; Principles and Procedures of Shielded Metal Arc Welding (SMAW)

A. Introduction _____
B. Welding Safety _____
   1. Clothes for Welding _____
      a. Protective Leather Clothing _____
      b. Welding Gloves _____
   2. Eye Protection _____
   3. Ear Protection _____
   4. Laboratory _____
      a. Under your supervision, have the trainees practice putting on safety equipment. Note the proficiency of each trainee. _____
C. Principles and Procedures of Shielded Metal Arc Welding (SMAW) _____
   1. Equipment, Power Source, and Current _____
      a. Electrodes _____

Session II. Principles of Orbital Welding; Principles and Procedures of Gas Tungsten Arc Welding (GTAW); Principles and Procedures of Gas Metal Arc Welding (GMAW)

A. Principles of Orbital Welding _____
   1. Orbital Welding Equipment and Accessories _____
      a. Orbital Welding Power Supplies _____
      b. Orbital Welding Weld Heads _____
      c. Electrodes for Orbital Welding _____
      d. Shield Gases and Purge Gases _____
   2. Advantages of Orbital Welding _____
   3. Applications of Orbital Welding _____
   4. Orbital Welding Basics and Setup _____
      a. The Process _____
      b. Fit-Up and Alignment _____
      c. Parameters _____
B. Principles and Procedures of Gas Tungsten Arc Welding (GTAW) _____
   1. Methods of Application, Equipment, and Power Source _____
   2. Shielding Gases, Electrodes, and Filler Metal _____
C. Principles and Procedures of Gas Metal Arc Welding (GMAW) _____
   1. Methods of Application, Equipment, and Power Source _____
   2. Shielding Gases, Electrodes, and Metal Transfer _____

Session III. Principles and Procedures for Brazing and Oxyacetylene Welding; Types of Welded Fittings

A. Principles and Procedures for Brazing and Oxyacetylene Welding _____
   1. Method of Operation and Equipment _____
      a. Torch Tips _____
      b. Regulators _____
      c. Gases and Gas Cylinders _____
   B. Types of Welded Fittings _____
      1. Socket Weld Fittings _____
      2. Butt Weld Fittings _____
      3. Copper Solder Joint Fittings _____

Session IV. Welding Applications for Instrumentation; Review; Module Examination and Performance Testing

A. Welding Applications for Instrumentation _____
B. Summary
   1. Summarize module _____
   2. Answer questions _____
C. Module Examination _____
   1. Trainees must score 70% or higher to receive recognition from the NCCER.
   2. Record the testing results on Craft Training Report Form 200 and submit the results to the Training Program Sponsor.
D. Performance Testing _____
   1. Trainees must perform each task to the satisfaction of the instructor to receive recognition from the NCCER.
   2. Record the testing results on Craft Training Report Form 200 and submit the results to the Training Program Sponsor.

MODULE OVERVIEW

This module covers the basic components and principles of operation of typical control systems found in industrial settings. It discusses common modes of control and their advantages and disadvantages. Applications are reviewed to reinforce an understanding of fundamentals as well as major types of controls, individual components, and their roles in typical control loops.

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 12203-03

OBJECTIVES

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

1. Define process measurement and control.
2. Explain process characteristics that demand process control.
3. Describe the elements of an instrumentation channel, including:
   - Detector (sensor)
   - Transducer
   - Amplifier or signal conditioner
   - Transmitter
   - Controller
   - Final element (control valve)
4. Define and describe process control loop types, including:
   - Feedforward
   - Feedback
   - Cascade
   - Ratio
5. Define and describe process controller modes, including:
   - On-off control (two-position control)
   - Modulating control
     – Proportional (P)
     – Integral (I)
     – Derivative (D)
     – Proportional plus integral (PI)
     – Proportional plus derivative (PD)
     – Proportional plus integral plus derivative (PID)
6. Discuss various types of process control applications and loops.

PERFORMANCE TASKS

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

1. Draw and accurately label a block diagram for a basic process control loop.
2. From a piping and instrumentation drawing (P&ID), identify the major components of each of these process control loops:
   - Feedforward
   - Feedback
   - Cascade
   - Ratio

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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
Straightedge
Appropriate personal protective equipment
Sample process control loops, P&IDs, and typical instrumentation documentation
Module Examinations*
Performance Profile Sheets*

* Single-module AIG purchases include the printed exam and performance task sheet. If you have purchased the perfect-bound version of this title, download these materials from the IRC using your access code.

