Hazardous Locations
Annotated Instructor’s Guide

MODULE OVERVIEW
This module introduces the National Electrical Code® (NEC®) requirements and installation procedures related to electrical equipment installed in hazardous locations. It also describes the methods used by the NEC® to classify hazardous locations.

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

OBJECTIVES
Upon completion of this module, the trainee will be able to do the following:
1. Define the various classifications of hazardous locations.
2. Describe the wiring methods permitted for branch circuits and feeders in specific hazardous locations.
3. Select seals and drains for specific hazardous locations.
4. Select wiring methods for Class I, Class II, and Class III hazardous locations.
5. Follow National Electrical Code® (NEC®) requirements for installing explosion-proof fittings in specific hazardous locations.

PERFORMANCE TASKS
Under the supervision of the instructor, the trainee should be able to do the following:
1. Using two rigid metal conduit nipples, a sealing fitting, three pieces of No. 12 THHN conductors, and a packing fiber/sealing kit, perform the following operations:
   • Secure one conduit nipple in each end of the seal.
   • Make sure the required number of threads are engaged.
   • Pull through the three THHN conductors through the nipples and seal so that about 6” is protruding from each nipple.
   • Pack the fiber following the instructions furnished with the sealing kit.
   • Mix the sealing compound.
   • Position the unit in the required location and pour in the sealing compound.

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
Copy of the latest edition of the National Electrical Code®

Sealoff fittings, packing fiber, and sealing compound
Short conduit nipples
No. 12 THHN conductors
Various types of explosion-proof fittings
Various types of sealing fittings used in hazardous locations, including those with drains
Portable conduit threader
Explosion-proof flexible connectors
Module Examinations*
Performance Profile Sheets*

*Located in the Test Booklet.
SAFETY CONSIDERATIONS

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

ADDITIONAL RESOURCES

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


NOTE

NFPA 70®, National Electrical Code®, and NEC® are registered trademarks of the National Fire Protection Association, Inc., Quincy, MA 02269. All National Electrical Code® and NEC® references in this module refer to the 2008 edition of the National Electrical Code®.

TEACHING TIME FOR THIS MODULE

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

<table>
<thead>
<tr>
<th>Topic</th>
<th>Planned Time</th>
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<tbody>
<tr>
<td>Session I. Introduction; Prevention of External Ignition/Explosion</td>
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<tr>
<td>A. Introduction</td>
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<tr>
<td>1. Class I Locations</td>
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<td>2. Class II Locations</td>
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<tr>
<td>3. Class III Locations</td>
<td></td>
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<tr>
<td>4. Applications</td>
<td></td>
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<tr>
<td>B. Prevention of External Ignition/Explosion</td>
<td></td>
</tr>
<tr>
<td>1. Sources of Ignition</td>
<td></td>
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<tr>
<td>2. Combustion Principles</td>
<td></td>
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<tr>
<td>Session II. Explosion-Proof Equipment</td>
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<tr>
<td>A. Explosion-Proof Equipment</td>
<td></td>
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<tr>
<td>1. Intrinsically Safe Equipment</td>
<td></td>
</tr>
<tr>
<td>2. Explosion-Proof Conduit and Fittings</td>
<td></td>
</tr>
<tr>
<td>3. Seals and Drains</td>
<td></td>
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<tr>
<td>B. Laboratory</td>
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</tr>
<tr>
<td>Have trainees practice installing sealoff fittings and pouring seals. This laboratory corresponds to Performance Task 1.</td>
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<tr>
<td>Session III. Garages and Similar Locations; Airport Hangars; Hospitals; Petrochemical Hazardous Locations; Manufacturers’ Data</td>
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<tr>
<td>A. Garages and Similar Locations</td>
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<td>B. Airport Hangars</td>
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<tr>
<td>C. Hospitals</td>
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<tr>
<td>D. Petrochemical Hazardous Locations</td>
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<tr>
<td>E. Manufacturers’ Data</td>
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</tbody>
</table>
Session IV. Review and Testing

A. Module Review

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

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

This module covers electronic components and their applications, and provides an introduction to the principles of electronics and semiconductor theory.

PREREQUISITES

Prior to training with this module, it is recommended that the trainee shall have successfully completed Core Curriculum; Industrial Maintenance E & I Technician Level One; Industrial Maintenance E & I Technician Level Two; and Industrial Maintenance E & I Technician Level Three, Module 40301-09.

OBJECTIVES

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

1. Identify electronic components.
2. Describe the electrical characteristics of solid-state devices.
3. Describe the basic materials that make up solid-state devices.
4. Describe and identify the various types of transistors and explain how they operate.
5. Describe and connect diodes, including light-emitting diodes (LEDs) and silicon-controlled rectifiers (SCRs).
6. Use a cross-reference manual to find substitutes for electronic components.
7. Identify fuses used in electronic devices.
8. Identify the leads of various solid-state devices.
9. Describe integrated circuits.
10. Identify applicable pin numbers of integrated circuit chips.
11. Explain the purpose of logic gates.
12. Check diodes.

PERFORMANCE TASKS

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

1. Using a cross reference manual, identify a substitute for a selected electronic component.
2. Build a simple bridge rectifier circuit and view the results.
3. Check diodes.

MATERIALS AND EQUIPMENT LIST

Overhead projector and screen
Transparencies
Blank acetate sheets
Transparency pens
Whiteboard/chalkboard
Markers/chalk
Pencils and scratch paper
Appropriate personal protective equipment
24V transformer with a plug and power cord
Filter capacitor
Oscilloscope
DC load resistance
Selection of diodes, LEDs, transistors, and SCRs
Multimeter
IC removal and insertion tools
Grounding strap
Selection of schematic and logic diagrams
Selection of printed circuit boards, sealed components, integrated circuits, and microprocessors
Pushbutton
Components and wire to connect basic test circuits
Module Examinations*
Performance Profile Sheets*

*Located in the Test Booklet.
SAFETY CONSIDERATIONS

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

ADDITIONAL RESOURCES

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


NOTE

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TEACHING TIME FOR THIS MODULE

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

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

A. Operational Amplifiers

B. Basic Digital Gates

C. Module Review

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

E. Performance Testing
   1. Trainees must perform each task to the satisfaction of the instructor to receive recognition from NCCER. If applicable, proficiency noted during laboratory exercises can be used to satisfy the Performance Testing requirements.
   2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.
MODULE OVERVIEW
This module covers the interpretation of electrical and instrumentation drawings. It also provides an overview of common drawing methods, notes, and symbols.

PREREQUISITES
Prior to training with this module, it is recommended that the trainee shall have successfully completed Core Curriculum; Industrial Maintenance E & I Technician Level One; Industrial Maintenance E & I Technician Level Two; and Industrial Maintenance E & I Technician Level Three, Modules 40301-09 and 40302-09.

OBJECTIVES
Upon completion of this module, the trainee will be able to do the following:
1. Identify common types of electrical and instrumentation diagrams and drawings.
2. Read and interpret electrical diagrams used in instrumentation work:
   - Wiring diagrams
   - Ladder diagrams
   - One-line diagrams
   - Motor controller diagrams
3. Read and interpret instrumentation diagrams:
   - P&ID diagrams
   - Loop diagrams
   - Raceway diagrams
4. Draw a loop diagram for a given instrumentation loop.

