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.


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><strong>Session V. Review and Testing</strong></td>
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<td>A. Module Review</td>
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<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>
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.


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.

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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>9. Ultrasonic Level Measurement</td>
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<td>10. Nuclear Level Detection</td>
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<td>Session III. Detectors, Part Two; Secondary Elements</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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<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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<td>5. Capacitance-Type Pressure Sensors</td>
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<td>6. Secondary Element Protection</td>
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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 | Wallace & Tiernan pneumatic calibrator (Wally Box®) or similar instrument |
| Transparencies | Pneumatic DP transmitter |
| Blank acetate sheets | Compressor |
| Transparency pens | Pneumatic temperature transmitter (Foxboro® 12Å or similar model) |
| Whiteboard/chalkboard | Multifunction loop calibrator (Fluke® Model 725 or similar model) |
| Markers/chalk | |
| Pencils and scratch paper | |
| Appropriate personal protective equipment | |

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.

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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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<tr>
<td>1. Calibrating Pneumatic Differential Pressure Transmitters</td>
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<td>2. Temperature Transmitters</td>
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<td><strong>Session II. Calibration, Part Two; Smart Transmitters</strong></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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</table>

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*
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 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 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>B. Pneumatic Control Valves</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>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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<td>F. Adjusting, Mounting, and Testing Valve Actuators</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>
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<tr>
<td>Have trainees practice bench setting actuators and mounting actuators onto control valves. This laboratory corresponds to Performance Task 2.</td>
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</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  
Overhead projector and screen  
Fluke® ProcessMeter™ or similar instrument  
Transparencies  
Process equipment with functional  
Blank acetate sheets  
sensors/detectors, transmitters, a controller,  
Transparency pens  
and control valves  
Whiteboard/chalkboard  
Wallace & Tiernan® Model 65-2000 pneumatic  
Markers/chalk  
tester (Wally Box®) or similar instrument  
Pencils and scratch paper  
Fluke® Model 725 multifunction process calibrator  
Appropriate personal protective equipment  
or similar instrument  
P&IDs for process equipment  
HART® communicator or similar instrument  
Sample loop sheets and diagrams  
Module Examinations*  
Vendor manuals for process equipment items  
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


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


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.

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<thead>
<tr>
<th>Topic</th>
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<tbody>
<tr>
<td><strong>Session I. Introduction; Troubleshooting</strong></td>
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<tr>
<td>A. Introduction</td>
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<tr>
<td>B. Fundamentals of Troubleshooting</td>
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<tr>
<td>1. Analyzing the Loop</td>
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<tr>
<td>2. Identifying the Problem</td>
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<td>3. Understanding the Loop and Its Function</td>
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<tr>
<td>C. Troubleshooting an Oscillating Process</td>
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<tr>
<td>1. Verifying That a Problem Exists</td>
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<tr>
<td>2. Gathering Information</td>
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<td>3. Identifying Possible Causes of the Problem</td>
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<td>4. Locating the Problem</td>
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<tr>
<td>5. Using a Troubleshooting Flowchart</td>
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<tr>
<td>D. Laboratory</td>
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<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>
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<tr>
<td><strong>Session II. Proving a Loop</strong></td>
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<tr>
<td>A. Proving a Loop</td>
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<tr>
<td>1. Interpreting a Loop Sheet</td>
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<tr>
<td>2. Applying Logical Steps in Troubleshooting a New Loop</td>
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<tr>
<td>B. Laboratory</td>
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<tr>
<td>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.</td>
<td></td>
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</tbody>
</table>
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

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

PREREQUISITES

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

Core Curriculum; Instrumentation Level One; Instrumentation Level Two, Modules 12201-03 through 12203-03

OBJECTIVES

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

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

PERFORMANCE TASKS

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

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

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

HOW TO USE THIS ANNOTATED INSTRUCTOR’S GUIDE

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

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

SAFETY CONSIDERATIONS

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

PREPARATION

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

MATERIALS AND EQUIPMENT LIST

- Overhead projector and screen
- Transparencies
- Transparency pens
- Blank acetate sheets
- Markers/chalk
- Whiteboard/chalkboard
- Pencils and scratch paper
- Straightedge
- Appropriate personal protective equipment
- Sample process control loops, P&IDs, and typical instrumentation documentation
- Module Examinations*
- Performance Profile Sheets*

*Located in the Test Booklet.

