Hazardous Locations
Annotated Instructor's Guide

Module 40301-09

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.

Code Digest. Latest Edition. Syracuse, NY: Cooper Crouse-Hinds.

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

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.

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

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.

Electronic Components
Annotated Instructor's Guide

Module 40302-09

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.

Electronic Devices (Electron Flow Version), 8/E. 2007. Thomas L. Floyd. Prentice Hall.

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

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.

Topic	**Planned Time**
Session I. Introduction; Semiconductor Fundamentals; Diodes	
A. Introduction	_____
B. Semiconductor Fundamentals	_____
C. Diodes	_____
D. Laboratory	_____
Have trainees practice building a simple bridge rectifier circuit and viewing the results. This laboratory corresponds to Performance Task 2.	
E. Light-Emitting Diodes	_____
F. Photo Diodes	_____
G. Zener Diodes	_____
H. Laboratory	_____
Have trainees check diodes for proper operation. This laboratory corresponds to Performance Task 3.	
Session II. Transistors and SCRs	
A. Transistors	_____
B. Silicon-Controlled Rectifiers	_____
Session III. Diacs; Triacs; Printed Circuit Boards	
A. Diacs	_____
B. Triacs	_____
C. Printed Circuit Boards	_____
D. Laboratory	_____
Have trainees practice identifying a substitute for an electronic component. This laboratory corresponds to Performance Task 1.	

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.

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

ANI/ISA-5.1, Instrumentation Symbols and Identification, July 1992.

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 *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.

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

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

Overhead projector and screen

Transparencies

Markers/chalk

Blank acetate sheets

Transparency pens

Pencils and scratch paper

Overhead projector and screen

Whiteboard/chalkboard

Appropriate personal protective equipment

Copy of the latest edition of the *National Electrical Code®*

Assorted wire and connectors necessary for making control circuit wiring connections

Assorted manufacturer's motor control device catalogs/data sheets

Examples of wiring diagrams

Examples of circuit schedules/wire lists

Examples of control ladder diagrams

Examples of logic diagrams

Open-frame electromechanical power relays

Miniature electromechanical plug-in relays

Assorted NEMA and IEC magnetic and manual contactors and motor starters

Melting-alloy thermal overload relays

Bimetallic overload relays

Magnetic overload relays

continued

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

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.

Electrical Motor Controls, Gary Rockis and Glen Mazur. Homewood, IL: American Technical Publishers, Inc., 1997.

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

NFPA 70E Recommended Practice for Electrical Equipment Maintenance. Quincy, MA: National Fire Protection Association, 2004.

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**
Session I. Introduction, Electromechanical Relays; Magnetic Contactors; Overload Protection	
A. Introduction	_____
B. Electromechanical Relays	_____
C. Magnetic Contactors	_____
D. Overload Protection	_____

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 _____
   4. Manual 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 dissemble, 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.

Distribution Equipment
Annotated Instructor's Guide

Module 40305-09

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*

*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.

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

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.

Topic	**Planned Time**
Session I. Introduction; Voltage Classifications; Switchboards	
A. Introduction	_____
B. Voltage Classifications	_____
C. Switchboards	_____
Session II. Switchgear	
A. Switchgear	_____
Session III. Switchboard Testing and Maintenance; *NEC®* Requirements; Ground Faults	
A. Switchboard Testing and Maintenance	_____
B. *NEC®* Requirements	_____
C. Ground Faults	_____
Session IV. HVL Switches; Bolted Pressure Switches; Transformers	
A. HVL Switches	_____
B. Bolted Pressure Switches	_____
C. Transformers	_____
Session V. Instrument Transformers; Circuit Breakers	
A. Instrument Transformers	_____
B. Circuit Breakers	_____
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.

Transformer Applications
Annotated Instructor's Guide

Module 40306-09

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.
3. Size and select buck-and-boost transformers.
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.

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

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.

Topic **Planned Time**

Session I. Introduction; Specialty Transformers

A. Introduction _____
   1. Types of Transformers _____
   2. Internal Connections in Three-Phase Transformers _____

B. Specialty Transformers _____
   1. Transformers with Multiple Secondaries _____
   2. Autotransformers _____
   3. Constant-Current Transformers _____
   4. Control Transformers _____
   5. Series Transformers _____
   6. Step-Voltage Regulators _____
   7. Other Specialty Transformers _____

C. Laboratory _____

   Have the trainees practice identifying various specialty transformers. This laboratory corresponds to Performance Task 1.

