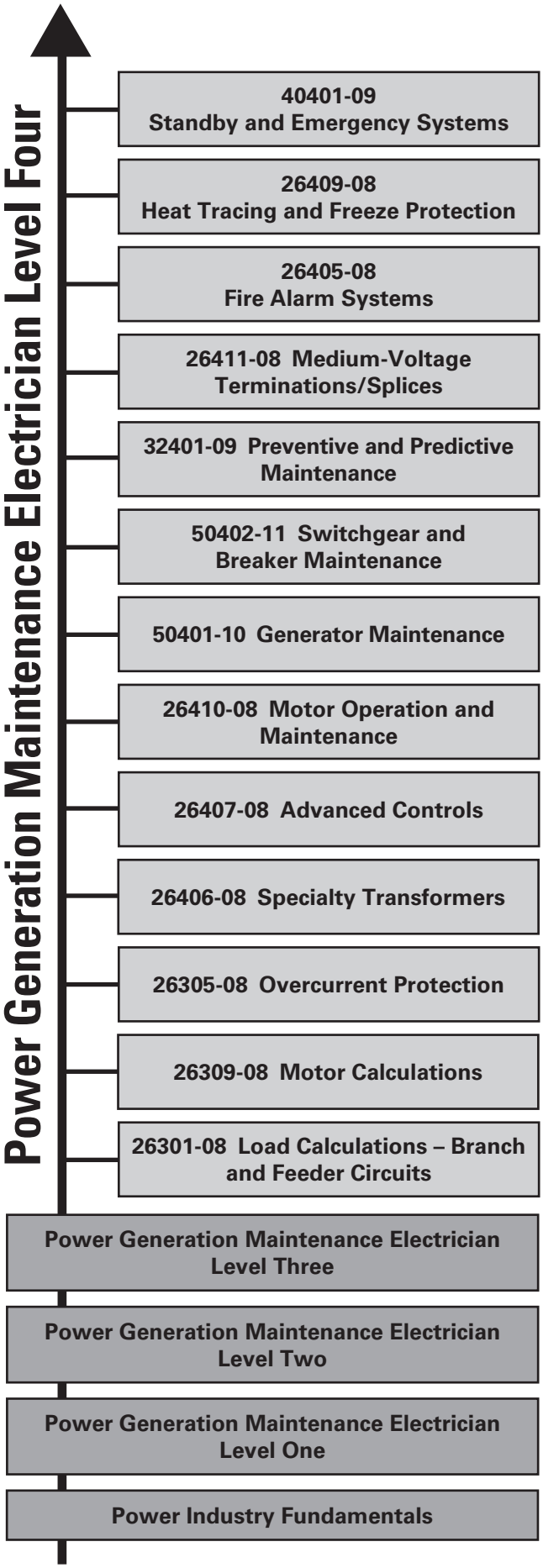
COMPTENCIES, OBJECTIVES, AND PERFORMANCE TASKS



Load Calculations – Branch and Feeder Circuits
Annotated Instructor's Guide

Module 26301-08

MODULE OVERVIEW

This module introduces the load calculations and *National Electrical Code® (NEC®)* requirements for branch and feeder circuits.

PREREQUISITES

Prior to training with this module, it is recommended that the trainee shall have successfully completed *Core Curriculum; Electrical Level One;* and *Electrical Level Two.*

OBJECTIVES

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

1. Calculate loads for single-phase and three-phase branch circuits.
2. Size branch circuit overcurrent protection devices (circuit breakers and fuses) for noncontinuous duty and continuous duty circuits.
3. Apply derating factors to size branch circuits.
4. Calculate ampacity for single-phase and three-phase loads.
5. Use load calculations to determine branch circuit conductor sizes.
6. Use *NEC Table 220.55* to calculate residential cooking equipment loads.
7. Select branch circuit conductors and overcurrent protection devices for electric heat, air conditioning equipment, motors, and welders.

PERFORMANCE TASKS

This is a knowledge-based module. There are no Performance Tasks.

MATERIALS AND EQUIPMENT LIST

Overhead projector and screen
Transparencies
Blank acetate sheets
Transparency pens
Whiteboard/chalkboard
Markers/chalk
Pencils and scratch paper
Appropriate personal protective equipment
Copy of the latest edition of the *National Electrical Code®*
Calculator
Module Examinations*

*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 17½ hours are suggested to cover *Load Calculations – Branch and Feeder Circuits.* You will need to adjust the time required for hands-on activity and testing based on your class size and resources.