PERFORMANCE TASKS
Under the supervision of the instructor, the trainee should be able to do the following:
1. Trace the circuit flow on a one-line diagram.
2. Read and interpret an electrical raceway drawing.
3. Read and interpret a piping and instrumentation drawing (P&ID).
4. Read and interpret a loop sheet.
5. Interpret component symbols on an electronic schematic diagram.

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

*Located in the Test Booklet.

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

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


TEACHING TIME FOR THIS MODULE

An outline for use in developing your lesson plan is presented below. Note that each Roman numeral in the outline equates to one session of instruction. Each session has a suggested time period of 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 E & I Drawings. You will need to adjust the time required for hands-on activity and testing based on your class size and resources. Because laboratories often correspond to Performance Tasks, the proficiency of the trainees may be noted during these exercises for Performance Testing purposes.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Planned Time</th>
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<tbody>
<tr>
<td>Session I. Introduction; Electrical Drawings</td>
<td></td>
</tr>
<tr>
<td>A. Introduction</td>
<td></td>
</tr>
<tr>
<td>B. Electrical Drawings</td>
<td></td>
</tr>
<tr>
<td>1. Block Diagrams</td>
<td></td>
</tr>
<tr>
<td>2. Single- and Three-Line Diagrams</td>
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<tr>
<td>a. Laboratory</td>
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<tr>
<td>Have trainees trace the circuit flow on a one-line diagram. This laboratory corresponds to Performance Task 1.</td>
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<tr>
<td>3. Wiring Diagrams</td>
<td></td>
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<tr>
<td>4. Raceway Drawings</td>
<td></td>
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<tr>
<td>a. Laboratory</td>
<td></td>
</tr>
<tr>
<td>Have trainees read and interpret a raceway drawing.</td>
<td></td>
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<tr>
<td>5. Schematic Diagrams</td>
<td></td>
</tr>
<tr>
<td>Session II. Instrumentation Drawings I</td>
<td></td>
</tr>
<tr>
<td>A. Piping and Instrumentation Drawings</td>
<td></td>
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<tr>
<td>1. Laboratory</td>
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<tr>
<td>Have trainees read and interpret P&amp;IDs. This laboratory corresponds to Performance Task 2.</td>
<td></td>
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<tr>
<td>B. Loop Sheets</td>
<td></td>
</tr>
<tr>
<td>Session III. Instrumentation Drawings II</td>
<td></td>
</tr>
<tr>
<td>A. Logic/Ladder Diagrams</td>
<td></td>
</tr>
<tr>
<td>B. Equipment Location Drawings</td>
<td></td>
</tr>
<tr>
<td>C. Installation Detail Drawings</td>
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<tr>
<td>D. Flow Drawings</td>
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<tr>
<td>E. Instrument Data Sheets</td>
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</tbody>
</table>
Session IV. Standardized Design Methods; Review and Testing

A. Standardized Design Methods

B. Electrical Symbols

1. Laboratory
   Have trainees read and interpret symbols on an electronic schematic diagram. Note the proficiency of each trainee. This laboratory corresponds to Performance Task 5.

C. Instrumentation Symbols

D. Module 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.

F. 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 introduces the trainee to the methods and procedures used in selecting and wiring motor controls.

PREREQUISITES
Prior to training with this module, it is recommended that the trainee shall have successfully completed Core Curriculum; Industrial Maintenance E & I Technician Level One; Industrial Maintenance E & I Technician Level Two; and Industrial Maintenance E & I Technician Level Three, Modules 40301-09 through 40303-09.

OBJECTIVES
Upon completion of this module, the trainee will be able to do the following:
1. Identify contactors and relays both physically and schematically and describe their operating principles.
2. Identify pilot devices both physically and schematically and describe their operating principles.
3. Interpret motor control wiring, connection, and ladder diagrams.
4. Select and size contactors and relays for use in specific electrical motor control systems.
5. Select and size pilot devices for use in specific electrical motor control systems.
6. Connect motor controllers for specific applications according to National Electrical Code® (NEC®) requirements.

PERFORMANCE TASK
Under the supervision of the instructor, the trainee should be able to do the following:
1. Make all connections for a magnetic motor controller controlled by two pushbutton stations, including the connections for the holding circuit interlock.
2. Disassemble, inspect, and reassemble a motor starter.

MATERIALS AND EQUIPMENT LIST

<table>
<thead>
<tr>
<th>Equipment/Device</th>
<th>Description</th>
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<tbody>
<tr>
<td>Overhead projector and screen</td>
<td>Assorted manufacturer’s motor control device catalogs/data sheets</td>
</tr>
<tr>
<td>Transparencies</td>
<td>Examples of wiring diagrams</td>
</tr>
<tr>
<td>Markers/chalk</td>
<td>Examples of circuit schedules/wire lists</td>
</tr>
<tr>
<td>Blank acetate sheets</td>
<td>Examples of control ladder diagrams</td>
</tr>
<tr>
<td>Transparency pens</td>
<td>Examples of logic diagrams</td>
</tr>
<tr>
<td>Pencils and scratch paper</td>
<td>Open-frame electromechanical power relays</td>
</tr>
<tr>
<td>Overhead projector and screen</td>
<td>Miniature electromechanical plug-in relays</td>
</tr>
<tr>
<td>Whiteboard/chalkboard</td>
<td>Assorted NEMA and IEC magnetic and manual contactors and motor starters</td>
</tr>
<tr>
<td>Appropriate personal protective equipment</td>
<td>Melting-alloy thermal overload relays</td>
</tr>
<tr>
<td>Copy of the latest edition of the National Electrical Code®</td>
<td>Bimetallic overload relays</td>
</tr>
<tr>
<td>Assorted wire and connectors necessary for making control circuit wiring connections</td>
<td>Magnetic overload relays</td>
</tr>
</tbody>
</table>

continued
SAFETY CONSIDERATIONS

Ensure that the trainees are equipped with appropriate personal protective equipment. This module requires trainees to work with motor controls. Brief the trainees on the proper safety procedures for working with motor controls.

ADDITIONAL RESOURCES

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


NOTE

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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 Motor Controls. You will need to adjust the time required for hands-on activity and testing based on your class size and resources. Because laboratories often correspond to Performance Tasks, the proficiency of the trainees may be noted during these exercises for Performance Testing purposes.