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.

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

Latest Standards on Terminology and Symbols, Instrument Society of America.

The Condensed Handbook of Measurement and Control, 1976. N.E. Battikha. Instrument Society of America.

Measurement and Control Basics, 2002. T.A. Hughes. Instrumentation Society of America.

TEACHING TIME FOR THIS MODULE

An outline for use in developing your lesson plan is presented below. Note that each Roman numeral in the outline equates to one session of instruction. Each session has a suggested time period of 2½ hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 20 hours are suggested to cover *Process Control Theory*. You will need to adjust the time required for hands-on activity and testing based on your class size and resources.

Topic **Planned Time**

Session I. Introduction; Process Characteristics; The Process Control System

A. Introduction _____
B. Process Characteristics _____
C. The Process Control System _____

Session II. Components of an Instrument Channel

A. Components of an Instrument Channel _____
1. Detector/Sensor _____
a. Direct vs. Inferred Measurements _____
2. Transducer _____
3. Amplifier/Signal Conditioner _____
4. Transmitter _____
5. Controller _____
6. Final Control Element (Control Valve) _____
a. Pneumatic Control Valve Actuators _____
b. Manual Actuators _____
c. Valve Positioners _____
d. Electric Proportional Valve Actuators _____
e. Solenoid Actuators _____

Session III. Control Loops

A. Control Loops _____
1. Feedforward Control (Open-Loop) _____
2. Feedback Control (Closed-Loop) _____
a. Operation of Closed-Loop Control _____
b. Performance of a Closed-Loop System _____
c. Criteria for Closed-Loop Control Quality _____
3. Cascade Control _____
4. Ratio Control _____

Session IV. Laboratory

A. Laboratory _____
Under your supervision, have the trainees identify the major components of feedforward, feedback, cascade, and ratio process control loops from a P&ID. Note the proficiency of each trainee.

Session V. Control Modes

A. Control Modes _____
1. On-Off Control (Two-Position Control) _____
a. On-Off Control Characteristics _____
2. Modulating Control _____
a. Proportional (Gain or P) Control _____
b. Integral (Reset or I) Control _____
c. Derivative (Rate or D) Control _____
d. Proportional Plus Integral (PI) Control _____

e. Proportional Plus Derivative (PD) Controllers _____
f. Proportional Plus Integral Plus Derivative (PID) Controllers _____

Session VI. Types of Control Applications

A. Types of Control Applications _____
1. Typical Temperature Control Loops _____
a. Pneumatic Temperature Control Loops _____
b. Electronic Temperature Control Loops _____
2. Typical Pressure Control Loops _____
a. Pneumatic Pressure Control Loops _____
b. Electronic Pressure Control Loops _____
3. Typical Flow Control Loops _____
a. Pneumatic Flow Control Loops _____
b. Electronic Flow Control Loops _____
4. Typical Level Control Loops _____
a. Pneumatic Level Control Loops _____
b. Electronic Level Control Loops _____

Session VII. Laboratory

A. Laboratory _____
Under your supervision, have the trainees draw and label a block diagram for a basic process control loop. Note the proficiency of each trainee.

Session VIII. Summary; Module Examination and Performance Profile Examination

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.

Detectors, Secondary Elements, Transducers, and Transmitters Annotated Instructor's Guide

Module 12205-03

MODULE OVERVIEW

This module covers the function and operation of detectors, transducers, amplifiers, transmitters, and secondary elements. It also describes the wiring diagrams associated with 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. Identify the following primary elements (detectors) and describe their operation:
   - Orifice plate
   - Pitot tube
   - Bimetallic strip device
   - Thermocouple
2. Identify the following secondary elements and describe their operation:
   - Bourdon tube
   - Diaphragm device
   - Pressure capsule
   - Bellows device
3. Define an I/P and a P/I transducer and describe their operation.
4. Describe the operation of a strain gauge.
5. Identify a pneumatic DP transmitter and an electronic DP transmitter and describe their operation.
6. Identify the following primary components in a DP cell transmitter:
   - Process measuring section (hi and lo sides)
   - Force bar section
   - Flapper-nozzle (pneumatic only)
   - Pneumatic relay (pneumatic only)
   - Input/output sections (pneumatic and electronic)
7. Draw a one-line diagram including a measuring element, transducer, and transmitter.

