MODULE OVERVIEW
This module explains the NEC® installation requirements for electric generators and storage.

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.

OBJECTIVES
Upon completion of this module, the trainee will be able to do the following:
1. Explain the basic differences between emergency systems, legally required standby systems, and optional standby systems.
2. Describe the operating principles of an engine-driven standby AC generator.
3. Recognize and describe the operating principles of both automatic and manual transfer switches.
4. Recognize the different types of storage batteries used in emergency and standby systems and explain how batteries charge and discharge.
5. For selected types of batteries, describe their characteristics, applications, maintenance, and testing.
6. Recognize double-conversion and single-conversion types of uninterruptible power supplies (UPSs) and describe how they operate.
7. Describe the NEC® requirements that pertain to the installation of standby and emergency power systems.
8. Explain normal vs. emergency sources for various applications.

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

MATERIALS AND EQUIPMENT LIST

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
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<td>Whiteboard/chalkboard</td>
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<td>Pencils and scratch paper</td>
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* 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 12½ hours are suggested to cover *Standby and Emergency Systems*. You will need to adjust the time required for hands-on activity and testing based on your class size and resources.

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<td>2. Transfer Switches</td>
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<td>3. Automatic Sequential Paralleling Emergency/Standby System</td>
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<td><strong>Session II. Storage Batteries; Static Uninterruptible Power Supply</strong></td>
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<td>2. Nickel Cadmium Batteries</td>
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<td>4. Battery and Battery Charger Operation</td>
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<td>B. Static Uninterruptible Power Supply</td>
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<td>1. Double-Conversion UPS Systems</td>
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<td>2. Single-Conversion UPS Systems</td>
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<td><strong>Session III. NEC® Requirements for Emergency Systems</strong></td>
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<td>A. Emergency System Circuits for Light and Power</td>
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<td>2. Battery-Powered Emergency Lighting</td>
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<td>3. Emergency Lighting Units</td>
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<td>4. Places of Assembly</td>
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<td><strong>Session V. Review and Testing</strong></td>
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<td>A. Module Review</td>
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<tr>
<td>B. Module Examination</td>
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<tr>
<td>1. Trainees must score 70 percent or higher to receive recognition from 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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</table>
Basic Process Control Elements, Transducers, and Transmitters
Annotated Instructor’s Guide

MODULE OVERVIEW
This module covers the devices that monitor, translate, and transmit process conditions to the process control devices. It introduces the basic terms and principles of control loops, and explains the operation of detectors (primary and secondary elements), transducers that allow the different devices to communicate with each other, and the transmitters that send the detected information to the controlling devices.

PREREQUISITES
Prior to training with this module, it is recommended that the trainee shall have successfully completed Core Curriculum; Industrial Maintenance E & I Technician Level One; Industrial Maintenance E & I Technician Level Two; Industrial Maintenance E & I Technician Level Three; and Industrial Maintenance E & I Technician Level Four, Module 40401-09.

OBJECTIVES
Upon completion of this module, the trainee will be able to do the following:
1. Identify the following primary elements (detectors) and describe their operation:
   • Orifice plate
   • Pitot tube
   • Thermocouple
   • Resistance temperature detector (RTD)
2. Identify the following secondary elements and describe their operation:
   • Bourdon tube
   • Diaphragm device
   • Capacitance-type pressure sensor
   • Bellows device
3. Define various transducer types:
   • I/Ps
   • Strain gauges
   • Linear-variable differential transformer (LVDT)
   • Accelerometers
4. Explain an I/P operation.
5. Describe the operation of a strain gauge.
6. Explain the function and installation of electronic transmitters and temperature detectors.
7. Draw a basic instrument channel diagram including a measuring element, transducer, and transmitter.

PERFORMANCE TASKS
Under the supervision of the instructor, the trainee should be able to do the following:
1. Draw a one-line diagram including a measuring element, transducer, and transmitter.
2. Install an electronic transmitter.
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
Pneumatic temperature transmitter
   (Foxboro® 12A or similar model)
Multifunction loop calibrator
   (Fluke® Model 725 or similar model)
Analog differential pressure transmitter
   (Rosemount 1151DP Alphaline® or similar model)
Analog temperature calibrator
   (Fluke® Model 724 or similar equipment)
Examples of orifice plates, pipe taps, detectors or
   sensors, transducers, and transmitters
Examples of bimetallic strip thermometers
Examples of wired thermocouples and multiple-
   element thermocouples
Example of a swamping box arrangement
Examples of Bourdon tubes
Examples or photographs of RTDs
Photographs or illustrations showing installed
   locations of RTDs (optional)
Metal-detecting proximity sensor wired into a
   circuit (optional)
Vibration data collector/ analyzer (optional)
Access to an operational process system
   with sensors (flow, pressure, level, and/or
   temperature), applicable actuators and
   positioners, and some kind of controller
New and used control devices
   (sensors, controllers, actuators)
   that can be taken apart and assembled
Extra process control equipment for lab evaluations
Samples of simple and complex process control
   system drawings
Applicable tools to remove, work on, and replace
   pneumatic system components
Module Examinations*
Performance Profile Sheets*

SAFETY CONSIDERATIONS

Ensure that the trainees are equipped with appropriate personal protective equipment and know how to
use it properly. Emphasize safe work practices for laboratory sessions.

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.

for manuals on control devices made by Emerson Electric Company

Parker Hannifin Corporation, http://www.parker.com
for bulletins and interactive technical data on hydraulic and pneumatic devices produced by Parker
Hannifin Corporation

for materials such as user manuals and product information bulletins on control or drive devices
made by Festo Corporation
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 *Basic Process Control Elements, Transducers, and Transmitters*. 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.