ADDITIONAL RESOURCES

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

TEACHING TIME FOR THIS MODULE

An outline for use in developing your lesson plan is presented below. Note that each Roman numeral in the outline equates to one session of instruction. Each session has a suggested time period of 2 1⁄2 hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 20 hours are suggested to cover Process Control Theory. You will need to adjust the time required for hands-on activity and testing based on your class size and resources.

<table>
<thead>
<tr>
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<td>Session I. Introduction; Process Characteristics; The Process Control System</td>
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<tr>
<td>A. Introduction</td>
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<td>B. Process Characteristics</td>
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<td>C. The Process Control System</td>
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<td>Session II. Components of an Instrument Channel</td>
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<tr>
<td>A. Components of an Instrument Channel</td>
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<tr>
<td>1. Detector /Sensor</td>
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<td>a. Direct vs. Inferred Measurements</td>
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<td>2. Transducer</td>
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<td>3. Amplifier /Signal Conditioner</td>
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<td>4. Transmitter</td>
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<td>5. Controller</td>
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<td>6. Final Control Element (Control Valve)</td>
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<td>a. Pneumatic Control Valve Actuators</td>
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<td>b. Manual Actuators</td>
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<td>c. Valve Positioners</td>
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<td>d. Electric Proportional Valve Actuators</td>
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<td>e. Solenoid Actuators</td>
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<td>Session III. Control Loops</td>
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<td>A. Control Loops</td>
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<tr>
<td>1. Feedforward Control (Open-Loop)</td>
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<td>2. Feedback Control (Closed-Loop)</td>
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<tr>
<td>a. Operation of Closed-Loop Control</td>
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<td>b. Performance of a Closed-Loop System</td>
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<tr>
<td>c. Criteria for Closed-Loop Control Quality</td>
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<td>3. Cascade Control</td>
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<td>4. Ratio Control</td>
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<td>Session IV. Laboratory</td>
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<tr>
<td>A. Laboratory</td>
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<tr>
<td>Under your supervision, have the trainees identify the major components of feedforward, feedback, cascade, and ratio process control loops from a P&amp;ID. Note the proficiency of each trainee.</td>
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<tr>
<td>Session V. Control Modes</td>
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<tr>
<td>A. Control Modes</td>
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<td>1. On-Off Control (Two-Position Control)</td>
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<tr>
<td>a. On-Off Control Characteristics</td>
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<tr>
<td>2. Modulating Control</td>
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<tr>
<td>a. Proportional (Gain or P) Control</td>
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<tr>
<td>b. Integral (Reset or I) Control</td>
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<tr>
<td>c. Derivative (Rate or D) Control</td>
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<tr>
<td>d. Proportional Plus Integral (PI) Control</td>
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</tbody>
</table>
e. Proportional Plus Derivative (PD) Controllers
f. Proportional Plus Integral Plus Derivative (PID) Controllers

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

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

Session VIII. Summary; Module Examination and Performance Profile Examination
A. Summary
   1. Summarize module
   2. Answer questions
B. Module Examination
   1. Trainees must score 70% or higher to receive recognition from the NCCER.
   2. Record the testing results on Craft Training Report Form 200 and submit the results to the Training Program Sponsor.
C. Performance Testing
   1. Trainees must perform each task to the satisfaction of the instructor to receive recognition from the NCCER.
   2. Record the testing results on Craft Training Report Form 200 and submit the results to the Training Program Sponsor.
**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
- 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


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.

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<tr>
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<tbody>
<tr>
<td>Session I. Introduction; Process Control Theory; Process and Control Loop Basics</td>
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</tr>
<tr>
<td>A. Introduction</td>
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<tr>
<td>B. Process Control Theory</td>
<td></td>
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<tr>
<td>1. Process Characteristics</td>
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<td>2. The Process Control System</td>
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<td>3. Components of an Instrument Channel</td>
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<td>C. Process and Control Loop Basics</td>
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<td>2. Feedback Control (Closed Loop)</td>
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<td>3. Cascade Control</td>
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<td>4. Ratio Control</td>
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<td>B. Control Modes</td>
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<td>1. On-Off Control (Two-Position Control)</td>
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<tr>
<td>2. Modulating Control</td>
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</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
- 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.