Topic | Planned Time
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Session I. Introduction, Electromechanical Relays; Magnetic Contactors; Overload Protection
A. Introduction
B. Electromechanical Relays
C. Magnetic Contactors
D. Overload Protection

Contactor/motor starter accessories including:
- Power-pole adder kit
- Timer attachment
- Fuse kit
- Transient suppression module
- Internal auxiliary contacts
- Control transformers
- Pushbutton switches
- Push-pull pushbutton switches
- Selector switches
- Pilot lights
- Assorted pushbutton stations
- Temperature switches
- Pressure switches

Mechanical limit switches
- Flow switches
- Float switches
- Foot switches
- Jogging and plugging switches
- Inductive and capacitive proximity sensors
- Photoelectric switches/sensors
- Drum switches
- Assorted NEMA enclosures
- 240V motor
- Tools necessary for making wiring connections

Module Examinations*
Performance Profile Sheets*

*Located in the Test Booklet
Session II. Magnetic and Manual Motor Starters; Control Transformers and Pilot Devices

A. Magnetic and Manual Motor Starters
   1. Nonreversing and Reversing Magnetic Motor Starters
   2. NEMA Magnetic Contactors/Motor Starters
   3. IEC Magnetic Contactors/Motor Starters
   5. Accessories

B. Control Transformers and Pilot Devices
   1. Pushbutton and Selector Switches; Pilot Devices
   2. Temperature and Pressure Switches
   3. Mechanical Limit Switches
   4. Flow, Float, and Foot Switches
   5. Jogging and Plugging Switches
   6. Proximity and Photoelectric Switches/Sensors

C. Laboratory
   Under your supervision, have the trainees disassemble, inspect, and reassemble a motor starter. This laboratory corresponds to Performance Task 2.

Session III. Drum Switches; Enclosures; Diagrams

A. Drum Switches
B. Enclosures
C. Diagrams
   1. Relating Diagrams to Equipment Wiring and Operation

Session IV. NEC® Regulations for the Installation of Motor Control Circuits and Connecting Motor Controllers for Specific Applications

A. NEC® Regulations for the Installation of Motor Control Circuits
B. Connecting Motor Controllers for Specific Applications

Session V. Motor Controller Laboratory

A. Laboratory
   Under your supervision, have the trainees make all connections for a magnetic motor controller controlled by two pushbutton stations, including the connections for the holding circuit interlock. This laboratory corresponds with Performance Task 1.

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 testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.
MODULE OVERVIEW
This module introduces the trainee to the methods and procedures related to distribution equipment, including grounding, switchboard testing and maintenance, ground fault sensing, and interpreting electrical drawings.

PREREQUISITES
Prior to training with this module, it is recommended that the trainee shall have successfully completed Core Curriculum; Industrial Maintenance E & I Technician Level One; Industrial Maintenance E & I Technician Level Two; and Industrial Maintenance E & I Technician Level Three, Modules 40301-09 through 40304-09.

OBJECTIVES
Upon completion of this module, the trainee will be able to do the following:
1. Explain the necessity of overcurrent protection devices in electrical circuits.
2. Define the terms associated with fuses and circuit breakers.
3. Describe the purpose of switchgear.
4. Describe the four general classifications of circuit breakers and list the major circuit breaker ratings.
5. Describe switchgear construction, metering layouts, wiring requirements, and maintenance.
6. List National Electrical Code® (NEC®) requirements pertaining to switchgear.
7. Describe the visual and mechanical inspections and electrical tests associated with low-voltage and medium-voltage cables, metal-enclosed busways, and metering and instrumentation.
8. Describe a ground fault relay system and explain how to test it.

PERFORMANCE TASKS
Under the supervision of the instructor, the trainee should be able to do the following:
1. Identify the following on a molded case circuit breaker:
   - Frame size
   - Trip unit rating
   - Pick up values

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

Copy of the latest edition of the National Electrical Code®
Molded case circuit breaker
Manufacturer’s literature for various types of distribution equipment
Module Examinations*
Performance Profile Sheets*

SAFETY CONSIDERATIONS
Ensure that the trainees are equipped with appropriate personal protective equipment.
ADDITIONAL RESOURCES

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


NOTE

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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 Distribution Equipment. You will need to adjust the time required for hands-on activity and testing based on your class size and resources. Because laboratories often correspond to Performance Tasks, the proficiency of the trainees may be noted during these exercises for Performance Testing purposes.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Planned Time</th>
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</thead>
<tbody>
<tr>
<td>Session I. Introduction; Voltage Classifications; Switchboards</td>
<td></td>
</tr>
<tr>
<td>A. Introduction</td>
<td></td>
</tr>
<tr>
<td>B. Voltage Classifications</td>
<td></td>
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<tr>
<td>C. Switchboards</td>
<td></td>
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<tr>
<td>Session II. Switchgear</td>
<td></td>
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<tr>
<td>A. Switchgear</td>
<td></td>
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<tr>
<td>Session III. Switchboard Testing and Maintenance; NEC® Requirements; Ground Faults</td>
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<tr>
<td>A. Switchboard Testing and Maintenance</td>
<td></td>
</tr>
<tr>
<td>B. NEC® Requirements</td>
<td></td>
</tr>
<tr>
<td>C. Ground Faults</td>
<td></td>
</tr>
<tr>
<td>Session IV. HVL Switches; Bolted Pressure Switches; Transformers</td>
<td></td>
</tr>
<tr>
<td>A. HVL Switches</td>
<td></td>
</tr>
<tr>
<td>B. Bolted Pressure Switches</td>
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<tr>
<td>C. Transformers</td>
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<tr>
<td>Session V. Instrument Transformers; Circuit Breakers</td>
<td></td>
</tr>
<tr>
<td>A. Instrument Transformers</td>
<td></td>
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<tr>
<td>B. Circuit Breakers</td>
<td></td>
</tr>
</tbody>
</table>
| C. Laboratory  
Have the trainees identify the markings on a molded case circuit breaker. This laboratory corresponds to Performance Task 1. |  |
| Session VI. Panelboards; NEC® Requirements for Services |  |
| A. Panelboards |  |
| B. NEC® Requirements for Services |  |
Session VII. Review and Testing

A. Module Review

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

C. Performance Testing
   1. Trainees must perform each task to the satisfaction of the instructor to receive recognition from the NCCER.
   2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.
MODULE OVERVIEW
This module covers various types of transformers and their applications, as well as information on selecting, sizing, and installing them.

PREREQUISITES
Prior to training with this module, it is recommended that the trainee shall have successfully completed Core Curriculum; Industrial Maintenance E & I Technician Level One; Industrial Maintenance E & I Technician Level Two; and Industrial Maintenance E & I Technician Level Three, Modules 40301-09 through 40305-09.

OBJECTIVES
Upon completion of this module, the trainee will be able to do the following:
1. Identify three-phase transformer connections.
2. Identify specialty transformer applications.
4. Calculate and install overcurrent protection for specialty transformers.
5. Ground specialty transformers in accordance with National Electrical Code® (NEC®) requirements.
6. Calculate transformer derating to account for the effects of harmonics.

PERFORMANCE TASKS
Under the supervision of the instructor, the trainee should be able to do the following:
1. Identify various specialty transformers.
2. Using a clamp-on ammeter, demonstrate the principles of a current transformer. Identify the primary winding, then calculate and measure the effects of increasing the number of turns (loops) in the primary winding.
3. Connect a buck-and-boost transformer to a single-phase circuit so that it will first be in the boost mode, and then in the buck mode. Record the voltage increase and decrease for each configuration.