Topic	**Planned Time**
Session I. Introduction; Branch Circuit Ratings; Derating; Calculating Branch Circuit Ampacity	
A. Introduction	_____
B. Branch Circuit Ratings	_____
C. Derating	_____
1. Temperature Derating	_____
2. Voltage Drop Derating for Single-Phase Circuits	_____
3. Voltage Drop Derating for Three-Phase Circuits	_____
D. Calculating Branch Circuit Ampacity	_____
Session II. Lighting Loads; Receptacle Loads; Multi-Outlet Assemblies	
A. Lighting Loads	_____
1. Recessed Lighting	_____
2. Heavy-Duty Lamp Holder Outlets	_____
B. Receptacle Loads	_____
C. Multi-Outlet Assemblies	_____
Session III. Show Window Loads; Sign Load	
A. Show Window Loads	_____
B. Sign Load	_____
Session IV. Residential Branch Circuits; Commercial Kitchen Equipment	
A. Residential Branch Circuits	_____
1. Small Appliance Load	_____
2. Laundry Circuit	_____
3. Dryers	_____
4. Cooking Appliances	_____
B. Commercial Kitchen Equipment	_____
Session V. Water Heaters; Electric Heating Loads; Air Conditioning Loads	
A. Water Heaters	_____
B. Electric Heating Loads	_____
C. Air Conditioning Loads	_____
Session VI. Motor Loads; Welders	
A. Motor Loads	_____
B. Welders	_____
Session VII. Review and Testing	
A. Module Review	_____
B. Module Examination	_____
1. Trainees must score 70 percent or higher to receive recognition from the NCCER.	
2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.	

MODULE OVERVIEW

This module introduces the calculations used to size motor branch and feeder circuits, overcurrent protection, and disconnects.

PREREQUISITES

Prior to training with this module, it is recommended that the trainee shall have successfully completed *Core Curriculum; Electrical Level One; Electrical Level Two;* and *Electrical Level Three,* Modules 26301-08 through 26308-08.

OBJECTIVES

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

1. Size branch circuits and feeders for electric motors.
2. Size and select overcurrent protective devices for motors.
3. Size and select overload relays for electric motors.
4. Size and select devices to improve the power factor at motor locations.
5. Size motor short circuit protectors.
6. Size multi-motor branch circuits.
7. Size motor disconnects.

PERFORMANCE TASKS

This is a knowledge-based module. There are no Performance Tasks.

MATERIALS AND EQUIPMENT LIST

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®*
Various types of fuses, including:
- Nontime-delay
- Dual-element, time-delay fuses

Various types of disassembled motors, including:
- Squirrel cage
- Wound-rotor
- Synchronous

Various types of circuit breakers
Motor short circuit protector
Devices used to provide motor overload protection, including:
- Overload relays
- Fuses
- Circuit breakers

Module Examinations*

*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 12½ hours are suggested to cover *Motor Calculations.* You will need to adjust the time required for hands-on activity and testing based on your class size and resources.

Topic	**Planned Time**
Session I. Introduction; Motor Basics	
A. Introduction	_____
B. Motor Basics	_____
1. Stator Windings	_____
2. Special Connections	_____
Session II. Calculating Motor Circuit Conductors	
A. Calculating Motor Circuit Conductors	_____
1. Wound-Rotor Motors	_____
2. Conductors for DC Motors	_____
3. Conductors for Miscellaneous Motor Applications	_____
Session III. Motor Protective Devices; Circuit Breakers	
A. Motor Protective Devices	_____
B. Circuit Breakers	_____
1. Application of MCPs	_____
2. Motor Short Circuit Protectors	_____
Session IV. Multi-Motor Branch Circuits; Equipment Grounding Conductors for Motor Feeder and Branch Circuits; Power Factor Correction at Motor Terminals	
A. Multi-Motor Branch Circuits	_____
B. Equipment Grounding Conductors for Motor Feeder and Branch Circuits	_____
C. Power Factor Correction at Motor Terminals	_____
Session V. Review and Testing	
A. Module Review	_____
B. Module Examination	_____
1. Trainees must score 70 percent or higher to receive recognition from the NCCER.	
2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.	

MODULE OVERVIEW

This module covers the procedures used when sizing and selecting overcurrent protection, along with the applicable *National Electrical Code®* (*NEC®*) requirements.

PREREQUISITES

Prior to training with this module, it is recommended that the trainee shall have successfully completed *Core Curriculum; Electrical Level One; Electrical Level Two;* and *Electrical Level Three,* Modules 26301-08 through 26304-08.

OBJECTIVES

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

1. Apply the key *National Electrical Code®* (*NEC®*) requirements regarding overcurrent protection.
2. Check specific applications for conformance to *NEC®* sections that cover short circuit current, fault currents, interrupting ratings, and other sections relating to overcurrent protection.
3. Determine let-through current values (peak and rms) when current-limiting overcurrent devices are used.
4. Select and size overcurrent protection for specific applications.

PERFORMANCE TASKS

This is a knowledge-based module. There are no Performance Tasks.

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®*
Various types of circuit breakers
Various types of fuses, including electronic fuses
Sample fuse blocks and holders with nonrejection bases
Sample fuse blocks and holders with rejection clips that accept only Class R fuses
Module Examinations*

*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 optional material is 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 25 hours are suggested to cover *Overcurrent Protection.* You will need to adjust the time required for hands-on activity and testing based on your class size and resources.