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<td>B. Review of Measurement Terminology</td>
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<td>C. Standards and Elements of Measurement</td>
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<td><strong>Session II. Detectors, Part One</strong></td>
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<td>A. Detectors</td>
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<td>1. Orifice Plates</td>
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<td>2. Tap Types and Locations</td>
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<td>3. Venturi Tubes</td>
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<td>4. Pitot Tubes</td>
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<td>5. Annubar Tubes</td>
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<td>6. Magnetic Flowmeters</td>
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<td>7. Ultrasonic Flowmeters</td>
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<td>8. Capacitance-Type Level Detectors</td>
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<td>9. Ultrasonic Level Measurement</td>
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<td>10. Nuclear Level Detection</td>
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<td>11. Bimetallic Strip Thermometers</td>
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<td><strong>Session III. Detectors, Part Two; Secondary Elements</strong></td>
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<td>A. Detectors (Continued)</td>
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<td>1. Thermocouples</td>
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<td>2. Resistance Temperature Detectors (RTDs)</td>
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<td>B. Secondary Elements</td>
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<tr>
<td>1. Bourdon Tubes</td>
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<td>2. Diaphragm Pressure Devices</td>
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<td>3. Pressure Capsules</td>
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<td>4. Bellows Pressure Devices</td>
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<tr>
<td>5. Capacitance-Type Pressure Sensors</td>
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<td>6. Secondary Element Protection</td>
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</tbody>
</table>
Session IV. Transducers
A. Transducers
   1. Transducer Functions
   2. Transducer Types
   3. I/P Transducers
   4. P/I Transducers
   5. Metallic Strain Gauges
   6. Pressure Strain Gauges
   7. Voltage-Divider Pressure Transducers
   8. Piezoelectric Transducers
   9. Linear-Variable Differential Transformer
  10. Vibration-Sensing Transducers
  11. Proximity Sensors

Session V. Transmitters; Laboratory
A. Transmitters
   1. Force Balance Differential Pressure Electronic Transmitters
   2. Variable Capacitance Cell Differential Pressure Electronic Transmitters
   3. Installation of Electronic Transmitters
B. Laboratory
   Have trainees practice the following tasks:
   1. Draw a one-line diagram including a measuring element, transducer, and transmitter.
   2. Install an electronic transmitter.
   This laboratory corresponds to Performance Tasks 1 and 2.

Session VI. Review and Testing
A. Module Review
B. Module Examination
   1. Trainees must score 70% or higher to receive recognition from NCCER.
   2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.
C. Performance Testing
   1. Trainees must perform each task to the satisfaction of the instructor to receive recognition from NCCER. If applicable, proficiency noted during laboratory exercises can be used to satisfy the Performance Testing requirements.
   2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.
MODULE OVERVIEW

This module covers instrument calibration and configuration for pneumatic, analog, and Smart transmitters and presents some generic calibration procedures that can be applied to most instruments. It also introduces the basic principles of the HART® protocol and discusses calibrating HART® transmitters.

PREREQUISITES

Prior to training with this module, it is recommended that the trainee shall have successfully completed Core Curriculum; Industrial Maintenance E & I Technician Level One; Industrial Maintenance E & I Technician Level Two; Industrial Maintenance E & I Technician Level Three; and Industrial Maintenance E & I Technician Level Four, Modules 40401-09 and 40402-09.

OBJECTIVES

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

1. Define calibration.
2. Discuss the three-point and five-point methods of calibration.
3. Explain zero suppression and elevation.
4. Calibrate the following pneumatic instruments using the proper equipment:
   • Differential pressure transmitters
   • Temperature transmitters
5. Calibrate the following 4–20mA instruments using the proper calibration equipment:
   • Differential pressure transmitters
   • Temperature transmitters
6. Define Smart instruments.
7. Identify a HART® communicator.
8. Calibrate a Smart transmitter using a HART® communicator.

PERFORMANCE TASKS

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

1. Calibrate a pneumatic pressure switch using the proper equipment.
2. For a given level application, determine the calibration range for a DP transmitter.
3. Calibrate a 4–20mA differential pressure transmitter using the proper calibration equipment.
4. Calibrate a Smart transmitter using a HART® communicator.
5. Check a transducer for proper operation.

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
- Wallace & Tiernan pneumatic calibrator (Wally Box®) or similar instrument
- Pneumatic DP transmitter
- Compressor
- Pneumatic temperature transmitter (Foxboro® 12A or similar model)
- Multifunction loop calibrator (Fluke® Model 725 or similar model)

continued
SAFETY CONSIDERATIONS

Ensure that the trainees are equipped with appropriate personal protective equipment and know how to use it properly. Emphasize safe work practices for laboratory sessions.

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 10 hours are suggested to cover Instrument Calibration and Configuration. 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>
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<th>Topic</th>
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<td>2. Signals (Output Energies)</td>
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<td>3. Five-Point Method of Calibration</td>
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<td>C. Pneumatic Calibration Equipment and Calibrating Procedures</td>
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<td>A. Analog Calibration Equipment and Calibrating Procedures</td>
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<td>B. Smart Transmitters</td>
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<td>1. HART® Communication and Communicator</td>
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<td>2. HART® Device Calibration</td>
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</tbody>
</table>

Analog differential pressure transmitter (Rosemount 1151 Range 4 or similar model)  HART® communicator
Analog temperature calibrator (Fluke® Model 724 or similar equipment)  Module Examinations*
Performance Profile Sheets*
Session III. Calibration Laboratory

A. Laboratory

Have trainees practice the following tasks:

1. Calibrate a pneumatic pressure switch using the proper equipment.
2. Calibrate the range for a DP transmitter.
3. Calibrate a 4–20mA temperature transmitter using the proper calibration equipment.
4. Calibrate a Smart transmitter using a HART® transmitter.

This laboratory corresponds to Performance Tasks 1, 2, 3, and 4.

Session IV. Transducers; Review and Testing

A. Transducers

1. Laboratory

   Have trainees practice checking a transducer for proper operation. This laboratory corresponds to Performance Task 5.

B. Module Review

C. 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.

D. 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 describes different types of control valves and the pneumatic actuators and positioners used to operate these valves. It also covers the materials used to keep valves from leaking, and how to install, set up, and calibrate pneumatic actuators and positioners.