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
- Copy of the latest edition of the National Electrical Code®
- Conductors for making transformer connections
- Connectors and related hand tools for making transformer connections
- Buck-and-boost transformer selection charts
- Various types of specialty transformers
- Buck-and-boost transformers
- Potential (voltage) and current transformers
- Clamp-on ammeter
- Multimeter
- Module Examinations*
- Performance Profile Sheets*

*Located in the Test Booklet

SAFETY CONSIDERATIONS
Ensure that the trainees are equipped with appropriate personal protective equipment.
ADDITIONAL RESOURCES

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


NOTE

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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 Transformer Applications. 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; Specialty Transformers</strong></td>
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<tr>
<td>A. Introduction</td>
<td></td>
</tr>
<tr>
<td>1. Types of Transformers</td>
<td></td>
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<tr>
<td>2. Internal Connections in Three-Phase Transformers</td>
<td></td>
</tr>
<tr>
<td>B. Specialty Transformers</td>
<td></td>
</tr>
<tr>
<td>1. Transformers with Multiple Secondaries</td>
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<tr>
<td>2. Autotransformers</td>
<td></td>
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<tr>
<td>3. Constant-Current Transformers</td>
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<tr>
<td>4. Control Transformers</td>
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<tr>
<td>5. Series Transformers</td>
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<tr>
<td>6. Step-Voltage Regulators</td>
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<tr>
<td>7. Other Specialty Transformers</td>
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<tr>
<td>C. Laboratory</td>
<td></td>
</tr>
<tr>
<td>Have the trainees practice identifying various specialty transformers. This laboratory corresponds to Performance Task 1.</td>
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</tr>
<tr>
<td><strong>Session II. Instrument Transformers; Sizing Buck-and-Boost Transformers</strong></td>
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<tr>
<td>A. Instrument Transformers</td>
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<tr>
<td>1. Current Transformers</td>
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<tr>
<td>2. Potential Transformers</td>
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<tr>
<td>B. Laboratory</td>
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<tr>
<td>Have the trainees practice using a clamp-on ammeter to demonstrate the principles of a current transformer. Have them identify the primary winding, then calculate and measure the effects of increasing the number of turns (loops) in the primary winding. This laboratory corresponds to Performance Task 2.</td>
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<tr>
<td>C. Sizing Buck-and-Boost Transformers</td>
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<tr>
<td>D. Laboratory</td>
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<tr>
<td>Have the trainees practice connecting a buck-and-boost transformer to a single-phase circuit so that it will first be in the boost mode, and then in the buck mode. Have them record the voltage increase and decrease for each configuration. This laboratory corresponds to Performance Task 3.</td>
<td></td>
</tr>
</tbody>
</table>
Session III. Harmonics; Review and Testing

A. Harmonics
   1. Defining the Problem
   2. Office Buildings and Plants
   3. Survey the Situation
   4. Solving the Problem

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.
MODULE OVERVIEW

This module provides information on conductor selection and calculations using various tables in the National Electrical Code® (NEC®).

PREREQUISITES

Prior to training with this module, it is recommended that the trainee shall have successfully completed Core Curriculum; Industrial Maintenance E & I Technician Level One; Industrial Maintenance E & I Technician Level Two; and Industrial Maintenance E & I Technician Level Three, Modules 40301-09 through 40306-09.

OBJECTIVES

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

1. Select electrical conductors for specific applications.
2. Calculate voltage drop in both single-phase and three-phase applications.
3. Apply National Electrical Code® (NEC®) regulations governing conductors to a specific application.
4. Calculate and apply NEC® tap rules to a specific application.
5. Size conductors for the load.
6. Derate conductors for fill, temperature, and voltage drop.
7. Select conductors for various temperature ranges and atmospheres.

PERFORMANCE TASKS

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

1. From a selection of conductors, identify the applications for which they can be used.
2. Given an application, identify the conductors that can be used for it.

MATERIALS AND EQUIPMENT LIST

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>Overhead projector and screen</td>
<td>Appropriate personal protective equipment</td>
</tr>
<tr>
<td>Transparencies</td>
<td>Copy of the latest edition of the National Electrical Code®</td>
</tr>
<tr>
<td>Blank acetate sheets</td>
<td>One length each of various solid, stranded, and compact conductors</td>
</tr>
<tr>
<td>Transparency pens</td>
<td>Module Examinations*</td>
</tr>
<tr>
<td>Whiteboard/chalkboard</td>
<td>Performance Profile Sheets*</td>
</tr>
<tr>
<td>Markers/chalk</td>
<td></td>
</tr>
<tr>
<td>Pencils and scratch paper</td>
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<tr>
<td>*Located in the Test Booklet</td>
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</tbody>
</table>

SAFETY CONSIDERATIONS

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

ADDITIONAL RESOURCES

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

NOTE

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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 Conductor Selection and Calculations. 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; Compact Conductors</strong></td>
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<tr>
<td>A. Introduction</td>
<td>____________</td>
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<tr>
<td>B. Compact Conductors</td>
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<tr>
<td><strong>Session II. Conductor Applications</strong></td>
<td></td>
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<tr>
<td>A. Conductor Applications</td>
<td>____________</td>
</tr>
<tr>
<td>1. Branch Circuits</td>
<td>____________</td>
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<tr>
<td>2. Conductor Protection</td>
<td>____________</td>
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<tr>
<td>a. Location of Overcurrent Protection in Circuits</td>
<td>____________</td>
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<tr>
<td><strong>Session III. Properties of Conductors</strong></td>
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<tr>
<td>A. Properties of Conductors</td>
<td>____________</td>
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<tr>
<td>1. Identifying Conductors</td>
<td>____________</td>
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<tr>
<td>a. Color Coding</td>
<td>____________</td>
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<tr>
<td>b. Changing Colors</td>
<td>____________</td>
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<tr>
<td>B. Laboratory</td>
<td>____________</td>
</tr>
<tr>
<td>Have trainees identify conductors and their applications from a selection of conductors. This laboratory corresponds with Performance Task 1.</td>
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<tr>
<td>C. Laboratory</td>
<td>____________</td>
</tr>
<tr>
<td>Have trainees identify an appropriate conductor for a given application. This laboratory corresponds with Performance Task 2.</td>
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<tr>
<td><strong>Session IV. Voltage Drop</strong></td>
<td></td>
</tr>
<tr>
<td>A. Voltage Drop</td>
<td>____________</td>
</tr>
<tr>
<td>1. Wire Sizes Based on Resistance</td>
<td>____________</td>
</tr>
<tr>
<td>a. Circular Mil-Unit of Conductor Area</td>
<td>____________</td>
</tr>
<tr>
<td>b. Conversion of Square Mils to Circular Mils</td>
<td>____________</td>
</tr>
<tr>
<td>2. Resistance of Conductors</td>
<td>____________</td>
</tr>
<tr>
<td>3. Resistance of Copper per Mil Foot</td>
<td>____________</td>
</tr>
<tr>
<td><strong>Session V. Voltage Drop Equations</strong></td>
<td></td>
</tr>
<tr>
<td>A. Voltage Drop Equations</td>
<td>____________</td>
</tr>
<tr>
<td>1. Equations for Voltage Drop Using Conductor Area or Conductor Resistance</td>
<td>____________</td>
</tr>
<tr>
<td>2. Use of Voltage Drop Equations</td>
<td>____________</td>
</tr>
<tr>
<td>3. Practice Voltage Drop Equations</td>
<td>____________</td>
</tr>
</tbody>
</table>
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 introduces the trainees to the equipment and methods used to ground de-energized high-voltage circuits during maintenance activities. An understanding of these principles is essential to the safety of electrical maintenance workers.