Topic	**Planned Time**
Session I. Introduction	
A. Introduction	_____
1. Fault Currents	_____
Session II. Fuses	
A. Fuses	_____
1. Types of Fuses	_____
2. Voltage Rating	_____
3. Ampere Rating	_____
4. Interrupting Rating	_____
5. Selective Coordination	_____
6. Current Limitation	_____
Session III. Operating Principles of Fuses	
A. Operating Principles of Fuses	_____
1. Nontime-Delay Fuses	_____
2. Dual-Element, Time-Delay Fuses	_____
Session IV. UL Fuse Classes	
A. UL Fuse Classes	_____
1. Branch Circuit Listed Fuses	_____
2. Medium-Voltage Fuses	_____
3. Current-Limiting Fuses	_____
4. Fuses for Selective Coordination	_____
5. Fuse Time-Current Curves	_____
Session V. Motor Overload and Short Circuit Protection	
A. Motor Overload and Short Circuit Protection	_____
Session VI. Circuit Breakers	
A. Circuit Breakers	_____
1. Interrupting Capacity Rating	_____
Session VII. Circuit Protection	
A. Circuit Protection	_____
1. Lighting/Appliance Branch Circuits	_____
Session VIII. Short Circuit Calculations	
A. Short Circuit Calculations	_____
1. Basic Short Circuit Calculation Procedure	_____
2. Practical Application	_____
3. Peak Let-Through Charts	_____

Session IX. Troubleshooting and Testing Circuit Breakers and Fuses

A. Troubleshooting and Testing Circuit Breakers and Fuses _____

1. Circuit Breakers _____
2. Fuses _____

Session X. Review and Testing

A. Module Review _____

B. Module Examination _____

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

Specialty Transformers
Annotated Instructor's Guide

Module 26406-08

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; Electrical Level One*; *Electrical Level Two; Electrical Level Three;* and *Electrical Level Four,* Modules 26401-08 through 26405-08.

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

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.

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 *Specialty Transformers.* 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

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

Session IV. Review; Testing

A. Review _____

B. Module Examination _____

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

C. Performance Testing _____

1. Trainees must perform each task to the satisfaction of the instructor to receive recognition from 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 explains applications and operating principles of solid-state controls, reduced-voltage starters, and adjustable frequency drives, as well as troubleshooting procedures.

PREREQUISITES

Prior to training with this module, it is recommended that the trainee shall have successfully completed *Core Curriculum; Electrical Level One*; *Electrical Level Two; Electrical Level Three;* and *Electrical Level Four,* Modules 26401-08 through 26406-08.

OBJECTIVES

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

1. Select and install solid-state relays for specific applications in motor control circuits.
2. Install non-programmable/programmable motor circuit protectors (solid-state overload relays) in accordance with the manufacturer's instructions.
3. Select and install electromechanical and solid-state timing relays for specific applications in motor circuits.
4. Recognize the different types of reduced-voltage starting motor controllers and describe their operating principles.
5. Connect and program adjustable frequency drives to control a motor in accordance with the manufacturer's instructions.
6. Demonstrate and/or describe the special precautions used when handling and working with solid-state motor controls.
7. Recognize common types of motor braking and explain the operating principles of motor brakes.
8. Perform preventive maintenance and troubleshooting tasks in motor control circuits.

PERFORMANCE TASKS

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

1. Identify and connect various control devices.

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
Heat sinks
Non-programmable solid-state overload relays (SSOLRs)
Programmable solid-state overload relays (SSOLRs)
Programmable overload relays
Timing relays
Pneumatic timing relay
Dashpot timing relay
Solid-state plug-in timing relays
Good and faulty contacts
Trade Terms Quiz*
Module Examinations**
Performance Profile Sheets**

*Located in the back of this module.

**Located in the Test Booklet.

SAFETY CONSIDERATIONS

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

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.

Adjustable Frequency Drives, Application Guide, Latest Edition. Milwaukee, WI: Cutler-Hammer.

Consulting Application Guide, Distribution and Control, Latest Edition. Pittsburgh, PA: Cutler-Hammer.

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

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

NFPA 70B Recommended Practice for Electrical Equipment Maintenance. Quincy, MA: National Fire Protection Association, 1998.