PREREQUISITES

Prior to training with this module, it is recommended that the trainee shall have successfully completed Core Curriculum; Industrial Maintenance E & I Technician Level One; Industrial Maintenance E & I Technician Level Two; Industrial Maintenance E & I Technician Level Three; and Industrial Maintenance E & I Technician Level Four, Modules 40401-09 through 40403-09.

OBJECTIVES

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

1. Identify the various parts of control valves.
2. Describe the various types of control valve trims.
3. Describe what conditions determine the type of valve trim to be used.
4. Describe how actuators work and are bench set.
5. Describe how various positioners work and are calibrated.
6. Describe the various signals used to control inputs to valve positioners.
7. Describe how Smart positioners work and are calibrated.
8. Describe the operation of Tri-Loop and HIM signal converters.
9. Safely perform common maintenance practices for control valves and actuators.
10. Troubleshoot control valve failures.
11. Calibrate a pneumatic positioner.

PERFORMANCE TASKS

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

1. Disassemble and reassemble one or more control valves.
2. Bench set an actuator and mount on a control valve.
3. Install and set up a positioner on a control valve.
4. Interpret valve markings and nameplate information.
5. Identify valve components from specific drawings.

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
- A source of compressed instrument air
- Access to small pneumatic valves and actuators and the tubing to connect them
- A selection of new control valves, and a selection of used and worn control valves for comparison:
  - Globe valves (with different kinds of plugs)
  - Angle valves
  - Butterfly valves
  - Ball valves
- Cut-away models of different types of control valves and pneumatic actuators (both diaphragm and piston)
SAFETY CONSIDERATIONS

Ensure that the trainees are equipped with appropriate personal protective equipment and know how to use it properly. Emphasize safe work practices for laboratory sessions.

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.

Emerson/Fisher Instruction Manual Form 1432, April 1998, Type 667 Diaphragm Actuators - Sizes 80 & 100
Emerson/Fisher Instruction Manual Form 5054, June 1998, 3582 Series Valve Positioners, Type 3582i Valve Positioner, and 3583 Series Valve Stem Position Transmitters
Emerson/Fisher Bulletin 61.2:585C, April 2001, Type 585C Piston Actuators
The Beck Actuators documentation page can be accessed at http://beckactuators.com/tech_library.htm
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 40 hours are suggested to cover *Pneumatic 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. Because laboratories often correspond to Performance Tasks, the proficiency of the trainees may be noted during these exercises for Performance Testing purposes.

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<td>A. Introduction</td>
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<td>1. Component Identification</td>
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<td>2. Valve Terms</td>
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<td>B. Pneumatic Control Valves</td>
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<td>1. Valve Types</td>
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<td>2. Functions</td>
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<td>3. Leakage Classifications</td>
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<td>C. Valves That Regulate Flow</td>
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<td>1. Globe Valves</td>
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<td>2. Butterfly Valves</td>
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<td>3. Ball Valves</td>
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<td>4. Diaphragm Valves</td>
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<tr>
<td>D. Laboratory</td>
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<tr>
<td>Have trainees practice disassembling, inspecting, and reassembling one or more control valves. This laboratory corresponds to Performance Task 1.</td>
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<td><strong>Sessions IV-VI. Pneumatic Valve Actuators</strong></td>
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<td>B. Piston Actuators</td>
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<td>C. Electro-Pneumatic Positioners Used with Actuators</td>
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<td>D. Rack and Pinion Actuators</td>
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<td>E. Fail-Safe Actuators</td>
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<tr>
<td>F. Adjusting, Mounting, and Testing Valve Actuators</td>
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<td>1. General Procedures</td>
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<td>2. Equipment-Specific Mounting Procedures</td>
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<td>3. Installing the Stem Connector and Stroking the Valve</td>
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<td>G. Repairing Valve Actuators</td>
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<tr>
<td>H. Laboratory</td>
<td></td>
</tr>
<tr>
<td>Have trainees practice bench setting actuators and mounting actuators onto control valves. This laboratory corresponds to Performance Task 2.</td>
<td></td>
</tr>
</tbody>
</table>
Sessions VII-IX. Positioners

A. Components and Theory of Operation
B. Selecting Positioners
   1. Pneumatic Positioners
   2. Analog I/P Positioners
   3. Smart Positioners
C. Calibrating Positioners
   1. Beam Alignment
   2. Positioner Calibration
D. Tri-Loop and HIM Signal Converters for Smart Positioners
E. Laboratory
   Have trainees practice installing, setting up, and calibrating positioners on control valves. This laboratory corresponds to Performance Task 3.

Sessions X and XI. Valve Stems and Leak Prevention; Replacing Bonnet Gaskets; Packing Valves

A. Valve Stems and Leak Prevention
B. Replacing Bonnet Gaskets
C. Identification of Leak Areas Associated with Packing
D. Packing Shapes and Materials
E. Repacking Valves
F. Laboratory
   Have trainees practice dismantling, inspecting, repacking, and reassembling valves.

Session XII. Lapping Valves

A. Lapping Valves
   1. Laboratory
      Have trainees practice lapping valves.

Sessions XIII and XIV. Storing and Handling Valves; Installing Valves

A. Storing and Handling Valves
   1. Safety Considerations
   2. Storing Valves
   3. Rigging Valves
B. Installing Valves
C. Laboratory
   Have trainees practice handling, installing, removing, and storing valves.
Session XV. Valve Markings and Nameplate Information;
Troubleshooting Actuators and Positioners

A. Valve Markings and Nameplate Information
   1. Rating Designation
   2. Trim Identification
   3. Size Designation
   4. Thread Markings
   5. Valve Schematic Symbols

B. Laboratory
   Have trainees practice the following tasks:
   1. Interpret valve markings and nameplate information.
   2. Identify valve components from specific drawings.
   This laboratory corresponds to Performance Tasks 4 and 5.

