Standby and Emergency Systems
Annotated Instructor's Guide

Module 40401-09

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

Overhead projector and screen

Transparencies

Blank acetate sheets

Transparency pens

Whiteboard/chalkboard

Markers/chalk

Pencils and scratch paper

Appropriate personal protective equipment

Engine-driven AC generator

Transfer switches

Storage batteries

Tools to perform resistance and capacity checks on batteries

Module Examinations*

* Located in the Test Booklet

SAFETY CONSIDERATIONS

Ensure that the trainees are equipped with appropriate personal protective equipment and know how to use it properly.

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.

Liquid-Cooled Generator Sets Application Manual, Latest Edition. Minneapolis, MN: Cummins Onan.

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

OT III Transfer Switches Application Manual, Latest Edition. Minneapolis, MN: Cummins Onan.

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.

Topic	**Planned Time**
Session I. Introduction; Emergency and Standby Power System Components	
A. Introduction	_____
B. Emergency and Standby Power System Components	_____
1. Engine-Driven Generator Sets	_____
2. Transfer Switches	_____
3. Automatic Sequential Paralleling Emergency/Standby System	_____
Session II. Storage Batteries; Static Uninterruptible Power Supply	
A. Storage Batteries	_____
1. Lead-Acid Batteries	_____
2. Nickel Cadmium Batteries	_____
3. Battery Maintenance	_____
4. Battery and Battery Charger Operation	_____
B. Static Uninterruptible Power Supply	_____
1. Double-Conversion UPS Systems	_____
2. Single-Conversion UPS Systems	_____
Session III. *NEC*® Requirements for Emergency Systems	
A. *NEC*® Requirements for Emergency Systems	_____
1. Legally Required Standby Systems	_____
2. Sources of Power	_____
Session IV. Emergency System Circuits for Light and Power	
A. Emergency System Circuits for Light and Power	_____
1. Health Care Facilities	_____
2. Battery-Powered Emergency Lighting	_____
3. Emergency Lighting Units	_____
4. Places of Assembly	_____
Session V. 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.	

Basic Process Control Elements, Transducers, and Transmitters

Module 40402-09

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*

*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.

Emerson Electric Company, http://www.emersonprocess.com/rosemount/document/manuals.html 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

Festo Corporation, http://www.festo.com/cms/en-us_us/index.htm for materials such as user manuals and product information bulletins on control or drive devices made by Festo Corporation

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 *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.

Topic	**Planned Time**
Session I. Introduction; Control Basics	
A. Review of Basic Instrument Control Channels	_____
B. Review of Measurement Terminology	_____
C. Standards and Elements of Measurement	_____
Session II. Detectors, Part One	
A. Detectors	_____
1. Orifice Plates	_____
2. Tap Types and Locations	_____
3. Venturi Tubes	_____
4. Pitot Tubes	_____
5. Annubar Tubes	_____
6. Magnetic Flowmeters	_____
7. Ultrasonic Flowmeters	_____
8. Capacitance-Type Level Detectors	_____
9. Ultrasonic Level Measurement	_____
10. Nuclear Level Detection	_____
11. Bimetallic Strip Thermometers	_____
Session III. Detectors, Part Two; Secondary Elements	
A. Detectors (Continued)	_____
1. Thermocouples	_____
2. Resistance Temperature Detectors (RTDs)	_____
B. Secondary Elements	_____
1. Bourdon Tubes	_____
2. Diaphragm Pressure Devices	_____
3. Pressure Capsules	_____
4. Bellows Pressure Devices	_____
5. Capacitance-Type Pressure Sensors	_____
6. Secondary Element Protection	_____

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.

Instrument Calibration and Configuration
Annotated Instructor's Guide

Module 40403-09

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

Analog differential pressure transmitter
(Rosemount 1151 Range 4 or similar model)

Analog temperature calibrator
(Fluke® Model 724 or similar equipment)

HART® communicator

Module Examinations*

Performance Profile Sheets*

*Located in the Test Booklet.

SAFETY CONSIDERATIONS

Ensure that the trainees are equipped with appropriate personal protective equipment and know how to use it properly. Emphasize 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.

Applied Instrumentation in the Process Industries, Volume 1, Second Edition. W.G. Andrew, H.B. Williams. Houston, TX: Gulf Publishing Company, 1979.

Measurement and Control Basics, Fourth Edition. T.A. Hughes. Research Triangle Park, NC: International Society of Automation (ISA), 2006.

Maintenance and Calibration of HART® Field Instrumentation. R. Pirret, P.E. Everett, WA: Fluke Corporation.

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.

Topic	**Planned Time**
Session I. Calibration, Part One	
A. Introduction	_____
B. Defining Calibration	_____
1. Measured Variables (Input Energies)	_____
2. Signals (Output Energies)	_____
3. Five-Point Method of Calibration	_____
C. Pneumatic Calibration Equipment and Calibrating Procedures	_____
1. Calibrating Pneumatic Differential Pressure Transmitters	_____
2. Temperature Transmitters	_____
Session II. Calibration, Part Two; Smart Transmitters	
A. Analog Calibration Equipment and Calibrating Procedures	_____
1. Analog Differential Pressure Transmitters	_____
2. Temperature Transmitters with Analog Output	_____
B. Smart Transmitters	_____
1. HART® Communication and Communicator	_____
2. HART® Device Calibration	_____

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.