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 20 hours are suggested to cover *Advanced 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; Solid-State Relays	
A. Introduction	_____
B. Solid-State Relays	_____
1. Solid-State Relay Operation	_____
2. Comparison of Electromechanical Relays to Solid-State Relays	_____
3. Two-Wire and Three-Wire SSR Control	_____
4. Connecting SSRs to Achieve Multiple Outputs	_____
5. SSR Temperature Considerations	_____
6. Solid-State Relay Overvoltage and Overcurrent Protection	_____
Session II. Solid-State Protective Relays; Timing Relays	
A. Solid-State Protective Relays	_____
1. Non-Programmable Solid-State Overload Relays	_____
2. Programmable Solid-State Overload Relays	_____
B. Timing Relays	_____
1. Pneumatic Timing Relays	_____
2. Dashpot Timing Relays	_____
3. Solid-State Timing Relays	_____
4. Timing Relay Applications	_____
Session III. Reduced-Voltage Starting Motor Control	
A. Reduced-Voltage Starting Motor Control	_____
1. Autotransformer Reduced-Voltage Starting Motor Control	_____
2. Part-Winding, Reduced-Voltage Starting Motor Control	_____
3. Wye-Delta, Reduced-Voltage Starting Motor Control	_____
4. Solid-State, Reduced-Voltage Starting Motor Control	_____
5. Selection of Reduced-Voltage Controllers	_____

Session IV. Adjustable Frequency Drives

A. Adjustable Frequency Drives _____
   1. Basic Adjustable Frequency Drive Operation _____
   2. AFD Parameters That Can Be Programmed or Monitored _____
   3. Classifications and Nameplate Markings for AFDs _____
   4. Types of Adjustable Speed Loads _____
   5. AFD Selection Considerations _____

Session V. Laboratory

A. Laboratory _____

   Have the trainees practice identifying and connecting various control devices. This laboratory corresponds to Performance Task 1.

Session VI. Motor Braking Methods; Precautions When Working with Solid-State Controls

A. Motor Braking Methods _____
   1. Dynamic Braking (DC Electric Braking) of an AC Motor _____
   2. Dynamic Braking (AC Drives) _____
   3. Electromechanical Braking _____

B. Precautions When Working with Solid-State Controls _____

Session VII. Motor Control Maintenance; Motor Control Troubleshooting

A. Motor Control Maintenance _____
   1. Preventive Maintenance Tasks _____

B. Motor Control Troubleshooting _____
   1. Customer Interface _____
   2. Physical Examination of the System _____
   3. Basic System Analysis _____
   4. Use of Manufacturer's Troubleshooting Aids _____
   5. Troubleshooting Motor Control Circuits and Components _____
   6. Electrical Troubleshooting Procedures Common to All Motor Control Circuits _____

Session VIII. Review; Testing

A. Review _____

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

C. Performance Testing _____
   1. Trainees must perform each task to the satisfaction of the instructor to receive recognition from 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 basic motor operation and maintenance.

PREREQUISITES

Prior to training with this module, it is recommended that the trainee shall have successfully completed *Core Curriculum; Electrical Level One; Electrical Level Two; Electrical Level Three;* and *Electrical Level Four,* Modules 26401-08 through 26409-08.

OBJECTIVES

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

1. Recognize the factors related to motor reliability and life span.
2. Measure motor winding insulation resistance and compensate for temperature.
3. Identify motors needing replacement.

PERFORMANCE TASKS

This is a knowledge-based module. There are no Performance Tasks.

MATERIALS AND EQUIPMENT LIST

Overhead projector and screen
Transparencies
Blank acetate sheets
Transparency pens
Whiteboard/chalkboard
Markers/chalk
Pencils and scratch paper
Appropriate personal protective equipment
Various couplings
Motors and megohmmeters for insulation resistance testing
Module Examinations*

*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.

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

Topic **Planned Time**

Session I. Introduction; Squirrel Cage Motors; Motor Maintenance

A. Introduction _____
   1. Usual Service Conditions _____
   2. Unusual Service Conditions _____
   3. Effects of Overloading and Single-Phasing _____
   4. Insulation Systems _____

B. Squirrel Cage Motors _____
   1. Starting Configurations _____
   2. Typical Squirrel Cage Motor Winding Failures _____

C. Motor Maintenance _____
   1. Tools for Maintenance and Troubleshooting _____
   2. Basic Care and Maintenance _____
   3. Periodic Predictive Testing _____

Session II. Motor Bearing Maintenance; Motor Insulation Testing

A. Motor Bearing Maintenance _____
   1. Frequency of Lubrication _____
   2. Lubrication Procedure _____
   3. Checking Bearings _____

B. Motor Insulation Testing _____
   1. Insulation Resistance Tests _____
   2. Determining the Polarization Index _____
   3. Insulation Testing Considerations _____

Session III. Receiving and Storing Motors; Troubleshooting Motors; Motor Installation and Commissioning Guidelines

A. Receiving and Storing Motors _____

B. Troubleshooting Motors _____
   1. Insulation Testing _____
   2. Grounded Coils _____
   3. Water-Damaged Motors _____

C. Laboratory _____
   Have the trainees practice performing an insulation resistance test.

D. Motor Installation and Commissioning Guidelines _____
   1. Alignment _____
   2. Endplay Adjustment _____
   3. First-Time Startup _____
   4. Coupled Startup _____
   5. Doweling _____

Session IV. Review; Testing

A. Review _____

B. Module Examination _____

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

Generator Maintenance
Annotated Instructor's Guide

Module Overview

This module describes basic AC and DC generation principles, turbo generator principles and construction, generator exciters, protection and relaying systems, auxiliary systems, and some maintenance requirements.