*Network Design Reference Manual.* Tampa, FL: BICSI.

[http://www.thecertificationhub.com/networkplus/the_osi_ref_model.htm](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>
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<tbody>
<tr>
<td><strong>Session I. Introduction; The Data Highway; Transfer Medium; OSI Reference Model</strong></td>
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<tr>
<td>A. Introduction</td>
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<td>B. Data Highway</td>
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<td>1. Serial Communication</td>
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<td>2. Parallel Communication</td>
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<td>3. Data Buses</td>
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<td>C. Transfer Medium</td>
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<tr>
<td>D. OSI Reference Model</td>
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<tr>
<td>1. Protocols</td>
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<tr>
<td><strong>Session II. Network Topologies; Access Control; Common Network Nomenclature</strong></td>
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<td>A. Network Topologies</td>
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<td>1. Star Topology</td>
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<td>2. Ring Topology</td>
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<td>3. Bus Topology</td>
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<td>4. Hybrid Topologies</td>
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<tr>
<td>B. Access Control</td>
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<tr>
<td>1. Random Access</td>
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<td>2. Polling</td>
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<tr>
<td>3. Dedicated Channel</td>
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<td>4. Token Passing</td>
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<tr>
<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. 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.
MODULE OVERVIEW
This module explains basic digital logic elements, flip-flops, shift registers, and counters.

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

Core Curriculum; Instrumentation Levels One through Three

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

1. Identify the different gates and circuits in digital logic.
2. Describe the truth tables and timing diagrams for various digital gates.
3. Describe the operation of different digital flip-flops.
4. Describe the operation of shift registers.
5. Describe the operation of counters.

PERFORMANCE TASKS
There are no performance tasks for this module.

MATERIALS AND EQUIPMENT LIST

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
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<tbody>
<tr>
<td>Overhead projector and screen</td>
<td>Whiteboard/chalkboard</td>
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<tr>
<td>Transparencies</td>
<td>Markers/chalk</td>
</tr>
<tr>
<td>Blank acetate sheets</td>
<td>Pencils and scratch paper</td>
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<tr>
<td>Transparency pens</td>
<td>Module Examinations*</td>
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</tbody>
</table>

*Located in the Test Booklet.

SAFETY CONSIDERATIONS
There are no required safety considerations for this module.

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 2 1/2 hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 10 hours are suggested to cover Digital Logic Circuits. You will need to adjust the time required for hands-on activity and testing based on your class size and resources.

<table>
<thead>
<tr>
<th>Topic</th>
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<tbody>
<tr>
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<td>A. AND Gates</td>
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<td>B. OR Gates</td>
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<td>C. Amplifiers</td>
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<td>E. NAND Gates</td>
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<td>F. NOR Gates</td>
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<td>G. Exclusive OR Gates</td>
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<td>H. Combination Logic</td>
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<td><strong>Session II. Basic Flip-Flops, Latches, and Shift Registers</strong></td>
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<tr>
<td>A. Basic Flip-Flops and Latches</td>
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<td>1. RS NOR Latch and RS NAND Latch</td>
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<td>2. Clocked RS Latch</td>
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<td>3. Data (D) Latch and D Flip-Flop</td>
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<td>4. JK Master-Slave Flip-Flop and Toggle (T) Flip-Flop</td>
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<td>B. Shift Registers</td>
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<tr>
<td>1. Basic</td>
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<td>2. Serial In–Serial Out</td>
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<td>3. Serial In–Parallel Out</td>
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<td>4. Parallel In–Serial Out</td>
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<td>5. Parallel In–Parallel Out</td>
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<td>6. Universal</td>
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<td>A. Four-Bit Binary</td>
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<td>B. Up</td>
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<td>C. Down</td>
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<td>E. Synchronous</td>
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<td>F. Ripple Carry</td>
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<td>G. Binary Coded Decimal</td>
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<td>H. Ring and Johnson</td>
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<tr>
<td>I. Programmable</td>
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</table>
Session IV. Arithmetic Elements, Decoders, Standards, Review, and Module Examination

A. Arithmetic Elements
   1. Half Adder
   2. Full Adder

B. Decoders

C. ANSI/ASQC Standards

D. Review

E. 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.
Module Overview

This module discusses how to identify sensing devices used to monitor a steam turbine/generator. It also describes the test equipment and calibration procedures used to calibrate these sensing devices.