PERFORMANCE TASKS

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

1. Given a measurement element, discuss the operation, advantages, and disadvantages of the device. Discuss at least three different devices.
2. Analyze the operation of a pressure-to-current transducer based on a diagram of the transducer. Point out the inlet and outlet ports and describe the installation procedure.
3. Draw a diagram containing the following devices:
   - Transducer
   - Electronic transmitter
   - Thermocouple as the primary element
   - Pneumatic receiver as the final element

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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
Straightedge
Appropriate personal protective equipment
Detectors, transducers, amplifiers, and transmitters
Wiring diagrams for detectors, transducers, amplifiers, and transmitters
Pressure-to-current transducer diagram
Module Examinations*
Performance Profile Sheets*

* Single-module AIG purchases include the printed exam and performance task sheet. If you have purchased the perfect-bound version of this title, download these materials from the IRC using your access code.

ADDITIONAL RESOURCES

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

Process Measurement Fundamentals, 1997. GPS.

Basic Instrumentation, 1966. Patrick J. Higgins. McGraw-Hill Book Company.

Instrumentation, 1975. Franklin Kirk and N.R. Rimboi. American Technical Society.

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 *Detectors, Secondary Elements, Transducers, & Transmitters*. You will need to adjust the time required for hands-on activity and testing based on your class size and resources.

Topic	**Planned Time**
Session I. Introduction	
A. Introduction	_____
1. Review of Basic Instrument Control Channels	_____
a. Detector (Sensor)	_____
b. Transducer/Converter	_____
c. Amplifier (Signal Conditioner)	_____
d. Transmitter	_____
2. Review of Measurement Terminology	_____
a. Accuracy	_____
b. Precision versus Accuracy	_____
c. Measurement Errors	_____
d. Reproducibility and Drift	_____
e. Sensitivity and Responsiveness	_____
3. Standards and Elements of Measurement	_____
a. Direct versus Inferred Measurements	_____
b. Measurement Standards	_____
c. Primary Standards	_____
d. Secondary Standards	_____
e. Working Standards	_____
f. Primary and Secondary Elements	_____
g. Calibration	_____
h. Significant Figures	_____
Session II. Detectors	
A. Detectors	_____
1. Orifice Plates	_____
2. Venturi Tubes	_____
3. Pitot Tubes	_____
4. Annubar Tubes	_____
5. Magnetic Flowmeters	_____
6. Ultrasonic Flowmeters	_____
Session III. Detectors, Continued	
A. Detectors	_____
1. Capacitance-Type Level Detectors	_____
2. Ultrasonic Level Measurement	_____
3. Nuclear Level Detection	_____
4. Bimetallic Strip Thermometers	_____
5. Thermocouples	_____
a. Thermocouple Metals	_____
b. Designations for Thermocouple Wire	_____
c. Thermocouple Construction	_____

Session IV. Secondary Elements

- A. Secondary Elements _____
  - 1. Bourdon Tubes _____
    - a. C-Type Bourdon Tubes _____
    - b. Spiral-Type Bourdon Tubes _____
    - c. Helical-Type Bourdon Tubes _____
  - 2. Diaphragm Pressure Devices _____
  - 3. Pressure Capsules _____
  - 4. Bellows Pressure Devices _____
  - 5. Capacitance-Type Pressure Sensors _____
  - 6. Secondary Element Protection _____
    - a. Diaphragm Seals _____
    - b. Pulsation Dampeners _____
    - c. Pressure Sensor Positioning _____

Session V. Transducers

- A. Transducers _____
  - 1. Transducer Functions _____
  - 2. Transducer Types _____
  - 3. I/P Transducers _____
  - 4. P/I Transducers _____
  - 5. Transducer Operation _____
    - a. I/P Transducer Operation _____
    - b. P/I Transducer Operation _____
  - 6. Metallic Strain Gauges _____
    - a. Semiconductor Strain Gauges _____
  - 7. Pressure Strain Gauges _____
    - a. Voltage-Divider Pressure Transducers _____
  - 8. Piezoelectric Transducers _____
  - 9. Linear-Variable Differential Transformers _____
  - 10. Accelerometers _____