C. Troubleshooting Actuators and Positioners
   1. Troubleshooting Pneumatic Actuators and Associated Systems
   2. Examining the Air Supply
   3. Inspecting the Actuator
   4. Inspecting the Control Valve
   5. Inspecting Sequence Circuits
   6. Inspecting Interlocks

Session XVI. 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.
Performing Loop Checks
Annotated Instructor’s Guide

MODULE OVERVIEW
This module explains how to inspect a loop, check the continuity of a loop, prove a loop, and calibrate a loop. The complete process is known as commissioning a loop.

PREREQUISITES
Prior to training with this module, it is recommended that the trainee shall have successfully completed Core Curriculum; Industrial Maintenance E & I Technician Level One; Industrial Maintenance E & I Technician Level Two; Industrial Maintenance E & I Technician Level Three; and Industrial Maintenance E & I Technician Level Four, Modules 40401-09 through Modules 40404-09.

OBJECTIVES
Upon completion of this module, the trainee will be able to do the following:
1. Verify mechanical installation.
2. Verify correct tag numbers according to loop sheets.
3. Perform continuity checks on both electrical and pneumatic loops.
4. Prove a loop.

PERFORMANCE TASKS
Under the supervision of the instructor, the trainee should be able to do the following:
1. Perform a continuity check on a pneumatic system.
2. Perform a continuity check on an electrical system.
3. Prove a loop.

MATERIALS AND EQUIPMENT LIST

<table>
<thead>
<tr>
<th>Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overhead projector and screen</td>
</tr>
<tr>
<td>Transparencies</td>
</tr>
<tr>
<td>Blank acetate sheets</td>
</tr>
<tr>
<td>Transparency pens</td>
</tr>
<tr>
<td>Whiteboard/chalkboard</td>
</tr>
<tr>
<td>Markers/chalk</td>
</tr>
<tr>
<td>Pencils and scratch paper</td>
</tr>
<tr>
<td>Appropriate personal protective equipment</td>
</tr>
<tr>
<td>P&amp;IDs for process equipment</td>
</tr>
<tr>
<td>Sample loop sheets and diagrams</td>
</tr>
<tr>
<td>Vendor manuals for process equipment items</td>
</tr>
<tr>
<td>Fluke® ProcessMeter™ or similar instrument</td>
</tr>
<tr>
<td>Process equipment with functional sensors/detectors, transmitters, a controller, and control valves</td>
</tr>
<tr>
<td>Wallace &amp; Tiernan® Model 65-2000 pneumatic tester (Wally Box®) or similar instrument</td>
</tr>
<tr>
<td>Fluke® Model 725 multifunction process calibrator or similar instrument</td>
</tr>
<tr>
<td>HART® communicator or similar instrument</td>
</tr>
<tr>
<td>Module Examinations*</td>
</tr>
<tr>
<td>Performance Profile Sheets*</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 safe work practices for laboratory sessions.
### 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 HART Communication Foundation is an independent, nonprofit organization that provides support for the application of the HART® Protocol.

[www.hartcomm.org](http://www.hartcomm.org)

The International Society of Automation (ISA) is a nonprofit organization that assists automation professionals in solving challenging technical problems.

[www.isa.org](http://www.isa.org)


### 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 *Performing Loop Checks*. 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; Verification</strong></td>
<td></td>
</tr>
<tr>
<td>A. Introduction</td>
<td></td>
</tr>
<tr>
<td>B. Verifying Mechanical Installation through Visual Inspection</td>
<td></td>
</tr>
<tr>
<td>1. Primary Element</td>
<td></td>
</tr>
<tr>
<td>2. Field Transmitter</td>
<td></td>
</tr>
<tr>
<td>3. Field Wiring, Conduit, Fiber-Optic Cable, and Tubing</td>
<td></td>
</tr>
<tr>
<td>4. Control Room Components</td>
<td></td>
</tr>
<tr>
<td><strong>Session II. Loop Continuity Tests; Proving a Loop</strong></td>
<td></td>
</tr>
<tr>
<td>A. Loop Continuity Tests</td>
<td></td>
</tr>
<tr>
<td>1. Electrical</td>
<td></td>
</tr>
<tr>
<td>2. Pneumatic</td>
<td></td>
</tr>
<tr>
<td>3. Fiber-Optic Cable</td>
<td></td>
</tr>
<tr>
<td>4. Laboratory</td>
<td></td>
</tr>
<tr>
<td>Have trainees practice pneumatic and electrical loop continuity tests. This laboratory corresponds to Performance Tasks 1 and 2.</td>
<td></td>
</tr>
<tr>
<td>B. Proving a Loop</td>
<td></td>
</tr>
<tr>
<td>1. Simulation</td>
<td></td>
</tr>
<tr>
<td>2. Required Test Equipment</td>
<td></td>
</tr>
<tr>
<td>3. Laboratory</td>
<td></td>
</tr>
<tr>
<td>Have trainees practice proving a loop. This laboratory corresponds to Performance Task 3.</td>
<td></td>
</tr>
</tbody>
</table>
Session III. Calibrating a Loop; Review and Testing

A. Calibrating a Loop
   1. Conventional 4–20mA Instrument Loops
   2. HART® Instruments

B. Module 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.

D. 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.
Troubleshooting and Commissioning a Loop
Annotated Instructor’s Guide

MODULE OVERVIEW
This module explains how to troubleshoot, prove, and commission a loop.

PREREQUISITES
Prior to training with this module, it is recommended that the trainee shall have successfully completed Core Curriculum; Industrial Maintenance E & I Technician Level One; Industrial Maintenance E & I Technician Level Two; Industrial Maintenance E & I Technician Level Three; and Industrial Maintenance E & I Technician Level Four, Modules 40401-09 through Modules 40405-09.

OBJECTIVES
Upon completion of this module, the trainee will be able to do the following:
1. Practice universal and methodical troubleshooting techniques in a loop.
2. Troubleshoot an oscillating process.
3. Troubleshoot a newly installed control loop.
4. Practice safety procedures when troubleshooting a loop.
5. Commission a loop.