PREREQUISITES
Prior to training with this module, it is recommended that the trainee shall have successfully completed Core Curriculum; Industrial Maintenance E & I Technician Level One; Industrial Maintenance E & I Technician Level Two; and Industrial Maintenance E & I Technician Level Three, Modules 40301-09 through 40307-09.

OBJECTIVES
When you have completed this module, you will be able to do the following:
1. Explain the purpose of temporary grounding.
2. Explain requirements associated with temporary grounding devices.
3. Identify and explain temporary grounding equipment.
4. Explain how to install and remove temporary grounding devices.

PERFORMANCE TASKS
Under the supervision of the instructor, the trainee should be able to:
1. Apply temporary grounding for a given application with correct PPE, tools, and parts.
2. Demonstrate inspection and storage of temporary grounding components.

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
Electrical safety analysis
Personal protective grounds
Lockout/tagout equipment

At least one copy of NFPA 70B, Recommended Practice for Electrical Equipment Maintenance
Hot stick and attachments
Insulating mats
Insulating covers
Grounding clamps
Grounding cables
Open-loop ammeter
Portable ground tester
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. Ensure that trainees are briefed on shop safety procedures. Emphasize any special safety precautions associated with working on or near high-voltage equipment and circuits. Review the different hazards that could cause voltage to be present on a de-energized circuit. Explain that grounding of the circuit being worked on will prevent such hazards. Review the requirements for an electrically safe work condition.
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.

OSHA Standard 1910.269, Electric Power Generation, Transmission, and Distribution


NFPA 70B (Recommended Practice for Electrical Equipment Maintenance)
http://www.nfpa.org/aboutthecodes/AboutTheCodes.asp?DocNum=70B

NFPA 70E (Standard for Electrical Safety in the Workplace)
http://www.nfpa.org/aboutthecodes/AboutTheCodes.asp?DocNum=70E

Hubbell Power Systems, Inc., source for products and training.
http://www.hubbellpowersystems.com

Codebook City, source for NEC® explanations.
http://www.codebookcity.com/codearticles/nec/index.htm

Offers a variety of manuals covering several maintenance-related career fields, including a Facilities Instructions, Standards, and Techniques manual, Volume 5-1 (FIST 5-1), which covers Personal Protective Grounding for Electric Power Facilities and Power Lines, 2005.
http://www.usbr.gov/power/data/fist_pub.html


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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 Temporary Grounding. You will need to adjust the time required for testing based on your class size and resources. There are no performance tasks for this module. Because laboratories often correspond to Performance Tasks, the proficiency of the trainees may be noted during these exercises for Performance Testing purposes.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Planned Time</th>
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<tbody>
<tr>
<td>Session I. Introduction; Safety Analysis; Purpose of Temporary Grounding</td>
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</tr>
<tr>
<td>A. Introduction</td>
<td></td>
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<tr>
<td>B. Electrical Safety Analyses</td>
<td></td>
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<tr>
<td>C. Purpose of Temporary Grounding</td>
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</tr>
</tbody>
</table>
Session II. Temporary Grounding Terms; Sources of Hazardous Energy

A. Terms
B. Sources of Hazardous Energy
   1. Stored Energy
   2. Static Buildup
   3. Backfeeding
   4. Faulted Equipment
   5. Induced-Voltage Areas
   6. High-Voltage Testing

Session III. Temporary Grounding Preparations; Requirements for Temporary Grounding Devices

A. Temporary Grounding Preparation
B. Requirements for Temporary Grounding Devices
   1. General Requirements
   2. Specific Requirements
   3. Installation Requirements

Session IV. Selection and Evaluation of Temporary Grounding Devices; Installation and Removal of Temporary Grounding Devices

A. Ground Cable Assemblies
B. Insulation Devices
C. Specialized Grounding and Testing Devices
D. Evaluating Ground Cable Assemblies
   1. Cables
   2. Ferrules and Clamps
E. Evaluating Hot Sticks and Attachments
F. Ground Tester Equipment
G. Installation of Temporary Grounding Devices
H. Removing PPGs

Session V. Laboratory

A. Laboratory
   Have trainees practice installing temporary grounding equipment.
   This laboratory corresponds to Performance Task 1.

Session VI. Laboratory; Review and Testing

A. Laboratory
   Have trainees practice inspecting and storing temporary grounding equipment. This laboratory corresponds to Performance Task 2.
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.
Module Overview

This module describes the procedure for laying out tubing and piping using the job drawings and/or specifications, and includes the calculations required to complete bends. It also covers the installation of tubing, piping, hangers, and supports.

Prerequisites

Prior to training with this module, it is recommended that the trainee shall have successfully completed Core Curriculum; Industrial Maintenance E & I Technician Level One; Industrial Maintenance E & I Technician Level Two; and Industrial Maintenance E & I Technician Level Three, Modules 40301-09 through 40308-09.

Objectives

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

1. Using prints, specifications, and visual inspections, determine the scope of the layout procedure.
2. Determine the proper methods for routing piping or tubing.
3. Apply fitter’s math to measure and bend piping or tubing.
4. Cut piping or tubing.
5. Apply the appropriate calculations and bender to accurately bend piping or tubing to the proper angle in an offset.
6. Identify and state the usage of various piping and tubing supports.
7. Install various piping and tubing supports.
8. Identify and state the usage of various piping and tubing fittings, including:
   - Flare tube fittings
   - Compression tubing fittings
   - Threaded pipe fittings
   - Pipe flanges

Performance Tasks

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

1. Given a partial system equipment location diagram (one loop) and observing all considerations covered in this module, create an isometric drawing of the given loop.
2. Measure and bend the tubing sections in the loop and select the fittings needed to install the layout shown in the isometric drawing in Performance Task 1.
3. Indicate the types and locations of minimal support needed for the tubing installation.
4. Make up compression fittings on tubing.

Materials and Equipment List

- Overhead projector and screen
- Transparencies
- Blank acetate sheets
- Transparency pens
- Whiteboard/chalkboard
- Markers/chalk
- Pencils and scratch paper
- Appropriate personal protective equipment
- Sample drawings for a piping layout
- Sample loop drawings and specifications
- Graph paper
- Protractor
- Straightedge
- 45-degree triangle
- Scientific calculator
- Copper tubing and fittings
- Assorted piping and tubing cutting tools
- Reamers

continued
SAFETY CONSIDERATIONS

Ensure that the trainees are equipped with appropriate personal protective equipment and know how to use it properly. Emphasize the importance of wearing safety glasses when cutting tubing or piping.