Prerequisites

Prior to training with this module, it is recommended that the trainee shall have successfully completed *Power Industry Fundamentals*; *Power Generation Maintenance Electrician Level One*; *Power Generation Maintenance Electrician Level Two*; and *Power Generation Maintenance Electrician Level Three*; and *Power Generation Maintenance Electrician Level Four*, Modules 26301-08, 26309-08, 26305-08, 26406-08, 26407-08, and 26410-08.

Objectives

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

1. Identify the components of AC and DC generators.
2. Describe how a generator produces single-phase and three-phase AC voltage.
3. Explain how AC voltage is changed to DC voltage.
4. Describe the different types of connections, including:
   - Delta and wye connections
   - Protective instrumentation (potential and current transformers)
5. Identify the factors that determine output voltage.
6. Describe how a voltage regulator/control system operates.
7. Explain how a generator can be converted to a motor for starting purposes in a combustion turbine.
8. Describe the purposes and identify the major components of auxiliary systems for AC generators.
9. Using prescribed safety precautions, perform an inspection of a brush assembly and remove and replace a brush.
10. Using prescribed safety precautions, inspect a filter assembly and remove and replace a filter.
11. Describe the typical actions and checks required during overhaul maintenance.
12. Using prescribed safety precautions, perform an insulation resistance test.

Performance Tasks

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

1. Using prescribed safety procedures, perform an inspection of a brush assembly and remove and replace a brush.
2. Using prescribed safety procedures, inspect a filter assembly and remove and replace a filter.
3. Using prescribed safety procedures, perform an insulation resistance test.

Materials and Equipment

Markers/chalk
Pencils and scratch paper
Whiteboard/chalkboard
Power Generation Maintenance Electrician Level 4 PowerPoint® Presentation Slides (ISBN 978-0-13-257325-2)
Multimedia projector and screen
Computer
Appropriate personal protective equipment
Handheld advanced-function calculator
Small hand-driven convertible, two-pole AC/DC generator model available from SK Science Kit (sciencekit.com) as SKU#WW47503M00
Basic function oscilloscope
Variable speed drill
Flat blade and Phillips head screwdrivers
Work gloves
Quantity of brush holders and brushes
Brush blocks
Collector ring enclosure with filters (or equivalent assemblies)

continued

5 kV or 10 kV megohmmeters
Grounding cables
A wye-wound medium-voltage three-phase generator or transformer
Hi-pot tester
Module Examinations*
Performance Profile Sheets*

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

Safety Considerations

Ensure that the trainees are equipped with appropriate personal protective equipment and know how to use it properly. Trainees may be required to work in close proximity to energized and rotating machinery. Emphasize the special safety precautions associated with this activity. Ensure that the trainees are briefed on the proper site or shop safety precautions and procedures.

Additional Resources

This module presents thorough resources for task training. The following resource material is suggested for further study.

Handbook of Large Turbo-Generator Operation and Maintenance. Second Edition. Geoff Klempner and Isidor Kerszenbaum. Hoboken, New Jersey: John Wiley & Sons, Inc.

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

Topic	**Planned Time**
Session I. Introduction; DC Brush Generator; AC Generator Principles and Construction	
A. Introduction	_____
B. DC Brush Generator Principles	_____
C. Synchronous AC Generator Principles and Construction	_____
Session II. Excitation Systems; Generator Operating Parameters; Protection and Relaying Systems	
A. Excitation Systems	_____
B. Basic Generator Operating Parameters	_____
C. Generator Protection and Relaying Systems	_____
Sessions III–IV. Auxiliary Systems; Brush and Filter Maintenance	
A. Auxiliary Systems and Equipment	_____
B. Typical Brush and Filter Maintenance for Operating Equipment	_____
C. Laboratory	_____
Have trainees demonstrate an inspection of a brush assembly and remove and replace a brush. Also have the trainees demonstrate inspection of filter assembly and remove and replace a filter. This laboratory corresponds to Performance Task 1 and 2.	

Sessions V and VI. Overhaul Maintenance

A. Typical Hydrogen Removal and Disassembly Procedures _____

B Testing _____

C. Laboratory _____

Have trainees demonstrate an insulation test. This laboratory corresponds to Performance Task 3.

Session VII. Review; Module Examination and Performance Testing

A. Module Review _____

B. Module Examination _____

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

C. Performance Testing _____

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

Switchgear and Breaker Maintenance
Annotated Instructor's Guide

Module 50402-11

Module Overview

This module introduces the trainee to general maintenance practices for power distribution equipment, including switchgear, motor control centers (MCCs), and circuit breakers.