Session VI. Pneumatic Transmitters

- A. Pneumatic Transmitters _____
  - 1. Force Balance Differential Pressure Pneumatic Transmitters _____
  - 2. Process Measuring Section _____
  - 3. Force Bar Section _____
  - 4. Balancing Section _____
  - 5. Pneumatic Input/Output Section _____
  - 6. Pneumatic Force Balance Transmitter Applications _____
  - 7. DP Cell Flow Measurement _____
  - 8. DP Cell Liquid Level Measurement _____
  - 9. DP Cell Pressure Measurement _____
  - 10. Pneumatic Force Balance Temperature Measurement _____
  - 11. Motion Balance Pneumatic Transmitters _____
  - 12. Measuring Section _____
  - 13. Link and Flapper-Nozzle Section _____
  - 14. Bellows and Relay Section _____
  - 15. Applications of Motion Balance Transmitters _____

Session VII. Electronic Transmitters; Laboratory

A. Electronic Transmitters _____

1. Force Balance Differential Pressure Electronic Transmitters _____
2. Variable Capacitance Cell Differential Pressure Electronic Transmitters _____

B. Laboratory _____

Under your supervision, have the trainees complete the following tasks:

1. Discuss the operation, advantages, and disadvantages of at least three different measurement elements. _____
2. Analyze the operation of a pressure-to-current transducer based on a diagram of the transducer. Point out the inlet and outlet ports and describe the installation procedure. _____
3. Draw a diagram that includes a transducer, an electronic transmitter, a thermocouple as the primary element, and a pneumatic receiver as the final element. _____

Note the proficiency of each trainee.

Session VIII. 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 covers electrical and mechanical controllers. It also describes the recording devices and gauges used in instrumentation applications.

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 operation of a controller.
2. Describe the operation of a recorder.
3. Describe the operation of an indicator.
4. Using samples, pictures, or specification sheets, identify common types of controllers, recorders, and indicators.
5. Identify the common parts of a pneumatic controller.
6. Describe the functions of an electronic controller.
7. Identify the common parts of an electronic controller.
8. Identify the three main sections of a recorder.
9. Connect and use a short recorder.

PERFORMANCE TASKS

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

1. Given a schematic of a pneumatic controller, explain the purpose and operation of all major components.
2. Given a block diagramof an electronic controller, explain the function of each block.
3. Given an application, select an appropriate indicator.
4. Connect and use a chart recorder.

NCCER STANDARDIZED CRAFT TRAINING PROGRAM

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

SAFETY CONSIDERATIONS

Ensure that the trainees are equipped with appropriate personal protective equipment. Review the safety practices associated with using electrical 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
Pneumatic controller
Electronic controller
Various on-off control devices
Electronic recorder
Mechanical recorder
Sample output records from a chart recorder
Chart recording paper
Electrical meter movement
Digital multimeter
Pyrometer
Module Examinations*
Performance Profile Sheets*

* Single-module AIG purchases include the printed exam and performance task sheet. If you have purchased the perfect-bound version of this title, download these materials from the IRC using your access code.

ADDITIONAL RESOURCES

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

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

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

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

Topic **Planned Time**

Session I. Introduction; Pneumatic Controllers

A. Introduction _____
B. Pneumatic Controllers _____
   1. On-Off Control _____
   2. Proportional Control _____
   3. Proportional Controllers with Reset (Integral) _____
   4. Proportional Controllers with Integral and Derivative (PID) _____
      a. Masoneilan® Controllers _____
      b. Taylor® Controllers _____
      c. Foxboro-Eckardt® Controllers _____
   5. Laboratory _____

      Under your supervision, have the trainees explain the purpose and operation of all major components on a schematic of a pneumatic controller. Note the proficiency of each trainee.

Session II. Electronic Controllers

A. Electronic Controllers _____
   1. On-Off Control _____
   2. Proportional Control _____
   3. Proportional Controllers with Reset (Integral) _____
   4. Proportional Controllers with Reset (Integral) and Derivative (PID) _____
   5. Laboratory _____

      Under your supervision, have the trainees explain the function of each block on a block diagram of an electronic controller. Note the proficiency of each trainee.

Session III. Recorders and Indicators

A. Recorders and Indicators _____
   1. Recorders _____
      a. Mechanical Recorders _____
      b. Electronic Recorders _____
      c. Newer Electronic Recorders _____
      d. Pneumatic Recorders _____
   2. Laboratory _____

      Under your supervision, have the trainees connect and operate a chart recorder. Note the proficiency of each trainee.
   3. Indicators _____
      a. Gauges _____
      b. Electrical Indicators _____
      c. Electronic Indicators _____
      d. Pneumatic Indicators _____
      e. Thermal Indicators _____
      f. Magnetic Indicators _____

4. Laboratory _____

   Under your supervision, have the trainees select the appropriate indicator for a given application. Note the proficiency of each trainee.