ADDITIONAL RESOURCES

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


TEACHING TIME FOR THIS MODULE

An outline for use in developing your lesson plan is presented below. Note that each Roman numeral in the outline equates to one session of instruction. Each session has a suggested time period of 2½ hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 22½ hours are suggested to cover *Layout and Installation of Piping and Tubing*. You will need to adjust the time required for hands-on activity and testing based on your class size and resources. Because laboratories often correspond to Performance Tasks, the proficiency of the trainees may be noted during these exercises for Performance Testing purposes.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Planned Time</th>
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<tbody>
<tr>
<td>Session I. Introduction to Layout</td>
<td></td>
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<tr>
<td>A. Introduction</td>
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<tr>
<td>B. Layout</td>
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<tr>
<td>1. Layout Preparation</td>
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<tr>
<td>2. Piping System Layout Considerations</td>
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<tr>
<td>3. Developing an Isometric Sketch</td>
<td></td>
</tr>
<tr>
<td>C. Laboratory</td>
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<tr>
<td>Provide the trainees with a partial system equipment location diagram and have them create an isometric drawing of one loop. This laboratory corresponds to Performance Task 1.</td>
<td></td>
</tr>
<tr>
<td>Session II. Measuring and Bending Tubing and Piping</td>
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<tr>
<td>A. Determining Initial Bend Position and Angle</td>
<td></td>
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<tr>
<td>B. Locating the Bend Position on Tubing</td>
<td></td>
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<tr>
<td>C. Pipe and Tube Cutting Tools</td>
<td></td>
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<tr>
<td>D. Bender Selection</td>
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<tr>
<td>E. Using a Compression Tube Bender</td>
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<tr>
<td>F. Adjustment (Gain) Calculations</td>
<td></td>
</tr>
</tbody>
</table>

| Hand benders | Compression fittings |
| Various hangers and supports | Flared fittings and flaring tool |
| Snubber | Cardboard boxes |
| Flanges and flange bolts | Module Examinations* |
| Torque wrenches | Performance Profile Sheets* |

*Located in the Test Booklet.
Sessions III–VI. Laboratory
A. Laboratory
  Have trainees measure and bend the tubing sections for a loop as they follow an isometric drawing. This laboratory corresponds to Performance Task 2.

Session VII. Supporting Tubing and Piping
A. Support Spacing
B. Variable Spring Hangers
C. Constant Supports
D. Rigid Hangers and Supports
E. Snubbers
F. Supporting Tubing
G. Laboratory
  Have trainees identify the types and locations of support devices required for an example tubing installation. This laboratory corresponds to Performance Task 3.

Session VIII. Fittings and Connectors
A. Flanged Connections
B. Compression Tubing Fittings
C. Laboratory
  Have trainees install compression fittings on tubing. This laboratory corresponds to Performance Task 4.
D. Flared Connectors

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

This module introduces the methods and procedures used in conduit bending.

PREREQUISITES

Prior to training with this module, it is recommended that the trainee shall have successfully completed Core Curriculum; Industrial Maintenance E & I Technician Level One; Industrial Maintenance E & I Technician Level Two; and Industrial Maintenance E & I Technician Level Three, Modules 40301-09 through 40309-09. It is also recommended that trainees read NEC Articles 342, 344, 352, and 358.

OBJECTIVES

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

1. Describe the process of conduit bending using power tools.
2. Identify all parts of electric and hydraulic benders.
3. Bend offsets, kicks, saddles, segmented, and parallel bends.
4. Explain the requirements of the National Electrical Code® (NEC®) for bending conduit.
5. Compute the radius, degrees in bend, developed length, and gain for conduit up to six inches.

PERFORMANCE TASKS

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

1. Use an electric or hydraulic bender to bend a 1” conduit stub-up to an exact distance of 15 1⁄4” above the deck.
2. Make an offset in a length of conduit to miss a 10” high obstruction with a clearance between the obstruction and the conduit of not less than 1” and no more than 1 1⁄2”.
3. Make a saddle in a length of conduit to cross an 8” pipe with 1” clearance between the pipe and the conduit.

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
- Copy of the latest edition of the National Electrical Code®
- Lengths of 3⁄4” rigid, EMT, and IMC conduit
- Lengths of 1” rigid, EMT, and IMC conduit
- Lengths of 2” rigid, EMT, and IMC conduit
- Lengths of PVC conduit
- Lengths of 8” pipe
- Samples of elbows, offsets, saddles, and kicks
- 10” sample obstructions
- Bending charts to match mechanical, electrical, and hydraulic benders
- PVC solvent cements
- End plugs for PVC conduit
- Pipe reamer
- Shop towels
- Brushes
- Felt-tip markers
- Portable mechanical conduit benders
- Electric bender
- Hydraulic bender
- Bending table
- Magnetic torpedo level
- EMT bending tools
- Conduit bending protractor

continued
SAFETY CONSIDERATIONS

Ensure that the trainees are equipped with appropriate personal protective equipment and know how to use it properly. This module requires trainees to bend conduit. Make sure that all trainees are briefed on appropriate safety procedures. Emphasize hand tool and hydraulic tool safety.

ADDITIONAL RESOURCES

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


NOTE

*NFPA 70*, *National Electrical Code*®, and *NEC*® are registered trademarks of the National Fire Protection Association, Inc., Quincy, MA 02269. All *National Electrical Code*® and *NEC*® references in this module refer to the 2008 edition of the *National Electrical Code*®.

TEACHING TIME FOR THIS MODULE

An outline for use in developing your lesson plan is presented below. Note that each Roman numeral in the outline equates to one session of instruction. Each session has a suggested time period of 2½ hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 15 hours are suggested to cover *Machine Bending of Conduit*. 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 to Conduit Bending</strong></td>
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<tr>
<td>A. Introduction</td>
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<tr>
<td>B. <em>NEC</em>® Requirements</td>
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<tr>
<td>C. Types of Bends</td>
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<tr>
<td>D. The Geometry of Bending Conduit</td>
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<tr>
<td><strong>Session II. Mechanical Bending</strong></td>
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<tr>
<td>A. Mechanical Benders</td>
<td></td>
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<tr>
<td>B. Mechanical Stub-Ups</td>
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<tr>
<td>C. Mechanical Offsets</td>
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</tbody>
</table>

| Hickey bar | Pipe vise |
| Tape measure | Pipe cutter |
| Straightedge | Cutting oil |
| Conduit leveling tools | Copies of Quick Quiz* |
| PVC heater | Module Examinations** |
| Scientific calculator | Performance Profile Sheets** |
| Hacksaw | |

* Located at the back of this module
**Located in the Test Booklet
Session III. Electric and Hydraulic Conduit Bending
   A. Electric Conduit Benders
   B. Hydraulic Conduit Benders
   C. Laboratory
      Have trainees practice using a hydraulic bender to form stub-ups. Note the
      proficiency of each trainee. This laboratory corresponds to Performance Task 1.

Sessions IV and V. Bending Techniques
   A. Segment Bending Techniques
   B. Laboratory
      Have trainees practice making offsets and saddle bends using a hydraulic bender.
      This laboratory corresponds to Performance Tasks 2 and 3.
   C. Tricks of the Trade
   D. PVC Conduit Installations
   E. Bending PVC Conduit

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 introduces the trainee to the basics of hydraulics and hydraulic system safety. It covers system components and methods of inspecting and troubleshooting hydraulic systems.

PREREQUISITES

Prior to training with this module, it is recommended that the trainee shall have successfully completed Core Curriculum; Industrial Maintenance E & I Technician Level One; Industrial Maintenance E & I Technician Level Two; and Industrial Maintenance E & I Technician Level Three, Modules 40301-09 through 40310-09.