PERFORMANCE TASKS
Under the supervision of the instructor, the trainee should be able to do the following:
1. Troubleshoot an oscillating process.
2. Troubleshoot a newly installed control loop.
3. Commission a loop.

MATERIALS AND EQUIPMENT LIST

<table>
<thead>
<tr>
<th>Overhead projector and screen</th>
<th>Process equipment P&amp;ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transparencies</td>
<td>Process equipment equipped with sensors/ detectors, transmitters, a controller, and control valves</td>
</tr>
<tr>
<td>Blank acetate sheets</td>
<td>Vendor manuals on process equipment items</td>
</tr>
<tr>
<td>Transparency pens</td>
<td>Strip chart recorder</td>
</tr>
<tr>
<td>Whiteboard/chalkboard</td>
<td>Computer simulator (may be used for controller and recorder)</td>
</tr>
<tr>
<td>Markers/chalk</td>
<td>Module Examinations*</td>
</tr>
<tr>
<td>Pencils and scratch paper</td>
<td>Performance Profile Sheets*</td>
</tr>
<tr>
<td>Appropriate personal protective equipment</td>
<td></td>
</tr>
<tr>
<td>Sample loop sheets</td>
<td></td>
</tr>
<tr>
<td>Process equipment loop diagram</td>
<td></td>
</tr>
</tbody>
</table>

* Located in the Test Booklet.

SAFETY CONSIDERATIONS
Ensure that the trainees are equipped with appropriate personal protective equipment and know how to use it properly. Emphasize safe work practices for laboratory sessions.
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.

This website is a resource of automation process control and instrumentation professionals.

www.Automation.com

The International Society of Automation (ISA) is a nonprofit organization that assists automation professionals in solving challenging technical problems.

www.isa.org


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 *Troubleshooting and Commissioning a Loop*. 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; Troubleshooting</strong></td>
<td>--------------</td>
</tr>
<tr>
<td>A. Introduction</td>
<td>--------------</td>
</tr>
<tr>
<td>B. Fundamentals of Troubleshooting</td>
<td>--------------</td>
</tr>
<tr>
<td>1. Analyzing the Loop</td>
<td>--------------</td>
</tr>
<tr>
<td>2. Identifying the Problem</td>
<td>--------------</td>
</tr>
<tr>
<td>3. Understanding the Loop and Its Function</td>
<td>--------------</td>
</tr>
<tr>
<td>C. Troubleshooting an Oscillating Process</td>
<td>--------------</td>
</tr>
<tr>
<td>1. Verifying That a Problem Exists</td>
<td>--------------</td>
</tr>
<tr>
<td>2. Gathering Information</td>
<td>--------------</td>
</tr>
<tr>
<td>3. Identifying Possible Causes of the Problem</td>
<td></td>
</tr>
<tr>
<td>4. Locating the Problem</td>
<td>--------------</td>
</tr>
<tr>
<td>5. Using a Troubleshooting Flowchart</td>
<td>--------------</td>
</tr>
<tr>
<td>D. Laboratory</td>
<td>--------------</td>
</tr>
<tr>
<td>Given a control loop to troubleshoot or a diagram with a simulated problem, have trainees practice troubleshooting an oscillating process. This laboratory corresponds to Performance Task 1.</td>
<td></td>
</tr>
</tbody>
</table>

| **Session II. Proving a Loop**               |           |
| A. Proving a Loop                           |           |
| 1. Interpreting a Loop Sheet                |           |
| 2. Applying Logical Steps in Troubleshooting a New Loop |         |
| B. Laboratory                              |           |
| Given a control loop to troubleshoot or a diagram with a simulated problem, have trainees practice troubleshooting a newly installed control loop. This laboratory corresponds to Performance Task 2. | |
Session III. Commissioning a Loop
   A. Commissioning a Loop
      1. Drawings and Documents
      2. Commissioning Procedure
   B. Laboratory
      Have trainees practice commissioning a loop. This laboratory corresponds to Performance Task 3.

Session IV. Review and Testing
   A. Module Review
   B. Module Examination
      1. Trainees must score 70 percent or higher to receive recognition from NCCER.
      2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.
   C. Performance Testing
      1. Trainees must perform each task to the satisfaction of the instructor to receive recognition from NCCER. If applicable, proficiency noted during laboratory exercises can be used to satisfy the Performance Testing requirements.
      2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.
MODULE OVERVIEW

Earlier modules introduced devices used to manage process flows and pressures. These devices can be linked to form a control loop for an entire process. This module covers the basics of process control loops and how they are tuned.

PREREQUISITES

Prior to training with this module, it is recommended that the trainee shall have successfully completed Core Curriculum; Industrial Maintenance E & I Technician Level One; Industrial Maintenance E & I Technician Level Two; Industrial Maintenance E & I Technician Level Three; and Industrial Maintenance E & I Technician Level Four, Modules 40401-09 through 40406-09.

OBJECTIVES

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

1. Describe basic process control theory.
2. Describe the function and applications of various PID controllers.
3. Describe how pneumatic controllers work.
4. Describe how electronic single loop controllers work.
5. Set up and maintain pneumatic controllers.
6. Apply the appropriate equations and perform closed-loop tuning.
7. Perform open-loop tuning.
8. Perform visual loop tuning.

PERFORMANCE TASKS

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

1. Perform closed-loop tuning.
2. Perform open-loop tuning.
3. Perform visual loop tuning.
4. Set up and use a pneumatic controller in a loop.