Session IV. 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 covers the operation and applications of various control valves, actuators, and positioners. It also discusses assembly and disassembly, component markings, and drawing symbols.

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 construction principles of operation of various control valves.
2. Describe the construction principles of operation of various actuators.
3. Describe the principles of operation of various positioners.
4. Describe the variables measured and used as inputs for various types of positioners.
5. Discuss valve selection criteria and identify various control valves, actuators, and positioners using specification sheets, pictures, or samples.

PERFORMANCE TASKS

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

1. Disassemble and reassemble one or more control valves.
2. Install a positioner on a control valve.
3. Locate bridgewall markings on a globe valve and determine the stem and packing orientation.
4. Identify different actuators and positioners from specific drawings.

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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
Basic hand tools for installing a positioner
Various types of valves, actuators, and positioners
Worn composition discs
Sample blueprints and schematics
Module Examinations*
Performance Profile Sheets*

* Single-module AIG purchases include the printed exam and performance task sheet. If you have purchased the perfect-bound version of this title, download these materials from the IRC using your access code.

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.

Valve Handbook, 1997. Philip L. Skousen. Columbus, OH: McGraw Hill Professional Publishing, Inc.

TEACHING TIME FOR THIS MODULE

An outline for use in developing your lesson plan is presented below. Note that each Roman numeral in the outline equates to one session of instruction. Each session has a suggested time period of 2½ hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 15 hours are suggested to cover *Control Valves, Actuators, and Positioners*. You will need to adjust the time required for hands-on activity and testing based on your class size and resources.

Topic **Planned Time**

Session I. Introduction; Principles of Operation and Construction of Various Control Valves; Laboratory

A. Introduction _____

B. Principles of Operation and Construction of Various Control Valves _____

1. Globe Valves _____
2. Gate Valves _____
3. Knife Valves _____
4. Ball Valves _____
5. Plug Valves _____
6. Butterfly Valves _____
7. Needle Valves _____

C. Laboratory _____

Under your supervision, have the trainees disassemble and reassemble one or more control valves. Note the proficiency of each trainee.

Session II. Principles of Operation and Construction of Various Actuators

A. Principles of Operation and Construction of Various Actuators _____

1. Valve Actuator Terms _____
   a. Fail Open _____
   b. Fail Closed _____
   c. Fail-as-Positioned _____
   d. Spring-to-Open _____
   e. Spring-to-Close _____
   f. Air-to-Open _____
   g. Air-to-Close _____
   h. Upstream _____
   i. Downstream _____

Session III. Principles of Operation and Construction of Various Positioners

A. Principles of Operation and Construction of Various Positioners _____

1. Direct or Reverse-Acting Positioners _____
2. Pneumatic Positioners _____
3. Analog Positioners _____
4. Modular Assembly Positioners _____
5. Digital Positioners _____
6. Process Precautions for Positioners _____

Session IV. Laboratory

A. Laboratory _____

Under your supervision, have the trainees install a positioner on a control valve. Note the proficiency of each trainee.

Session V. Valve Selection, Types, and Applications

A. Valve Selection, Types, and Applications _____

1. Valve Selection _____
2. Valve Types and Applications _____
3. Valve Markings and Nameplate Information _____
   a. Rating Designation _____
   b. Trim Identification _____
   c. Size Designation _____
   d. Thread Markings _____
   e. Valve Schematic Symbols _____
4. Laboratory _____

   Under your supervision, have the trainees complete the following tasks:

   a. Locate bridgewall markings on a globe valve and determine the stem and packing orientation.
   b. Identify different actuators and positioners from specific drawings.

   Note the proficiency of each trainee.

Session VI. 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 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

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

SAFETY CONSIDERATIONS

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

PREPARATION

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

MATERIALS AND EQUIPMENT LIST

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

* Single-module AIG purchases include the printed exam and performance task sheet. If you have purchased the perfect-bound version of this title, download these materials from the IRC using your access code.

ADDITIONAL RESOURCES

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

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

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

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

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

Standards and Practices for Instrumentation, Instrumentation Society of America.

TEACHING TIME FOR THIS MODULE

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

Topic **Planned Time**

Session I. Introduction; Electrical Relays; Laboratory

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

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

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

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

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

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

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

A. Laboratory _____

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

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

D. Performance Testing _____

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

MODULE OVERVIEW

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

PREREQUISITES

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

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

OBJECTIVES

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

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

PERFORMANCE TASKS

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

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

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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*

* Single-module AIG purchases include the printed exam and performance task sheet. If you have purchased the perfect-bound version of this title, download these materials from the IRC using your access code.