Session II. Instrument Transformers; Sizing Buck-and-Boost Transformers

A. Instrument Transformers _____
   1. Current Transformers _____
   2. Potential Transformers _____

B. Laboratory _____

   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.

C. Sizing Buck-and-Boost Transformers _____

D. Laboratory _____

   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.

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.

Conductor Selection and Calculations
Annotated Instructor's Guide

Module 40307-09

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

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®*

One length each of various solid, stranded, and compact conductors

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.

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

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 *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.

Topic	**Planned Time**
Session I. Introduction; Compact Conductors	
A. Introduction	_____
B. Compact Conductors	_____
Session II. Conductor Applications	
A. Conductor Applications	_____
1. Branch Circuits	_____
2. Conductor Protection	_____
a. Location of Overcurrent Protection in Circuits	_____
Session III. Properties of Conductors	
A. Properties of Conductors	_____
1. Identifying Conductors	_____
a. Color Coding	_____
b. Changing Colors	_____
B. Laboratory Have trainees identify conductors and their applications from a selection of conductors. This laboratory corresponds with Performance Task 1.	_____
C. Laboratory Have trainees identify an appropriate conductor for a given application. This laboratory corresponds with Performance Task 2.	_____
Session IV. Voltage Drop	
A. Voltage Drop	_____
1. Wire Sizes Based on Resistance	_____
a. Circular Mil-Unit of Conductor Area	_____
b. Conversion of Square Mils to Circular Mils	_____
2. Resistance of Conductors	_____
3. Resistance of Copper per Mil Foot	_____
Session V. Voltage Drop Equations	
A. Voltage Drop Equations	_____
1. Equations for Voltage Drop Using Conductor Area or Conductor Resistance	_____
2. Use of Voltage Drop Equations	_____
3. Practice Voltage Drop Equations	_____

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.

Temporary Grounding
Annotated Instructor's Guide

Module 40308-09

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
http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=standards&p_id=9868

ANSI/IEEE C2-2007 (National Electrical Safety Code). New York, NY: Institute of Electrical and Electronic Engineers.

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

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

U.S. Department of the Interior, Bureau of Reclamation, Denver, Colorado.
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

ASTM F855-04, Standard Specifications for Temporary Protective Grounds to Be Used on De-Energized Electric Power Lines and Equipment, 2004. ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA, 19428-2959.

ASTM F2249-03 Standard Specification for In-Service Test Methods for Temporary Grounding Jumper Assemblies Used on De-Energized Electric Power Lines and Equipment, 2003. ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA, 19428-2959.

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 *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.

Topic	**Planned Time**
Session I. Introduction; Safety Analysis; Purpose of Temporary Grounding	
A. Introduction	_____
B. Electrical Safety Analyses	_____
C. Purpose of Temporary Grounding	_____

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.

Layout and Installation of Tubing and Piping Systems Annotated Instructor's Guide

Module 40309-09

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

Hand benders
Various hangers and supports
Snubber
Flanges and flange bolts
Torque wrenches
Compression fittings
Flared fittings and flaring tool
Cardboard boxes
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 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.

Tube Fitter's Manual, Swagelok Inc., MS 13-03.
Instrument Tube Fitter's Manual, Parker Fluid Connectors.

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.

Topic	**Planned Time**
Session I. Introduction to Layout	
A. Introduction	_____
B. Layout	_____
1. Layout Preparation	_____
2. Piping System Layout Considerations	_____
3. Developing an Isometric Sketch	_____
C. Laboratory 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.	_____
Session II. Measuring and Bending Tubing and Piping	
A. Determining Initial Bend Position and Angle	_____
B. Locating the Bend Position on Tubing	_____
C. Pipe and Tube Cutting Tools	_____
D. Bender Selection	_____
E. Using a Compression Tube Bender	_____
F. Adjustment (Gain) Calculations	_____

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.

Machine Bending of Conduit
Annotated Instructor's Guide

Module 40310-09

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 15¼" 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 1½".
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 ¾" 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

Hickey bar
Tape measure
Straightedge
Conduit leveling tools
PVC heater
Scientific calculator
Hacksaw
Pipe vise
Pipe cutter
Cutting oil
Copies of 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 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.

Benfield Conduit Bending Manual, 2nd Edition. Overland Park, KS: EC&M Books.

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

Tom Henry's Conduit Bending Package (includes video, book, and bending chart). Winter Park, FL: Code Electrical Classes, Inc.

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 *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.