Prerequisites

Prior to training with this module, it is recommended that the trainee shall have successfully completed *Power Industry Fundamentals*; *Power Generation Maintenance Electrician Level One*; *Power Generation Maintenance Electrician Level Two*; *Power Generation Maintenance Electrician Level Three*; and *Power Generation Maintenance Electrician Level Four*, Modules 26301-08, 26309-08, 26305-08, 26406-08, 26407-08, 26410-08, and 50401-10.

Objectives

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

1. Describe the safety practices that must be followed when installing and maintaining medium- and low-voltage equipment.
2. Describe and demonstrate how to safely rack out, remove, inspect, and replace low-voltage and medium-voltage breakers.
3. Describe and demonstrate procedures for testing and maintenance of circuit breakers, switchgear, MCCs, and associated components.
4. Describe methods used to coordinate protective devices.
5. Rack out, remove, and rack in low- and medium-voltage breakers.
6. Test and maintain switchgear, MCCs, and associated components.

Performance Tasks

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

1. Rack out, remove, and rack in low- and medium-voltage breakers.
2. Test and maintain switchgear, MCCs, and associated components.

Materials and Equipment

Markers/chalk
Pencils and scratch paper
Whiteboard/chalkboard
Power Generation Maintenance Electrician Level 4 PowerPoint® Presentation Slides (ISBN 978-0-13-257325-2)
Multimedia projector and screen
Computer
Appropriate personal protective equipment
Several types of protective gloves
Several articles of arc-resistant PPE
Protective gloves
Copy of *NFPA 70E®*
Selection of electrical protection devices
Selection of overcurrent relays
Selection of transformer protection relays
Breaker, switchgear enclosure, and associated electrical drawing
Air circuit breaker and manufacturer's maintenance guide
Vacuum container
Hi-pot tester
Megohmmeter (megger)
Access to switchgear and MCCs along with associated manufacturer's maintenance guides
Module Examinations*
Performance Profile Sheets*

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

Safety Considerations

Ensure that the trainees are equipped with appropriate personal protective equipment and know how to use it properly. Review safety guidelines associated with working on electrical power distribution systems, including switchgear and associated components. Emphasize the importance of proper housekeeping.

Additional Resources

This module presents thorough resources for task training. The following resource material is suggested for further study.

ABB: www.abb.com/.

Arc Flash Demonstration. www.youtube.com/watch?v=-Qq7U7tFsvQ&feature=related.

Arc Flash Hazard Incident Energy Calculations: A Historical Perspective and Comparative Study of the Standards IEEE 1584 and NFPA 70E® (2008). R.F. Ammerman, P.K. Sen, and J.P. Nelson: Calgary, Canada.

Eaton (Cutler-Hammer): www.eaton.com/EatonCom/Markets/Electrical/index.htm.

General Electric (GE) Electrical: www.geindustrial.com/cwc/electrical_homepage.htm.

IEEE C2-2007, National Electrical Safety Code. Institute of Electrical and Electronics Engineers: New York, NY.

IEEE 1584-2002, IEEE Guide for Performing Arc-Flash Hazard Calculations. Institute of Electrical and Electronics Engineers: New York, NY.

NFPA 70B-2006, Recommended Practice for Electrical Equipment Maintenance. National Fire Protection Association: Quincy, MA.

NFPA 70E®-2009, Standard for Electrical Safety in the Workplace. National Fire Protection Association: Quincy, MA.

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 25 hours are suggested to cover *Switchgear and Breaker Maintenance*. You will need to adjust the time required for hands-on activity and testing based on your class size and resources. Because laboratories often correspond to Performance Tasks, the proficiency of trainees may be noted during these exercises for Performance Testing purposes.

Topic	**Planned Time**
Session I. Introduction; Electrical Safety; Circuit Breaker Maintenance	
A. Introduction	_____
B. Electrical Safety	_____
1. Relevant Standards	_____
2. Arc Flash and Arc Blast	_____
3. Hazard Boundaries	_____
4. Hand and Arm Protection	_____
5. Arc-Rated Clothing	_____
C. Circuit Breaker Maintenance	_____
1. Racking-Out Breakers	_____
2. Racking-In Switchgear and Breaker Devices	_____
3. Maintaining Medium-Voltage Air Circuit Breakers	_____
4. Inspecting Medium-Voltage Oil Circuit Breakers	_____
5. Maintaining Medium-Voltage Oil Circuit Breakers	_____
6. Maintaining Primary Contacts on Medium-Voltage Vacuum Circuit Breakers	_____
7. Measuring Force in a Vacuum Contactor	_____

Sessions II through IV. Circuit Breaker Maintenance Laboratory

A. Laboratory _____

Have trainees rack out, remove, and rack in low- and medium-voltage breakers. This laboratory corresponds to Performance Task 1.