ADDITIONAL RESOURCES

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

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

National Electrical Code Handbook, National Fire Protection Association.

TEACHING TIME FOR THIS MODULE

An outline for use in developing your lesson plan is presented below. Note that each Roman numeral in the outline equates to one session of instruction. Each session has a suggested time period of 2½ hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 5 hours are suggested to cover *Switches and Photoelectric Devices*. You will need to adjust the time required for hands-on activity and testing based on your class size and resources.

Topic **Planned Time**

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

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

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

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

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

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

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

MODULE OVERVIEW

This module covers the operation and applications of filters, regulators, and dryers. 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. Define and discuss principles of operation of various filters.
2. Define and discuss principles of operation of various regulators.
3. Define and discuss principles of operation of dryers.
4. Define and discuss variables measured and used as inputs to various types of regulators.
5. Discuss selection criteria, and identify various filters, regulators, and dryers using specification sheets, pictures, and samples.

PERFORMANCE TASKS

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

1. Identify the components of filters and regulators.
2. Select the appropriate filter for a given application.
3. Disassemble and reassemble a pressure regulator.
4. Select the appropriate dryer element for a given application.

NCCER STANDARDIZED CRAFT TRAINING PROGRAM

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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
Electrostatic precipitator
Filters
Dryers
Pressure regulators
Hand tools
Module Examinations*
Performance Profile Sheets*

* Single-module AIG purchases include the printed exam and performance task sheet. If you have purchased the perfect-bound version of this title, download these materials from the IRC using your access 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 7½ hours are suggested to cover *Filters, Regulators, and Dryers*. You will need to adjust the time required for hands-on activity and testing based on your class size and resources.

Topic **Planned Time**

Session I. Introduction; Principles of Operation of Various Filters; Principles of Operation of Various Regulators; Laboratory

A. Introduction _____
B. Principles of Operation of Various Filters _____
   1. Electronic/Electrostatic Filters _____
   2. Compressed Air Filters _____
C. Principles of Operation of Various Regulators _____
   1. Electrical/Electropneumatic Regulators _____
   2. Pneumatic Regulators _____
      a. Direct-Operated Regulators _____
      b. Pilot-Operated Regulators _____
D. Laboratory _____

   Under your supervision, have the trainees complete the following tasks:

   a. Identify the components of filters and regulators.
   b. Select the appropriate filter for a given application.
   c. Disassemble and reassemble a pressure regulator.

   Note the proficiency of each trainee.

Session II. Principles of Operation of Various Dryers; Filter, Dryer, and Regulator Selection and Identification

A. Principles of Operation of Various Dryers _____
   1. Absorbent (Deliquescent) Dryers _____
   2. Refrigerated Dryers _____
   3. Adsorptive Desiccant (Heat-Reactivated) Dryers _____
   4. Adsorptive Desiccant (Heatless) Dryers _____
B. Filter, Dryer, and Regulator Selection and Identification _____
   1. General Guidelines for Pressure Regulator Selection _____
   2. Guidelines for Selecting a Dryer System _____
   3. Component Schematic Symbols _____

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

A. Laboratory _____

   Under your supervision, have the trainees select the appropriate dryer element for a given application. Note the proficiency of each trainee.

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

D. Performance Testing

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

MODULE OVERVIEW

This module provides an overview of basic chemical principles and relates those principles to the analysis of fluids in process systems. It covers the measurement of pH, conductivity, density, specific gravity, and viscosity. It also provides an overview of the specialized equipment used in chemical analysis.

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 purpose of the periodic table.
2. Describe the scale used for measuring pH.
3. Define conductivity, and describe the method used to measure conductivity.
4. Define specific gravity, and list two methods used for measuring specific gravity.
5. Define viscosity, and list two methods used for measuring viscosity.
6. Describe the purpose of gas chromatography.
7. Describe the purpose of thermal conductivity gas analysis.
8. List two methods commonly used for measuring hydrocarbons.

PERFORMANCE TASKS

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

1. Use test strips to determine the pH of a given solution and propose the proper adjustment.

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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
Samples of acids, bases, and salts
pH measuring instrument
pH test strips
Various fluid samples
Conductivity meter
Hydrometer
Module Examinations*
Performance Profile Sheets*

* Single-module AIG purchases include the printed exam and performance task sheet. If you have purchased the perfect-bound version of this title, download these materials from the IRC using your access code.