Topic	**Planned Time**
Session I. Introduction to Conduit Bending	
A. Introduction	_____
B. *NEC®* Requirements	_____
C. Types of Bends	_____
D. The Geometry of Bending Conduit	_____
Session II. Mechanical Bending	
A. Mechanical Benders	_____
B. Mechanical Stub-Ups	_____
C. Mechanical Offsets	_____

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.

Hydraulic Controls
Annotated Instructor's Guide

Module 40311-09

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

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 hydraulic system with actuators

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

Samples of simple and complex hydraulic system drawings

Samples of hydraulic fluids with matching MSDSs

New and used hydraulic components, including:
- Filters
- Strainers
- Regulators
- Pumps
- Accumulators
- Hoses
- Fittings and quick disconnects
- Control valves
- Cylinders
- Motors

Solenoid valves

Pressure regulators

Vendor manuals on both a hydraulic system and hydraulic components such as pumps and actuators

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 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 are 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

Industrial Hydraulic Technology, Second Edition, Bulletin 0232-B1, Parker Hannifin Corporation; Cleveland, OH 44124, 1997.

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.

Topic **Time**

Session I. Introduction; Hydraulic System Safety; Principles of Hydraulics; Hydraulic Fluids

A. Introduction _____
B. Hydraulic System Safety _____
C. Principles of Hydraulics _____
1. Fluid Power _____
a. Laboratory _____
Have trainees practice calculating the area of pistons inside of cylinders with different diameters.
D. Hydraulic Fluids _____

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 40312-09

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.
7. Explain compressed-air treatment.
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.

Industrial Fluid Power, *Vol. 1, 2, and 3*, 2005. Womack and Hedges. Dallas, TX:
Womack Educational Publications (for training materials)
www.womack-machine.com

Industrial Pneumatic Technology, Bulletin 0275-B1. 1980. Cleveland, OH: Parker Hannifin Corporation.

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.

Topic **Planned Time**

Session I. Introduction; Pneumatic System Safety; Characteristics of Gases; Effects of Atmospheric Pressure; Compressing Gases; Transmission of Energy; Compressor Operation and Types

A. Introduction _____
B. Pneumatic System Safety _____
C. Physical Characteristics of Gases _____
D. Effects of Atmospheric Pressure _____
E. Compressing Gases _____
   1. Intermittent-Flow Class _____
   2. Continuous-Flow Class _____
F. Pneumatic Transmission of Energy _____
G. Compressor Operation and Types _____
   1. Compressor Basics _____
   2. Positive-Displacement Compressors _____
   3. Continuous-Flow Compressors _____
   4. Compressor Controls _____

Session II. Treatment of Compressed Air

A. Intake Filters _____
B. Intercoolers and Aftercoolers _____
C. Oil and Water Separators _____
D. Chemical Dryers _____
E. Receivers _____
F. In-line Filters _____
G Pressure Regulators _____
H. Lubricators and Filter-Regulator-Lubricators _____
I. Air Treatment Controls _____

Session III. Pneumatic System Components; Troubleshooting Pneumatic Systems

A. Valves _____
B. Actuators _____
C. Mufflers _____
D. Pneumatic Symbols _____
   1. Laboratory _____
      Have trainees draw simple pneumatic circuits using pneumatic symbols.
E. Troubleshooting Pneumatic Systems _____

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 40313-09

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.

The Steam and Condensate Loop Book, Spirax Sarco, 2007.

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.

Topic **Planned Time**

Session I. Introduction; MOV Safety Issues

A. Introduction _____
B. MOV Safety Issues _____
   1. Hazardous Atmospheres _____
   2. Emergency Shutdowns _____
   3. MOV Operation Control _____

Session II. Types of MOVs

A. Actuator Gearing _____
   1. Worm-Gear Actuators _____
   2. Bevel-Gear Actuators _____
   3. Variable-Reduction Actuators _____
B. Pneumatic and Hydraulic Actuators _____
   1. Gas Actuators _____
   2. Rotary Vane Actuator _____
   3. Double-Cylinder Hydraulic Actuators _____
   4. Electro-Hydraulic Actuators _____
   5. Pneumatic Rack and Pinion Actuators _____
   6. Pneumatic Fail-Safe Actuators _____

Sessions III–V. Setup Activities for MOVs

A. Initial Installation _____
B. Verifying Pneumatic, Hydraulic, and Electrical MOV Controls _____
C. Test Operating Electrical MOVs _____
D. Inspecting and Adjusting Electrical MOV Cams and Limit Switches _____
E. Removing and Replacing Switching Assemblies _____
F. Laboratory _____
   Have the trainees set up a MOV and remove and replace a limit switch. These laboratories correspond 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 the NCCER.
   2. Record the training results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.