OBJECTIVES

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

1. Explain hydraulic system safety.
2. Explain the principles of hydraulics.
3. Identify hydraulic devices and symbols and explain their functions.
4. Explain a hydraulic system in a process application.

PERFORMANCE TASKS

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

1. Repair a solenoid valve.
2. Bleed down a system.
3. Clean and inspect a pressure regulator.

MATERIALS AND EQUIPMENT LIST

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Description</th>
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<tbody>
<tr>
<td>Overhead projector and screen</td>
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<tr>
<td>Transparencies</td>
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<tr>
<td>Blank acetate sheets</td>
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<td>Transparency pens</td>
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<td>Whiteboard/chalkboard</td>
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<td>Markers/chalk</td>
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<td>Pencils and scratch paper</td>
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<tr>
<td>Appropriate personal protective equipment</td>
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<tr>
<td>Full face shields</td>
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<tr>
<td>An operational hydraulic system with actuators</td>
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<tr>
<td>Applicable tools to remove, work on, and replace hydraulic system components</td>
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<tr>
<td>Samples of simple and complex hydraulic system drawings</td>
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<tr>
<td>Samples of hydraulic fluids with matching MSDSs</td>
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<tr>
<td>New and used hydraulic components, including:</td>
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<tr>
<td>Filters</td>
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<td>Strainers</td>
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<td>Regulators</td>
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<td>Pumps</td>
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<td>Accumulators</td>
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<td>Hoses</td>
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<td>Fittings and quick disconnects</td>
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<tr>
<td>Control valves</td>
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<tr>
<td>Cylinders</td>
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<tr>
<td>Motors</td>
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<tr>
<td>Solenoid valves</td>
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<tr>
<td>Pressure regulators</td>
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<tr>
<td>Vendor manuals on both a hydraulic system and hydraulic components such as pumps and actuators</td>
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<tr>
<td>Module Examinations*</td>
<td></td>
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<tr>
<td>Performance Profile Sheets*</td>
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</tbody>
</table>

* Located in the Test Booklet
SAFETY CONSIDERATIONS

Ensure that the trainees are equipped with appropriate personal protective equipment and know how to use it properly. Ensure that trainees are briefed on shop safety procedures. Emphasize any special safety precautions associated with working on or near hydraulic fluids and system components. Stress the fact that hydraulic fluid and components become very hot in operation. In addition, hydraulic fluid is usually under very high pressures; lines may rupture, and line connectors and component seals may leak. Warn trainees of high-pressure leaks, especially when the fluid is hot.

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.

- **Industrial Fluid Power**, Womack and Hedges, Womack Educational Publications; Dallas, TX 75235, 2005, for training materials.  
  www.womack-machine.com
  Parker Hannifin Corporation, for training materials, products, and product information (literature, specifications, drawings)
  www.parker.com
  Hydraulic Fittings Company, for products and job aides.
  www.discounthydraulichose.com
- **Viking Pump, Inc.**, for products and product information (literature, specifications, drawings)  
  www.vikingpump.com
- **Bosch Rexroth Corporation**, for training materials, products, and product information (literature, specifications, drawings)  
  www.boschrexroth-us.com
- **Eaton Hydraulics**, for training materials, products, and product information (literature, specifications, drawings)  
  http://hydraulics.eaton.com/products/menu_main.htm
  Hosecraft USA, for products and product information (literature, specifications, drawings)
  www.hosecraftusa.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 15 hours are suggested to cover *Hydraulic Controls*. You will need to adjust the time required for testing based on your class size and resources. Because laboratories often correspond to Performance Tasks, the proficiency of the trainees may be noted during these exercises for Performance Testing purposes.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Time</th>
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</thead>
<tbody>
<tr>
<td><strong>Session I. Introduction; Hydraulic System Safety; Principles of Hydraulics; Hydraulic Fluids</strong></td>
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</tr>
<tr>
<td>A. Introduction</td>
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<tr>
<td>B. Hydraulic System Safety</td>
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<tr>
<td>C. Principles of Hydraulics</td>
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<tr>
<td>1. Fluid Power</td>
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<tr>
<td>a. Laboratory</td>
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<tr>
<td>Have trainees practice calculating the area of pistons inside of cylinders with different diameters.</td>
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</tr>
<tr>
<td>D. Hydraulic Fluids</td>
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</tr>
</tbody>
</table>
Session II. Hydraulic System Parts
A. Strainers and Filters
B. Reservoirs
C. Accumulators
D. Piping, Tubing, and Fittings
E. Directional-Control Valves
F. Pressure-Control Valves
G. Cylinders
H. Hydraulic Pumps
I. Hydraulic Motors

Session III. Inspecting and Troubleshooting Hydraulic System Components
A. Inspecting Hydraulic System Components
B. Troubleshooting Hydraulic System Components
  1. Reading Hydraulic Schematic Diagrams
  2. Troubleshooting Hydraulic Systems

Session IV. Removing, Replacing, and Repairing Hydraulic System Components; Applications
A. Preparing Systems for Shutdown and Repair
B. Removing and Replacing Directional Control Valve Solenoids
C. Applications

Session V. Laboratory
A. Laboratory
  Have trainees practice repairing solenoid valves, bleeding down a system, and cleaning and inspecting a pressure regulator. This laboratory corresponds to Performance Tasks 1, 2, and 3.

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.
Pneumatic Controls
Annotated Instructor’s Guide

MODULE OVERVIEW

This module covers the basics of pneumatic (compressed air) systems and components. It includes information on pneumatic system safety and ways to treat compressed air. Methods for inspecting and troubleshooting pneumatic systems are also discussed.

PREREQUISITES

Prior to training with this module, it is recommended that the trainee shall have successfully completed Core Curriculum; Industrial Maintenance E & I Technician Level One; Industrial Maintenance E & I Technician Level Two; and Industrial Maintenance E & I Technician Level Three, Modules 40301-09 through 40311-09.

OBJECTIVES

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

1. Explain pneumatic system safety.
2. Explain the physical characteristics of gases.
3. Explain compressing gases.
4. Explain the pneumatic transmission of energy.
5. Explain the principles of compressor operation.
6. Identify and explain types of compressors.
8. Identify and explain pneumatic system components and symbols.

PERFORMANCE TASKS

This is a knowledge-based module; there is no performance testing.

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
Portable air tank
An operational pneumatic system with actuators
Samples of simple and complex pneumatic system drawings
Vendor manuals on compressed air components and systems

New and used pneumatic system components, including:
- Compressor
- Filters
- Regulators
- Hoses
- Fittings and quick disconnects
- Control valves
- Cylinders
- Motors
- Solenoid valves
- Pressure regulators

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

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. Ensure that trainees are briefed on shop safety procedures. Emphasize any special safety precautions associated with working on or near pneumatic system components. Stress the fact that pneumatic system components can become very hot and that compressed air can penetrate human skin.