MATERIALS AND EQUIPMENT LIST

Overhead projector and screen
An operational process system with electronic sensors (flow, pressure, level, and/or temperature), controller, and applicable actuators

Transparencies
New and used control devices (sensors, controllers, actuators) that can be taken apart and assembled

Blank acetate sheets
Extra process control equipment for lab evaluations

Transparency pens
Samples of simple and complex process control system drawings

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

Markers/chalk
Copies of the Quick Quiz*

Pencils and scratch paper
Module Examinations**

Appropriate personal protective equipment
Performance Profile Sheets**

Full-face shields

An operational process system with pneumatic sensors (flow, pressure, level, and/or temperature), controller, and applicable actuators

* 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. Ensure that trainees are briefed on shop safety procedures. Emphasize any special safety precautions associated with working on or near process machinery that is under the control of automated process control devices. Remind the trainees that control devices are often housed near high-voltage terminals and that additional precautions must be taken when work is performed on or near live circuits.

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 optional materials are for continued education rather than for task training.

The International Society of Automation is a nonprofit organization that assists automation professionals in solving challenging technical problems.

www.isa.org


TEACHING TIME FOR THIS MODULE

An outline for use in developing your lesson plan is presented below. Note that each Roman numeral in the outline equates to one session of instruction. Each session has a suggested time of 2½ hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 20 hours are suggested to cover *Process Control Loops and Tuning*. You will need to adjust the time required for testing based on your class size and resources. Because laboratories often correspond to Performance Tasks, the proficiency of the trainees may be noted during these exercises for Performance Testing purposes.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Planned Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Session I. Introduction; Process Control Theory; Process and Control Loop Basics</td>
<td></td>
</tr>
<tr>
<td>A. Introduction</td>
<td>_________</td>
</tr>
<tr>
<td>B. Process Control Theory</td>
<td>_________</td>
</tr>
<tr>
<td>1. Process Characteristics</td>
<td>_________</td>
</tr>
<tr>
<td>2. The Process Control System</td>
<td>_________</td>
</tr>
<tr>
<td>3. Components of an Instrument Channel</td>
<td>_________</td>
</tr>
<tr>
<td>C. Process and Control Loop Basics</td>
<td>_________</td>
</tr>
<tr>
<td>1. Error</td>
<td>_________</td>
</tr>
<tr>
<td>2. Manual and Automatic Feedback Control</td>
<td>_________</td>
</tr>
<tr>
<td>Session II. Control Loops; Control Modes</td>
<td></td>
</tr>
<tr>
<td>A. Control Loops</td>
<td>_________</td>
</tr>
<tr>
<td>1. Feedforward Control (Open Loop)</td>
<td>_________</td>
</tr>
<tr>
<td>2. Feedback Control (Closed Loop)</td>
<td>_________</td>
</tr>
<tr>
<td>3. Cascade Control</td>
<td>_________</td>
</tr>
<tr>
<td>4. Ratio Control</td>
<td>_________</td>
</tr>
<tr>
<td>B. Control Modes</td>
<td>_________</td>
</tr>
<tr>
<td>1. On-Off Control (Two-Position Control)</td>
<td>_________</td>
</tr>
<tr>
<td>2. Modulating Control</td>
<td>_________</td>
</tr>
</tbody>
</table>
**Session III. Control Applications; Loop Tuning Methods**

**A. Typical Control Applications**
1. Temperature Control Loops
2. Pressure Control Loops
3. Flow Control Loops
4. Level Control Loops

**B. Loop Tuning Methods**
1. Ultimate Period/Ziegler-Nichols Closed-Loop Method
2. Dampened Oscillation

**Session IV. Open-Loop and Visual Loop Tuning**

**A. Open-Loop Tuning**
1. Time Constant
2. Reaction Rate

**B. Visual Loop Tuning**
1. Incremental Changes
2. Apparent Instability
3. Sluggish Response

**Session V. Application**

**A. Application**
1. Pneumatic Controllers (Fisher-Rosemount 4195)
2. Electronic Controllers (Honeywell UDC 3300)

**Sessions VI and VII. Laboratory**

**A. Laboratory**
Have the trainees practice performing closed-loop tuning. This laboratory corresponds with Performance Task 1.

**B. Laboratory**
Have the trainees practice performing open-loop tuning. This laboratory corresponds with Performance Task 2.

**C. Laboratory**
Have the trainees practice performing visual loop tuning. This laboratory corresponds with Performance Task 3.

**D. Laboratory**
Have the trainees practice setting up and using a pneumatic controller in a loop. This laboratory corresponds with Performance Task 4.

**Session VIII. Review and Testing**

**A. Module Review**

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

**C. Performance Testing**
1. Trainees must perform each task to the satisfaction of the instructor to receive recognition from the NCCER.
2. Record the training results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.
MODULE OVERVIEW
This module covers the methods used to establish communications between computers and devices in an industrial network. It covers the types of networks, the common industrial network protocols, and the equipment used to establish networks.

PREREQUISITES
Prior to training with this module, it is recommended that the trainee shall have successfully completed Core Curriculum; Industrial Maintenance E & I Technician Level One; Industrial Maintenance E & I Technician Level Two; Industrial Maintenance E & I Technician Level Three; and Industrial Maintenance E & I Technician Level Four, Modules 40401-09 through 40407-09.

OBJECTIVES
Upon completion of this module, the trainee will be able to do the following:
1. Describe how data networks are used in industrial facilities.
2. Identify the types of data networks used in industrial facilities and describe the methods used to control information flow within a network.
3. Describe how open connectivity is used in industrial data networks.
4. Identify the types of cables used to connect computers and other devices within a network and explain their applications.
5. Describe the physical layer of two or more device buses.
6. Apply connectors to UTP and coaxial cable.

PERFORMANCE TASKS
Under the supervision of the instructor, the trainee should be able to do the following:
1. Properly run and terminate CAT 6 and coaxial cables.