Prerequisites

Prior to training with this module, it is recommended that the trainee shall have successfully completed Power Industry Fundamentals; Power Generation I&C Maintenance Technician Level One; Power Generation I&C Maintenance Technician Level Two; and Power Generation I&C Maintenance Technician Level Three.

Objectives

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

1. Identify sensing devices commonly used in supervisory instrumentation.
   • Vibration detectors and probes
   • Eccentricity sensors
   • Rotor and shell position sensors
   • Speed sensors
   • Shaft position detectors (Keyphasor® transducer signals)
   • Thrust bearing wear detectors
2. Identify test equipment commonly used to calibrate supervisory instrumentation elements.
   • Shakers and Wobulators®
   • Frequency generators
   • Oscilloscopes
   • Precision mechanical measurement instruments (micrometers)
   • Digital multimeters
3. Describe and demonstrate the setup, testing, and calibration of supervisory instrumentation elements in accordance with manufacturer’s specifications.

Performance Tasks

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

1. From a collection of sensing devices, select ones suitable for measuring vibration, shaft eccentricity, rotor and shell position, shaft speed, shaft position, and thrust bearing wear.
2. From a collection of test equipment, select a portable shaker (or Wobulator®), a frequency generator, an oscilloscope, a micrometer, and a digital multimeter.
3. Demonstrate how to set up and calibrate a proximity transducer using the so-called electrical method (requiring a voltmeter and a power supply), based on the probe manufacturer’s recommendations.

Materials and Equipment

- Multimedia projector and screen
- Computer
- Whiteboard/chalkboard
- Markers/chalk
- Pencils and scratch paper
- Appropriate personal protective equipment
- Specification sheets and/or manufacturer’s product catalogs/data sheets for various sensing devices and testing devices
Samples or pictures of the following devices:
- Displacement transducer
- Accelerometer
- Velocity transducer
- Eddy current sensor
- Linear variable differential transformer (LVDT) displacement transducer
- Speed sensor
- Shaft position detector
- Thrust bearing wear detector
- Vibration shake table (Wobulator®)
- Frequency generator
- Oscilloscope
- Outside micrometer

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

**Safety Considerations**

Ensure that the trainees are equipped with appropriate personal protective equipment and know how to use it properly. This module requires that the trainees select and operate various types of electrical test equipment. Ensure that trainees are briefed on basic electrical safety and shop safety policies.

**Additional Resources**

This module is intended to present thorough resources for task training. The following references 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.reliabilitydirect.com
- If available, user manuals and operating guides for supervisory instrumentation manufacturers and/or applicable test equipment manufacturers

**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 *Calibrate Supervisory Instrumentation Elements*. 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>
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<td><strong>Session I. Introduction; Sensing Devices</strong></td>
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<tr>
<td>A. Introduction</td>
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<tr>
<td>B. Sensing Devices</td>
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<tr>
<td>1. Vibration Detectors</td>
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<td>2. Eccentricity Sensors</td>
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<td>3. Rotor and Shell Expansion Sensors</td>
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<td>4. Speed Sensors</td>
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<td>5. Shaft Position Detectors</td>
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<td>6. Thrust Bearing Wear Detectors</td>
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<tr>
<td>C. Laboratory</td>
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</table>

Have trainees identify and select sensing devices suitable for measuring vibration, shaft eccentricity, rotor and shell position, shaft speed, shaft position, and thrust bearing wear. This laboratory corresponds to Performance Task 1.
Session II. Test Equipment

A. Test Equipment
   1. Shakers and Wobulators®
   2. Frequency Generators
   3. Oscilloscopes
   4. Micrometers
   5. Calipers
   6. Digital Multimeters

B. Laboratory
   Have trainees identify and select a portable shaker (or Wobulator®), a frequency generator, an oscilloscope, a micrometer, and a digital multimeter. This laboratory corresponds to Performance Task 2.