Sessions V through VIII. Testing and Maintenance of Switchgear and MCCs

A. Testing and Maintenance of Switchgear and MCCs _____

1. Maintaining Switchgear _____
2. Maintaining Cables _____
3. Maintaining MCCs _____

B. Laboratory _____

Have trainees perform test and maintenance procedures on switchgear, MCCs, and associated components. This laboratory corresponds to Performance Task 2.

Session IX. Protection and Coordination

A. Protection and Coordination _____

1. Protective Relays _____
2. Motor Protection _____
3. Transformer Protection _____
4. Lockout Relay to Prevent Re-Energizing _____
5. Settings for Protective Relays _____
6. Time-Current Coordination Examples _____

Session X. Review; Module Examination and Performance Testing

A. Module Review _____

B. Module Examination _____

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

C. Performance Testing _____

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

Preventive and Predictive Maintenance
Annotated Instructor's Guide

Module 32401-09

MODULE OVERVIEW

This module provides an overview of the preventive and predictive maintenance processes. Information about nondestructive testing is also included.

PREREQUISITES

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

OBJECTIVES

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

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

PERFORMANCE TASKS

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

MATERIALS AND EQUIPMENT LIST

Overhead projector and screen

Transparencies

Blank acetate sheets

Transparency pens

Whiteboard/chalkboard

Markers/chalk

Pencils and scratch paper

Appropriate personal protective equipment

Examples of flawed welds, stress cracks, etc.

NDT equipment, including:
- Ultrasonic tester
- Pyrometer
- Eddy current tester
- Borescope
- Liquid penetrant kit
- Magnetic particle yoke

Copies of the Quick Quizzes*

Module Examination**

* Located at the back of this module.

**Located in the Test Booklet.

SAFETY CONSIDERATIONS

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

ADDITIONAL RESOURCES

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

An Introduction to Predictive Maintenance, 2002. R. Keith Mobley. Woburn, MA: Butterworth-Heinsmann.

Encyclopedia of Materials Science and Engineering – Supplementary, Vol. 1, 1989. Michael B. Bever and Robert W. Cahn, ed. Cambridge, MA: The MIT Press.

Encyclopedia of Materials Science and Engineering – Supplementary, *Vol. 2,* 1990. Robert W. Cahn, ed. Cambridge, MA: The MIT Press.

Nondestructive Evaluation and Quality Control Metals Handbook, *Vol. 17*, 9th Ed. 1989. Materials Park, OH: ASM International.

TEACHING TIME FOR THIS MODULE

An outline for use in developing your lesson plan is presented below. Note that each Roman numeral in the outline equates to one session of instruction. Each session has a suggested time period of 2½ hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 10 hours are suggested to cover *Preventive and Predictive Maintenance*. You will need to adjust the time required for hands-on activity and testing based on your class size and resources.

Topic	**Planned Time**
Session I. Introduction; Preventive Maintenance; Predictive Maintenance	
A. Introduction	_____
B. Preventive Maintenance	_____
1. Program Benefits	_____
C. Predictive Maintenance	_____
1. Requirements and Priorities	_____
2. Documentation	_____
Session II. Nondestructive Testing and Evaluation, Part One	
A. Introduction	_____
B. Ultrasonics	_____
C. Radiography	_____
D. Eddy Current Inspection	_____
E. Visual and Optical Inspection	_____
Session III. Nondestructive Testing and Evaluation, Part Two	
A. Liquid Penetrant Inspection	_____
B. Magnetic Particle Inspection	_____
C. Acoustic Emission Testing	_____
D. Infrared Testing	_____
E. Vibration Analysis	_____
F. Tribology	_____

Session IV. Review and Testing

A. Trade Terms and Quick Quizzes _____

B. Module Review _____

C. Module Examination _____

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

MODULE OVERVIEW

This module offers an overview of the *NEC*® and cable manufacturers' requirements for medium-voltage terminations and splices.

PREREQUISITES

Prior to training with this module, it is recommended that the trainee shall have successfully completed *Core Curriculum; Electrical Level One; Electrical Level Two; Electrical Level Three;* and *Electrical Level Four,* Modules 26401-08 through 26410-08.

OBJECTIVES

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

1. Select the proper materials and tools for medium-voltage terminations and splices.
2. Prepare medium-voltage cable for terminations and splices.
3. Complete cable assemblies using terminations and splices.
4. Inspect and test medium-voltage terminations and splices.

PERFORMANCE TASKS

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

1. Prepare a cable and complete a splice or stress cone.

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
Common types of medium-voltage cable
Inline tape splicing kits
Various types of tape applied for primary insulation
Manufactured termination and splice kits
Quick inline splicing kit
Photos of terminations/cables that have been damaged by flashover and/or tracking
Insulators used with medium-voltage terminations
Trade Terms Quiz*
Module Examinations**
Performance Profile Sheets**

*Located in the back of this module.

**Located in the Test Booklet.

SAFETY CONSIDERATIONS

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

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.