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.

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

Basic Instrumentation, 1966. Patrick J. O'Higgens. McGraw-Hill.

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

Topic **Planned Time**

Session I. Introduction; Chemistry; pH Measurement; Conductivity Measurement

A. Introduction _____
B. Chemistry _____
   1. Chemical Reactivity _____
   2. Atomic Mass _____
   3. Concentration _____
   4. Electrolytes _____
   5. pH _____
C. pH Measurement _____
   1. pH Probes _____
   2. pH Analyzer/Controller _____
   3. Laboratory _____

      Under your supervision, have the trainees use test strips to determine the pH of a given solution and propose the proper adjustment. Note the proficiency of each trainee.

D. Conductivity Measurement _____

Session II. Density and Specific Gravity; Viscosity Measurement; Chemical Composition Measurement; Summary; Module Examination and Performance Testing

A. Density and Specific Gravity _____
   1. Measurement of Density and Specific Gravity _____
      a. Hydrometer _____
      b. Air Bubbler Method _____
      c. Differential Pressure Method _____
      d. Specific Gravity and Density Values _____
B. Viscosity Measurement _____
   1. Viscometers _____
   2. Rotating Spindle Viscometers _____
   3. Vibrating Reed Viscometers _____
   4. Temperature Effects on Viscosity _____
C. Chemical Composition Measurement _____
   1. Gas Chromatography _____
   2. Thermal Conductivity Gas Analysis _____
   3. Smoke Density Measurement _____
   4. Hydrocarbons _____
      a. Flame Ionization Methods _____
      b. Infrared Methods _____
D. Summary
   1. Summarize module _____
   2. Answer questions _____

E. 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.

F. 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 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.

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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*

* Single-module AIG purchases include the printed exam and performance task sheet. If you have purchased the perfect-bound version of this title, download these materials from the IRC using your access code..

ADDITIONAL RESOURCES

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

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

TEACHING TIME FOR THIS MODULE

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

Topic **Planned Time**

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

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

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

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

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

A. Laboratory _____

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

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

D. Performance Testing _____

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

Installing Field-Mounted Instruments
Annotated Instructor's Guide

Module 12213-03

MODULE OVERVIEW

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

PREREQUISITES

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

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

OBJECTIVES

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

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

PERFORMANCE TASKS

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

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

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SAFETY CONSIDERATIONS

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

PREPARATION

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

MATERIALS AND EQUIPMENT LIST

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

* Single-module AIG purchases include the printed exam and performance task sheet. If you have purchased the perfect-bound version of this title, download these materials from the IRC using your access code.

ADDITIONAL RESOURCES

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

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

TEACHING TIME FOR THIS MODULE

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

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

Session V. In-Line Mounted Instruments, Continued _____

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

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

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

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

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

Session VII. Laboratory

A. Laboratory _____

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

Session VIII. Flanges; Manifold Valve Assemblies

A. Flanges _____

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

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

B. Manifold Valve Assemblies _____

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

Session IX. Laboratory

A. Laboratory _____

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

Session X. Review; Module Examination and Performance Testing

A. Summary

1. Summarize module _____
2. Answer questions _____

B. Module Examination _____

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

C. Performance Testing _____

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

MODULE OVERVIEW

Introduces raceways and covers identification and selection of conduit, raceways, wireways, cable trays, fittings, and NEC requirements for installation.

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 12213-03

OBJECTIVES

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

1. Identify various types of metallic conduit and fittings and state their uses.
2. Identify types of nonmetallic conduit and fittings and state their uses.
3. Identify raceway supports and their uses.
4. Prepare various types of conduit for installation.
5. Describe wireways and cable trays and their associated fittings.

PERFORMANCE TASKS

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

1. Cut and deburr various types of conduit.
2. Thread, clean, and connect various types of conduit.
3. Install and support raceways in accordance with the job specifications and the NEC.

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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. Stress the need for safety goggles and hand protection when cutting conduit. Also, when using electrically powered cutting tools, make sure they are either double insulated or are connected to a GFCI-protected circuit.