Session III. Setup, Testing, and Calibration

A. Equipment Setup
B. Proximity Transducer Testing
C. Proximity Transducer Calibration
D. Laboratory
   Have trainees demonstrate how to set up and calibrate a proximity transducer using the electrical method (requiring a voltmeter and a power supply), based on the probe manufacturer’s recommendations. This laboratory corresponds to Performance Task 3.

Session IV. Review and Testing

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

This module focuses on control strategies aimed at the safe and efficient operation of boilers and heat recovery steam generators (HRSGs). It identifies devices and connections shown on boiler control loops that use either ISA or SAMA symbols. Examples of control loops for major boiler systems are covered, and precautions and regulatory requirements for burner and furnace fuel safety control are described.

Prerequisites

Prior to training with this module, it is recommended that the trainee shall have successfully completed Power Industry Fundamentals; Power Generation I&C Maintenance Technician Level One; Power Generation I&C Maintenance Technician Level Two; Power Generation I&C Maintenance Technician Level Three; and Power Generation I&C Maintenance Technician Level Four, Modules 40401-09 – 51401-10.

Objectives

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

1. Identify symbols commonly used to represent devices and connections associated with the control of boilers and heat recovery steam generators (HRSGs).
2. Describe the layout and function of a single-element steam drum level control loop.
3. Describe control strategies used for major boiler and HRSG variables, including:
   - Furnace pressure
   - Fuel flow
   - Air flow
   - Oxygen and excess air
   - Feedwater flow and drum level
   - Steam flow and pressure
   - Steam temperature
   - HRSG drum level and steam temperature control
   - HRSG emissions control
4. Identify precautions and regulatory requirements for burner and furnace fuel safety control, including:
   - Furnace light-off sequence
   - Fuel tripping

Performance Tasks

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

1. Identify the devices and connections shown on a boiler control loop that uses either ISA or SAMA symbols.
2. Sketch a single-element steam drum level control loop using SAMA symbology.
3. Sketch an SAMA digital logic diagram that represents the boiler purge permissives for a selected boiler.
Materials and Equipment

- Markers/chalk
- Pencils and scratch paper
- Whiteboard/chalkboard
- Multimedia projector and screen
- Computer
- Appropriate personal protective equipment
- Flow diagrams, P&IDs, and control system diagrams and displays

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

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 basic electrical safety and shop safety policies.

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 Boiler/HRSG Control. 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 trainees may be noted during these exercises for Performance Testing purposes.

<table>
<thead>
<tr>
<th>Topic</th>
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<tbody>
<tr>
<td><strong>Session I. Introduction; Process Control Symbology</strong></td>
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<tr>
<td>A. Introduction</td>
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<tr>
<td>B. Process Control Symbology</td>
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<tr>
<td>1. ISA Symbols</td>
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<td>2. SAMA Symbols</td>
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<tr>
<td>3. Control Loop Examples</td>
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<tr>
<td>C. Laboratory</td>
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<tr>
<td>Have trainees identify the devices and connections shown on a boiler control loop that uses either ISA or SAMA symbols. This laboratory corresponds with Performance Task 1.</td>
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</tbody>
</table>
Sessions II and III. Control Strategies
A. Boiler Control
B. HRSG Control
C. Laboratory
   Have trainees sketch a single-element steam drum level control loop using SAMA symbology. This laboratory corresponds with Performance Task 2.

Session IV. Furnace Fuel Safety Control
A. Furnace Fuel Safety Control
   1. Furnace Light-off Sequence
   2. Fuel Tripping
B. Laboratory
   Have trainees sketch an SAMA digital logic diagram that represents the boiler purge permissives for a selected boiler. This laboratory corresponds with Performance Task 3.

Session V. Review and Testing
A. Review
B. Module Examination
   1. Trainees must score 70 percent or higher to receive recognition from NCCER.
   2. Record the testing results on 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 Training Report Form 200, and submit the results to the Training Program Sponsor.
MODULE OVERVIEW
This module provides an overview of the preventive and predictive maintenance processes. Information about nondestructive testing is also included.

PREREQUISITES
Prior to training with this module, it is recommended that the trainee shall have successfully completed Core Curriculum; Industrial Maintenance Mechanic Level One; Industrial Maintenance Mechanic Level Two; and Industrial Maintenance Mechanic Level Three.