MATERIALS AND EQUIPMENT LIST

| Overhead projector and screen | Coaxial cable compression tools |
| Transparencies               | Examples of network cables: |
| Blank acetate sheets         |   USB                       |
| Transparency pens            |   Twisted pair              |
| Whiteboard/chalkboard       |   Coaxial                   |
| Markers/chalk                |   Optical fiber             |
| Pencils and scratch paper   |   IEEE 1394 (FireWire®)    |
| Appropriate personal protective equipment | Cable connectors: |
| Diagram of an industrial network | RJ45 jacks and plugs |
| Crimping tools              | Coaxial cable connectors   |
| Punchdown tools             | Copies of the Quick Quiz*  |
| Coaxial cable stripping tools | Module Examinations**      |

* Located at 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.

- http://www.thecertificationhub.com/networkplus/the_osi_ref_model.htm

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 Data Networks. 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; The Data Highway; Transfer Medium; OSI Reference Model</td>
<td></td>
</tr>
<tr>
<td>A. Introduction</td>
<td></td>
</tr>
<tr>
<td>B. Data Highway</td>
<td></td>
</tr>
<tr>
<td>1. Serial Communication</td>
<td></td>
</tr>
<tr>
<td>2. Parallel Communication</td>
<td></td>
</tr>
<tr>
<td>3. Data Buses</td>
<td></td>
</tr>
<tr>
<td>C. Transfer Medium</td>
<td></td>
</tr>
<tr>
<td>D. OSI Reference Model</td>
<td></td>
</tr>
<tr>
<td>1. Protocols</td>
<td></td>
</tr>
<tr>
<td>Session II. Network Topologies; Access Control; Common Network Nomenclature</td>
<td></td>
</tr>
<tr>
<td>A. Network Topologies</td>
<td></td>
</tr>
<tr>
<td>1. Star Topology</td>
<td></td>
</tr>
<tr>
<td>2. Ring Topology</td>
<td></td>
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<tr>
<td>3. Bus Topology</td>
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<tr>
<td>4. Hybrid Topologies</td>
<td></td>
</tr>
<tr>
<td>B. Access Control</td>
<td></td>
</tr>
<tr>
<td>1. Random Access</td>
<td></td>
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<tr>
<td>2. Polling</td>
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<td>3. Dedicated Channel</td>
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<td>4. Token Passing</td>
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<td>C. Common Network Nomenclature</td>
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</tbody>
</table>
Session III. The Internet; Industrial Networks

A. Background

B. Transmission Control Protocol/Internet Protocol (TCP/IP)
   1. Internet Protocol
   2. IP Addressing
   3. Transmission Control Protocol

C. Internet Application Protocols
   1. Hypertext Transfer Protocol
   2. Simple Mail Transfer Protocol
   3. Post Office Protocol
   4. Internet Mail Access Protocol
   5. Network News Transfer Protocol
   6. File Transfer Protocol

D. Industrial Networks
   1. Ethernet
   2. Industrial Ethernet
   3. Modbus
   4. Proﬁbus
   5. DeviceNet
   6. AS-i Bus
   7. OLE for Process Control (OPC)
   8. Manufacturing Automation Protocol (MAP)

Session IV. Microcomputer-Based LANs; Proprietary Control Networks; Bridges, Routers, and Gateways

A. Microcomputer-based LANs
   1. Basic Input/Output Systems (BIOS)
   2. Operating Systems
   3. Networking Software/Network Operating Systems
   4. Real-Time Performance Issues

B. Proprietary Control Networks
   1. PLC Communication Systems
   2. DCS Communication Systems

C. Bridges, Routers, and Gateways
   1. Bridges
   2. Routers
   3. Gateways

Session V. Network Cabling; Optical Fiber Cabling; Cable Testing

A. Network Cabling
   1. Unshielded Twisted Pair (UTP) Cable
   2. Screened Twisted Pair (ScTP) Cable and Patch Cord
   3. UTP Jack and Plug Terminations
   4. Laboratory

       Have the trainees properly run and terminate Cat 6 cables. This laboratory corresponds to Performance Task 1.
5. Coaxial Cable
6. RG-6 Coax F-Type Terminations
7. Laboratory
   - Have the trainees properly run and terminate coaxial cables. This laboratory corresponds to Performance Task 1.

B. Optical Fiber Cable
   1. Fiber-Optic Installation Considerations

C. Cable Testing

Session VI. Review and Testing

A. Module Review

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

C. Performance Testing
   1. Trainees must perform each task to the satisfaction of the instructor to receive recognition from the NCCER.
   2. Record the training results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.
MODULE OVERVIEW
This module provides information on the operating principles, uses, and programming methods for PLCs used in industrial environments.

PREREQUISITES
Prior to training with this module, it is recommended that the trainee shall have successfully completed Core Curriculum; Industrial Maintenance E & I Technician Level One; Industrial Maintenance E & I Technician Level Two; Industrial Maintenance E & I Technician Level Three; and Industrial Maintenance E & I Technician Level Four, Modules 40401-09 through 40408-09.

OBJECTIVES
Upon completion of this module, the trainee will be able to do the following:
1. Describe the function and purpose of a programmable logic controller (PLC).
2. Compare hardwired and PLC systems.
3. Explain number systems.
4. Explain the general function of an input/output (I/O) module, including the following types:
   - Discrete
   - Numerical and analog data
   - Special
   - Remote
5. Explain the power supply and ground connections to I/O modules.
6. Explain PLC architecture.
7. Explain the purpose of PLC software and firmware.
8. Describe the features and the differences between PLC programming languages.
9. Describe the features of relay ladder logic instruction categories.
10. Explain the principles used to correlate PLC hardware components to software instructions.

PERFORMANCE TASKS
Under the supervision of the instructor, the trainee should be able to do the following:
1. Locate the specific I/O point associated with a given software address.
2. Connect to a PLC and turn on an output device.

MATERIALS AND EQUIPMENT LIST

- Overhead projector and screen
- Transparencies
- Blank acetate sheets
- Transparency pens
- Whiteboard/chalkboard
- Markers/chalk
- Pencils and scratch paper
- Appropriate personal protective equipment
- Ladder diagrams
- Functional diagrams
- An operating PLC-controlled system or simulator
- Copies of the Quick Quiz*
- Module Examinations**
- Performance Profile Sheets**

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

Ensure that the trainees are equipped with appropriate personal protective equipment and know how to use it properly. This module may require that the trainees visit job sites. Ensure that trainees are briefed on site safety policies prior to any site visits.