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.womack-machine.com

Parker Hannifin Corporation, for training materials, products, and product information (literature, specifications, drawings)
www.parker.com

SULLAIR Corporation, for training materials, products, and product information (literature, specifications, drawings)
www.sullair.com

MFD Pneumatics, for pneumatic products and product information (literature, specifications, drawings)
www.mfdpneumatics.com

Quincy Compressor, for training materials, products, and product information (literature, specifications, drawings)
www.quincycompressor.com

Ingersoll-Rand Company, for hydraulic and pneumatic products and product information (literature, specifications, drawings)
www.fluids.ingersollrand.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 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 Pneumatic Controls. You will need to adjust the time required for 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; Pneumatic System Safety; Characteristics of Gases; Effects of Atmospheric Pressure; Compressing Gases; Transmission of Energy; Compressor Operation and Types</strong></td>
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<tr>
<td>A. Introduction</td>
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<tr>
<td>B. Pneumatic System Safety</td>
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<tr>
<td>C. Physical Characteristics of Gases</td>
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<tr>
<td>D. Effects of Atmospheric Pressure</td>
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<tr>
<td>E. Compressing Gases</td>
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<tr>
<td>1. Intermittent-Flow Class</td>
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<td>2. Continuous-Flow Class</td>
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<td>F. Pneumatic Transmission of Energy</td>
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<tr>
<td>G. Compressor Operation and Types</td>
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<tr>
<td>1. Compressor Basics</td>
<td></td>
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<tr>
<td>2. Positive-Displacement Compressors</td>
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<tr>
<td>3. Continuous-Flow Compressors</td>
<td></td>
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<tr>
<td>4. Compressor Controls</td>
<td></td>
</tr>
<tr>
<td><strong>Session II. Treatment of Compressed Air</strong></td>
<td></td>
</tr>
<tr>
<td>A. Intake Filters</td>
<td></td>
</tr>
<tr>
<td>B. Intercoolers and Aftercoolers</td>
<td></td>
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<tr>
<td>C. Oil and Water Separators</td>
<td></td>
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<td>D. Chemical Dryers</td>
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<td>E. Receivers</td>
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<tr>
<td>F. In-line Filters</td>
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<td>G. Pressure Regulators</td>
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<td>H. Lubricators and Filter-Regulator-Lubricators</td>
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<tr>
<td>I. Air Treatment Controls</td>
<td></td>
</tr>
<tr>
<td><strong>Session III. Pneumatic System Components; Troubleshooting Pneumatic Systems</strong></td>
<td></td>
</tr>
<tr>
<td>A. Valves</td>
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<td>B. Actuators</td>
<td></td>
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<tr>
<td>C. Mufflers</td>
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<tr>
<td>D. Pneumatic Symbols</td>
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<tr>
<td>1. Laboratory</td>
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<tr>
<td>Have trainees draw simple pneumatic circuits using pneumatic symbols.</td>
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<tr>
<td>E. Troubleshooting Pneumatic Systems</td>
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</tbody>
</table>
Session IV and V. Laboratory

A. Laboratory

Have trainees practice identifying components; checking compressor motor current; inspecting, cleaning, and adjusting pneumatic pressure regulators; adjusting system components to change actuator actions; and troubleshooting a pneumatic system with at least two malfunctions.

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.
Motor-Operated Valves
Annotated Instructor’s Guide

MODULE OVERVIEW
This module introduces the trainees to motor-operated valves that are controlled by programmable devices, such as PLCs.

PREREQUISITES
Prior to training with this module, it is recommended that the trainee shall have successfully completed Core Curriculum; Industrial Maintenance E & I Technician Level One; Industrial Maintenance E & I Technician Level Two; and Industrial Maintenance E & I Technician Level Three, Modules 40301-09 through 40312-09.

OBJECTIVES
Upon completion of this module, the trainee will be able to do the following:
1. State safety regulations associated with motor-operated valves (MOVs).
2. Explain the operating principles of various types of MOVs.
3. Identify applications of MOVs.
4. Set up a MOV.
5. Remove and replace a limit switch.

PERFORMANCE TASKS
Under the supervision of the instructor, the trainee should be able to do the following:
1. Set up a MOV.
2. Remove and replace a limit switch.

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

Examples of automatic valve actuators:
- Electrical
- Hydraulic
- Pneumatic

Limit switches
- Screwdriver
- Module Examinations*
- Performance Profile Sheets*

*Located in the Test Booklet

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

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

Flowserve Corporation – Limitorque website: http://www.flowserve.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 15 hours are suggested to cover Motor-Operated Valves. 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; MOV Safety Issues</strong></td>
<td></td>
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<tr>
<td>A. Introduction</td>
<td></td>
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<tr>
<td>B. MOV Safety Issues</td>
<td></td>
</tr>
<tr>
<td>1. Hazardous Atmospheres</td>
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<tr>
<td>2. Emergency Shutdowns</td>
<td></td>
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<tr>
<td>3. MOV Operation Control</td>
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<tr>
<td><strong>Session II. Types of MOVs</strong></td>
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<tr>
<td>A. Actuator Gearing</td>
<td></td>
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<tr>
<td>1. Worm-Gear Actuators</td>
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<td>2. Bevel-Gear Actuators</td>
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<tr>
<td>3. Variable-Reduction Actuators</td>
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<tr>
<td>B. Pneumatic and Hydraulic Actuators</td>
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<tr>
<td>1. Gas Actuators</td>
<td></td>
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<tr>
<td>2. Rotary Vane Actuator</td>
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<tr>
<td>3. Double-Cylinder Hydraulic Actuators</td>
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<tr>
<td>4. Electro-Hydraulic Actuators</td>
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<tr>
<td>5. Pneumatic Rack and Pinion Actuators</td>
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<tr>
<td>6. Pneumatic Fail-Safe Actuators</td>
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<tr>
<td><strong>Sessions III–V. Setup Activities for MOVs</strong></td>
<td></td>
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<tr>
<td>A. Initial Installation</td>
<td></td>
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<tr>
<td>B. Verifying Pneumatic, Hydraulic, and Electrical MOV Controls</td>
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<tr>
<td>C. Test Operating Electrical MOVs</td>
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<tr>
<td>D. Inspecting and Adjusting Electrical MOV Cams and Limit Switches</td>
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<tr>
<td>E. Removing and Replacing Switching Assemblies</td>
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<tr>
<td>F. Laboratory</td>
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<tr>
<td>Have the trainees set up a MOV and remove and replace a limit switch. These laboratories correspond to Performance Tasks 1 and 2.</td>
<td></td>
</tr>
<tr>
<td><strong>Session VI. Review and Testing</strong></td>
<td></td>
</tr>
<tr>
<td>A. Module Review</td>
<td></td>
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<tr>
<td>B. Module Examination</td>
<td></td>
</tr>
<tr>
<td>1. Trainees must score 70% or higher to receive recognition from NCCER.</td>
<td></td>
</tr>
<tr>
<td>2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.</td>
<td></td>
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<tr>
<td>C. Performance Testing</td>
<td></td>
</tr>
<tr>
<td>1. Trainees must perform each task to the satisfaction of the instructor to receive recognition from the NCCER.</td>
<td></td>
</tr>
<tr>
<td>2. Record the training results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.</td>
<td></td>
</tr>
</tbody>
</table>