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

1. Explain preventive and predictive maintenance.
2. Explain nondestructive testing.
3. Explain ultrasonics.
4. Explain radiography.
5. Explain eddy current inspection.
6. Explain visual and optical inspection.
7. Explain liquid penetrant inspection.
8. Explain magnetic particle inspection.
10. Explain infrared testing.
11. Explain vibration analysis.
12. Explain tribology.

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

MATERIALS AND EQUIPMENT LIST

<table>
<thead>
<tr>
<th>Overhead projector and screen</th>
<th>NDT equipment, including:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transparencies</td>
<td>Ultrasonic tester</td>
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<tr>
<td>Blank acetate sheets</td>
<td>Pyrometer</td>
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<tr>
<td>Transparency pens</td>
<td>Eddy current tester</td>
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<tr>
<td>Whiteboard/chalkboard</td>
<td>Borescope</td>
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<tr>
<td>Markers/chalk</td>
<td>Liquid penetrant kit</td>
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<tr>
<td>Pencils and scratch paper</td>
<td>Magnetic particle yoke</td>
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<tr>
<td>Appropriate personal protective equipment</td>
<td>Copies of the Quick Quizzes*</td>
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<tr>
<td>Examples of flawed welds, stress cracks, etc.</td>
<td>Module Examination**</td>
</tr>
</tbody>
</table>

* 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.

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

<table>
<thead>
<tr>
<th>Topic</th>
<th>Planned Time</th>
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<tbody>
<tr>
<td><strong>Session I. Introduction; Preventive Maintenance; Predictive Maintenance</strong></td>
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<tr>
<td>A. Introduction</td>
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<tr>
<td>B. Preventive Maintenance</td>
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<tr>
<td>1. Program Benefits</td>
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<tr>
<td>C. Predictive Maintenance</td>
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<tr>
<td>1. Requirements and Priorities</td>
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<td>2. Documentation</td>
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<tr>
<td><strong>Session II. Nondestructive Testing and Evaluation, Part One</strong></td>
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<tr>
<td>A. Introduction</td>
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<td>B. Ultrasonics</td>
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<td>C. Radiography</td>
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<td>D. Eddy Current Inspection</td>
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<tr>
<td>E. Visual and Optical Inspection</td>
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<tr>
<td><strong>Session III. Nondestructive Testing and Evaluation, Part Two</strong></td>
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<tr>
<td>A. Liquid Penetrant Inspection</td>
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<tr>
<td>B. Magnetic Particle Inspection</td>
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<tr>
<td>C. Acoustic Emission Testing</td>
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<td>D. Infrared Testing</td>
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<td>E. Vibration Analysis</td>
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<td>F. Tribology</td>
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</tbody>
</table>
Session IV. Review and Testing

A. Trade Terms and Quick Quizzes
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.
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.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Planned Time</th>
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<tbody>
<tr>
<td><strong>Session I. Introduction; System Architecture</strong></td>
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<tr>
<td>A. Introduction</td>
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<td>B. System architecture</td>
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<tr>
<td>1. Controllers and I/O</td>
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<tr>
<td>2. Software Server and Engineering Workstation</td>
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<td>3. Operator Workstation</td>
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<td>4. Network</td>
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<td>5. Other Drops</td>
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<tr>
<td><strong>Session II. Controllers and Their I/O</strong></td>
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<tr>
<td>A. Controllers and Their I/O</td>
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<tr>
<td>1. The Database and How It Relates to Controllers</td>
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<td>2. The Process I/O</td>
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<td>3. The Application Program</td>
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<td>4. Modifying the Application Program</td>
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<td>5. Adding and Deleting Points</td>
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<td>6. Redundancy</td>
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<td>7. Memory and Speed</td>
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<tr>
<td><strong>Session III. The Software Server and Engineering Workstation; Operator Workstation</strong></td>
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<tr>
<td>A. The Software Server and Engineering Workstation</td>
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<tr>
<td>1. Operating Systems</td>
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<td>2. Applications on an Engineering Workstation</td>
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<tr>
<td>3. Backing up the System</td>
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<td>4. System Security</td>
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</tbody>
</table>
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.