ADDITIONAL RESOURCES

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


TEACHING TIME FOR THIS MODULE

An outline for use in developing your lesson plan is presented below. Note that each Roman numeral in the outline equates to one session of instruction. Each session has a suggested time period of 2½ hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 17½ hours are suggested to cover *Programmable Logic Controllers*. You will need to adjust the time required for hands-on activity and testing based on your class size and resources. Because laboratories often correspond to Performance Tasks, the proficiency of the trainees may be noted during these exercises for Performance Testing purposes.

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<td>B. PLC Architecture</td>
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<td>1. Hardwired and PLC Systems</td>
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<td>C. Number Systems Review</td>
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<td>A. PLC Hardware</td>
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<td>2. Addressing Modules</td>
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<td>3. Input/Output Modules</td>
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<td>B. Processor Modules</td>
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<td>2. PLC Memory</td>
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<td>C. Software</td>
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<td>1. Ladder Logic</td>
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<td>2. Boolean</td>
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<td>3. English Statement</td>
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<td>4. Functional Block</td>
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<td>5. Machine Stage</td>
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</table>
D. Hardware to Program Correlation
E. Guidelines for Programming and Installation
   1. Programming
   2. Installation
   3. I/O Wiring
   4. Dynamic System Checkout

Sessions III–VI. PLC Testing, Installation, and Programming Laboratory
A. Laboratory
   Have trainees practice locating a specific I/O point associated with a given software address. This laboratory corresponds with Performance Task 1.
B. Laboratory
   Have trainees practice connecting to a PLC to turn on an output device. This laboratory corresponds with Performance Task 2.

Session VII. Review and Testing
A. Module Review
B. Module Examination
   1. Trainees must score 70% or higher to receive recognition from NCCER.
   2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.
C. Performance Testing
   1. Trainees must perform each task to the satisfaction of the instructor to receive recognition from the NCCER.
   2. Record the training results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.
MODULE OVERVIEW

This module introduces the applications of distributed control systems in industrial environments. It explains DCS architecture and operator interfaces, along with DCS installation, maintenance, and troubleshooting.

PREREQUISITES

Prior to training with this module, it is recommended that the trainee shall have successfully completed Core Curriculum; Industrial Maintenance E & I Technician Level One; Industrial Maintenance E & I Technician Level Two; Industrial Maintenance E & I Technician Level Three; and Industrial Maintenance E & I Technician Level Four, Modules 40401-09 through 40409-09.

OBJECTIVES

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

1. Define distributed control systems and explain how they are applied in an industrial facility.
2. Identify and describe components of a DCS.
3. Describe network configurations for a DCS.
4. Describe basic service procedures that may have to be performed on a field device.
5. Describe installation practices of a DCS.
6. Describe power distribution requirements for a DCS.
7. Describe power supplies and their applications in a DCS.
8. Describe how to use a DCS interface to obtain process data and to troubleshoot plant equipment.

PERFORMANCE TASKS

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

1. Develop a diagram of the basic system architecture of a DCS, including the components and information flow.
2. Use a DCS interface to obtain process data.

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
- Diagram of an industrial network
- Control book
- Functional diagram showing redundancies
- As-built drawings
- DCS self-documentation listings
- Marked-up loop drawings
- Examples of I/O modules
- Copies of the Quick Quiz*
- Module Examinations**
- Performance Profile Sheets**

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

Ensure that the trainees are equipped with appropriate personal protective equipment and know how to use it properly. This module may require that the trainees visit job sites. Ensure that trainees are briefed on site safety policies prior to any site visits.

ADDITIONAL RESOURCES

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

www.fieldbus.com
www.emersonprocess.com

TEACHING TIME FOR THIS MODULE

An outline for use in developing your lesson plan is presented below. Note that each Roman numeral in the outline equates to one session of instruction. Each session has a suggested time period of 2½ hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 17½ hours are suggested to cover Distributed Control 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.

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### Session I. Introduction; System Architecture

A. Introduction

B. System architecture

1. Controllers and I/O
2. Software Server and Engineering Workstation
3. Operator Workstation
4. Network
5. Other Drops

### Session II. Controllers and Their I/O

A. Controllers and Their I/O

1. The Database and How It Relates to Controllers
2. The Process I/O
3. The Application Program
4. Modifying the Application Program
5. Adding and Deleting Points
6. Redundancy
7. Memory and Speed

### Session III. The Software Server and Engineering Workstation; Operator Workstation

A. The Software Server and Engineering Workstation

1. Operating Systems
2. Applications on an Engineering Workstation
3. Backing up the System
4. System Security
B. The Operator Workstation
   1. Graphics
   2. The Alarming System
   3. Detailed Point Displays
   4. Trends

Session IV. Laboratory
A. Laboratory
   Have the trainees develop a diagram of the basic system architecture of a DCS, including the components and information flow. This laboratory corresponds to Performance Task 1.

B. Laboratory
   Have the trainees use a DCS interface to obtain process data. This laboratory corresponds to Performance Task 2.

Session V. The Network
A. The Network
   1. Management Systems
   2. Fieldbuses
   3. Fieldbus Standardization
   4. Modbus
   5. Profibus
   6. Foundation Fieldbus
   7. Other Network Systems

Session VI. Installation and Commissioning
A. Installation and Commissioning
   1. DCS Installation
   2. Grounding
   3. Power Conditioning and Distribution
   4. Backup Power and Redundancy
   5. Network Installation
   6. Checkout and Commissioning
   7. Documentation and Upgrades

Session VII. Maintenance and Troubleshooting; Review and Testing
A. Maintenance and Troubleshooting
   1. Field Device Failures
   2. DCS Component Failures

B. Troubleshooting Plant Equipment with a DCS

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