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
Copy of the Latest Edition of the *National Electrical Code®*
Lengths of various types of conduit, including EMT, RMC, IMC, FMC, LFMC, PVC, and ENT
Various metal conduit couplings and connectors
PVC couplings and connectors
Various conduit bodies and unions
Threaded hubs
Various types of bushings and locknuts
Seal-off fittings and seal-off compound
Various metal and nonmetallic outlet boxes
Knockout punch
Various straps, standoff supports, and beam clamps
Hand bender and fish tape (optional)
Hacksaw and assorted blades
Bandsaw
Pipe cutter, chain vise, and cutting oil
Tubing cutter
Utility knife
PVC conduit cutters
Half-round file
Pipe reamer
Lineman's pliers
Ratchet and power pipe threaders
Various wrenches
PVC cleaner, primer, and cement
Sections of wireways, raceways, cable trays, and associated fittings and supports
Module Examinations*
Performance Profile Sheets*

* Single-module AIG purchases include the printed exam and performance task sheet. If you have purchased the perfect-bound version of this title, download these materials from the IRC using your access code.

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. Quincy, MA: National Fire Protection Association, Inc.

National Electrical Code Handbook, 1990. New York, NY: McGraw-Hill Publishing Company.

Ugly's Electrical References, 1990. Houston, TX: United Printing Arts.

ANSI/ASME Standards

TEACHING TIME FOR THIS MODULE

An outline for use in developing your lesson plan is presented below. Note that each Roman numeral in the outline equates to one session of instruction. Each session has a suggested time period of 2½ hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 17½ hours are suggested to cover *Raceways for Instrumentation*. You will need to adjust the time required for hands-on activity and testing based on your class size and resources.

Topic **Planned Time**

Session I. Introduction; Conduit

A. Introduction _____
B. Conduit _____
1. Metal Conduit _____
a. Electrical Metallic Tubing (EMT) and Fittings _____
b. Rigid Metal Conduit (RMC) and Fittings _____
c. Intermediate Metal Conduit (IMC) _____
d. Flexible Metal Conduit (FMC), Liquidtight Flexible Metal Conduit (LFMC), and Fittings _____
e. Conduit Nipples _____
2. Nonmetallic Conduit _____
a. Rigid Nonmetallic Conduit and Fittings _____
b. Electrical Nonmetallic Tubing (ENT) _____
3. Boxes _____
a. Metal Boxes _____
b. Nonmetallic Boxes _____
4. Conduit Supports _____
a. One-Hole and Two-Hole Straps _____
b. Standoff Supports _____
c. Strut Supports _____
d. Beam Clamps _____

Session II. Installing Conduit; Cutting Conduit; Deburring Conduit; Threading Conduit; Joining Conduit _____

A. Installing Conduit _____
1. Size Requirements _____
2. Conduit Bend Requirements _____
B. Cutting Conduit _____
1. Cutting RMC and IMC _____
2. Cutting EMT _____
3. Cutting FMC and LFMC _____
4. Cutting RNC (PVC) and ENT _____
C. Deburring Conduit _____
1. Deburring RMC and IMC _____
2. Deburring EMT _____
3. Deburring FMC and LFMC _____
4. Deburring RNC (PVC) and ENT _____
D. Threading Conduit _____
E. Joining Conduit _____
1. Joining Metal Conduit _____
2. Joining PVC Conduit _____

Session III. Laboratory

A. Laboratory _____

Under your supervision, have the trainees cut, deburr, thread, and join various types of conduit. Note the proficiency of each trainee.

Session IV. Metal Wireways; Wireway Fittings

A. Metal Wireways _____

1. Wireway Fittings _____
   a. Connectors _____
   b. End Plates _____
   c. Tees _____
   d. Crosses _____
   e. Elbows _____
   f. Nipples _____
   g. Telescopic Fittings _____
2. Wireway Supports _____
   a. Suspended Hangers _____
   b. Gusset Bracket _____
   c. Standard Hanger _____
   d. Trapeze Hanger _____
   e. Nonmetallic Wireways _____

Session V. Surface Metal and Nonmetallic Raceways; Cable Trays; Storing Raceways; Handling Raceways

A. Surface Metal and Nonmetallic Raceways _____

B. Cable Trays _____

1. Cable Tray Fittings _____
2. Cable Tray Supports _____
   a. Direct Rod Suspension _____
   b. Trapeze Mounting _____
   c. Wall Mounting _____
   d. Pipe Rack or Bridge Mounting _____

C. Storing Raceways _____

D. Handling Raceways _____

Session VI. Laboratory

A. Laboratory _____

Under your supervision, have the trainees install and support a raceway. Note the proficiency of each trainee.

Session VII. 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.