Pneumatic Control Valves, Actuators, and Positioners
Annotated Instructor's Guide

Module 40404-09

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)

continued

New and used control devices (sensors and pneumatic positioners and actuators) that can be taken apart and assembled:

- Diaphragm actuators
- Piston actuators
- Rack and pinion actuators
- Double block and bleed actuators
- One or more Fisher® 667 actuators
- One or more Fisher® 3582 positioners
- One or more Smart positioners
- One or more HART® Tri-Loop and HIM signal converters

Access to non-operational piping that can be used for valve removal and installations

Samples of valves with rising, nonrising, and OS&Y stems

Samples of different types of valve packing

A supply of clear tubing and piping for demonstrations

Access to operational process equipment using different types of control valves and pneumatic positioners and actuators

Samples of simple and complex process control system drawings with pneumatic controls

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

Tools and supplies needed to lap valves

Tools and supplies needed to remove and install control valves and pneumatic actuators and positioners

Sample maintenance logs

Rigging and lifting equipment

Module Examinations*

Performance Profile Sheets*

*Located in the Test Booklet.

SAFETY CONSIDERATIONS

Ensure that the trainees are equipped with appropriate personal protective equipment and know how to use it properly. Emphasize 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 *Control Valve Handbook* is available on the Emerson website at http://www.documentation.emersonprocess.com/groups/public/documents/book/cvh99.pdf

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 62.1:3582, February 2001, *3582 Series Pneumatic and Type 3582i Electro-Pneumatic Valve Positioners*

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.

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

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 40405-09

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

Overhead projector and screen

Transparencies

Blank acetate sheets

Transparency pens

Whiteboard/chalkboard

Markers/chalk

Pencils and scratch paper

Appropriate personal protective equipment

P&IDs for process equipment

Sample loop sheets and diagrams

Vendor manuals for process equipment items

Fluke® ProcessMeter™ or similar instrument

Process equipment with functional sensors/detectors, transmitters, a controller, and control valves

Wallace & Tiernan® Model 65-2000 pneumatic tester (Wally Box®) or similar instrument

Fluke® Model 725 multifunction process calibrator or similar instrument

HART® communicator or similar instrument

Module Examinations*

Performance Profile Sheets*

* Located in the Test Booklet.

SAFETY CONSIDERATIONS

Ensure that the trainees are equipped with appropriate personal protective equipment and know how to use it properly. Emphasize 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

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

Instrumentation for Process Measurement and Control, 3rd edition. Norman A. Anderson. Boca Raton, FL: CRC Press, 1997.

*Maintenance and Calibration of HART® Field Instrumentatio*n. R. Pirret, P.E. Everett, WA: Fluke Corporation.

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.

Topic	**Planned Time**
Session I. Introduction; Verification	
A. Introduction	_____
B. Verifying Mechanical Installation through Visual Inspection	_____
1. Primary Element	_____
2. Field Transmitter	_____
3. Field Wiring, Conduit, Fiber-Optic Cable, and Tubing	_____
4. Control Room Components	_____
Session II. Loop Continuity Tests; Proving a Loop	
A. Loop Continuity Tests	_____
1. Electrical	_____
2. Pneumatic	_____
3. Fiber-Optic Cable	_____
4. Laboratory	_____
Have trainees practice pneumatic and electrical loop continuity tests. This laboratory corresponds to Performance Tasks 1 and 2.	
5. Signal Generators	_____
B. Proving a Loop	_____
1. Simulation	_____
2. Required Test Equipment	_____
3. Laboratory	_____
Have trainees practice proving a loop. This laboratory corresponds to Performance Task 3.	

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 40406-09

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

Overhead projector and screen

Transparencies

Blank acetate sheets

Transparency pens

Whiteboard/chalkboard

Markers/chalk

Pencils and scratch paper

Appropriate personal protective equipment

Sample loop sheets

Process equipment loop diagram

Process equipment P&ID

Process equipment equipped with sensors/ detectors, transmitters, a controller, and control valves

Vendor manuals on process equipment items

Strip chart recorder

Computer simulator (may be used for controller and recorder)

Module Examinations*

Performance Profile Sheets*

* Located in the Test Booklet.

SAFETY CONSIDERATIONS

Ensure that the trainees are equipped with appropriate personal protective equipment and know how to use it properly. Emphasize 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

Process Control Instrumentation Technology. Curtis D. Johnson. New York, NY: Prentice Hall, 2002.

Troubleshooting: A Technician's Guide. William A. Mostica. Research Triangle Park, NC: International Society of Automation, 2006.

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.

Topic	**Planned Time**
Session I. Introduction; Troubleshooting	
A. Introduction	_____
B. Fundamentals of Troubleshooting	_____
1. Analyzing the Loop	_____
2. Identifying the Problem	_____
3. Understanding the Loop and Its Function	_____
C. Troubleshooting an Oscillating Process	_____
1. Verifying That a Problem Exists	_____
2. Gathering Information	_____
3. Identifying Possible Causes of the Problem	_____
4. Locating the Problem	_____
5. Using a Troubleshooting Flowchart	_____
D. Laboratory 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.	_____
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.

Process Control Loops and Tuning
Annotated Instructor's Guide

Module 40407-09

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

Transparencies

Blank acetate sheets

Transparency pens

Whiteboard/chalkboard

Markers/chalk

Pencils and scratch paper

Appropriate personal protective equipment

Full-face shields

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

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

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

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. 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

Good Tuning: A Pocket Guide. 2nd Edition. Gregory K. McMillan. Research Triangle Park, NC: The International Society of Automation, 2005.

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.

Topic	**Planned Time**
Session I. Introduction; Process Control Theory; Process and Control Loop Basics	
A. Introduction	_____
B. Process Control Theory	_____
1. Process Characteristics	_____
2. The Process Control System	_____
3. Components of an Instrument Channel	_____
C. Process and Control Loop Basics	_____
1. Error	_____
2. Manual and Automatic Feedback Control	_____
Session II. Control Loops; Control Modes	
A. Control Loops	_____
1. Feedforward Control (Open Loop)	_____
2. Feedback Control (Closed Loop)	_____
3. Cascade Control	_____
4. Ratio Control	_____
B. Control Modes	_____
1. On-Off Control (Two-Position Control)	_____
2. Modulating Control	_____

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.

Data Networks
Annotated Instructor's Guide

Module 40408-09

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

Transparencies

Blank acetate sheets

Transparency pens

Whiteboard/chalkboard

Markers/chalk

Pencils and scratch paper

Appropriate personal protective equipment

Diagram of an industrial network

Crimping tools

Punchdown tools

Coaxial cable stripping tools

Coaxial cable compression tools

Examples of network cables:
- USB
- Twisted pair
- Coaxial
- Optical fiber
- *IEEE 1394* (FireWire®)

Cable connectors:
- RJ45 jacks and plugs
- Coaxial cable connectors

Copies of the Quick Quiz*

Module Examinations**

Performance Profile Sheets**

* 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

Practical Industrial Data Networks: Design, Installation, and Troubleshooting (IDC Technology). Burlington, MA: Newnes Press.

Network Design Reference Manual. Tampa, FL: BICSI.

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.

Topic	**Planned Time**
Session I. Introduction; The Data Highway; Transfer Medium; OSI Reference Model	
A. Introduction	_____
B. Data Highway	_____
1. Serial Communication	_____
2. Parallel Communication	_____
3. Data Buses	_____
C. Transfer Medium	_____
D. OSI Reference Model	_____
1. Protocols	_____
Session II. Network Topologies; Access Control; Common Network Nomenclature	
A. Network Topologies	_____
1. Star Topology	_____
2. Ring Topology	_____
3. Bus Topology	_____
4. Hybrid Topologies	_____
B. Access Control	_____
1. Random Access	_____
2. Polling	_____
3. Dedicated Channel	_____
4. Token Passing	_____
C. Common Network Nomenclature	_____

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. Bridgers, 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.

Programmable Logic Controllers
Annotated Instructor's Guide

Module 40409-09

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

Process Control Instrumentation Technology, 2007. Curtis D. Johnson. New York, NY: Prentice Hall.

Programmable Logic Controllers, 2/E, 2008. James A Rehg, Glenn J. Sartori. New York, NY: Prentice Hall.

Fundamentals of Programmable Logic Controllers, Sensors, and Communications, 3/E, 2004. Jon Stenerson. New York, NY: Prentice Hall.

TEACHING TIME FOR THIS MODULE

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

Topic	**Planned Time**
Session I. Introduction; PLC Architecture; Number Systems Review	
A. Introduction	_____
B. PLC Architecture	_____
1. Hardwired and PLC Systems	_____
2. Comparison of Hardwired and PLC Systems	_____
C. Number Systems Review	_____
1. Binary Numbers	_____
2. Octal	_____
3. Hexadecimal	_____
4. Binary Codes	_____
Session II. PLC Hardware; Processor Modules; Software; Hardware to Program Correlation; Installation	
A. PLC Hardware	_____
1. Power Supplies and Grounds	_____
2. Addressing Modules	_____
3. Input/Output Modules	_____
B. Processor Modules	_____
1. Scans	_____
2. PLC Memory	_____
C. Software	_____
1. Ladder Logic	_____
2. Boolean	_____
3. English Statement	_____
4. Functional Block	_____
5. Machine Stage	_____

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.

Distributed Control Systems
Annotated Instructor's Guide

Module 40410-09

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.

Topic	**Planned Time**
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.