American Electrician's Handbook, Terrell Croft and Wilfred I. Summers. New York, NY: McGraw-Hill, 1996.

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

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 *Medium-Voltage Terminations/Splices.* 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; Medium-Voltage Power Cable; Splicing I	
A. Introduction	_____
1. Straight Splices	_____
B. Medium-Voltage Power Cable	_____
1. Medium-Voltage Cable Components	_____
2. Strand Shielding	_____
3. Insulation	_____
4. Insulation Shield System	_____
5. Jacket	_____
C. Splicing	_____
1. Splicing Steps	_____
2. Inline Tape Splices	_____
Session II. Splicing II	
A. Splicing	_____
1. Tee Tape Splice	_____
2. Manufactured Termination and Splice Kits	_____
3. Quick Inline Splicing Kits	_____
4. Paper-Insulated Cable Splices	_____
B. Laboratory	_____
Have the trainees practice preparing a cable and completing a splice or stress cone. This laboratory corresponds to Performance Task 1.	
Session III. Terminations; High-Potential (Hi-Pot) Testing	
A. Terminations	_____
1. Stress Control	_____
2. Sealing to the External Environment	_____
B. High-Potential (Hi-Pot) Testing	_____
1. Method of Application	_____
2. Selective Guard Circuits	_____
3. Connections	_____
4. Selective Guard Service Connections	_____
5. Corona Guard Ring and Guard Shield	_____
6. Detailed Operating Procedure	_____
7. Go/No-Go Testing	_____
8. Insulation Resistance Measurements	_____

Session IV. Review; Testing

A. Review _____

B. Module Examination _____

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

C. Performance Testing _____

1. Trainees must perform each task to the satisfaction of the instructor to receive recognition from 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 fire alarm control units, Digital Alarm Communicator Systems (DACS), installation wiring for alarm initiating and notification devices, and alarm system maintenance.

PREREQUISITES

Prior to training with this module, it is recommended that the trainee shall have successfully completed *Core Curriculum; Electrical Level One*; *Electrical Level Two; Electrical Level Three;* and *Electrical Level Four,* Modules 26401-08 through 26404-08.

OBJECTIVES

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

1. Define the unique terminology associated with fire alarm systems.
2. Describe the relationship between fire alarm systems and life safety.
3. Explain the role that various codes and standards play in both commercial and residential fire alarm applications.
4. Describe the characteristics and functions of various fire alarm system components.
5. Identify the different types of circuitry that connect fire alarm system components.
6. Describe the theory behind conventional, addressable, and analog fire alarm systems and explain how these systems function.

PERFORMANCE TASKS

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

1. Connect selected fire alarm system(s).

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
If possible, provide samples of:
- Automatic detectors
- Fixed-temperature heat detectors
- Combination heat detectors
- Photoelectric smoke detectors
- Ionization smoke detectors
- Projected beam smoke detectors
- Duct detectors
- Cloud chamber smoke detectors
- Semiconductor heat detectors
- Fusible line-type heat detectors
- Ultraviolet and infrared flame detectors
- Water flow detectors
- UV and IR flame detectors
- Photoelectric beam smoke detectors
- Spot detectors

Tools used to connect fire alarm systems
Trade Terms Quiz*
Module Examinations**
Performance Profile Sheets**

*Located in the back of this module.

**Located in the Test Booklet.

SAFETY CONSIDERATIONS

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

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.

Certified Alarm Technician Level 1, Latest Edition. Silver Spring, MD: National Burglar and Fire Alarm Association.

Practical Fire Alarm Course, Latest Edition. Silver Spring, MD: National Burglar and Fire Alarm Association.

Understanding Alarm Systems, Latest Edition. Silver Spring, MD: National Burglar and Fire Alarm Association.

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

Topic **Planned Time**

Session I. Introduction; Codes and Standards; Fire Alarm Systems Overview; Fire Alarm System Equipment

A. Introduction _____
B. Codes and Standards _____
   1. The National Fire Protection Association _____
C. Fire Alarm Systems Overview _____
   1. Conventional Hardwired Systems _____
   2. Multiplex Systems _____
   3. Addressable and Analog Addressable Systems _____
D. Fire Alarm System Equipment _____

Session II. Fire Alarm Initiating Devices

A. Fire Alarm Initiating Devices _____
   1. Conventional versus Addressable Commercial Detectors _____
   2. Automatic Detectors _____
   3. Heat Detectors _____
   4. Smoke Detectors _____
   5. Other Types of Detectors _____
   6. Manual (Pull Station) Fire Detection Devices _____
   7. Auto-Mechanical Fire Detection Equipment _____

Session III. Control Panels; FACP Primary and Secondary Power; Notification Appliances

A. Control Panels _____
   1. User Control Points _____
   2. FACP Initiating Circuits _____
   3. Types of FACP Alarm Outputs _____
   4. FACP Listings _____

B. FACP Primary and Secondary Power _____

C. Notification Appliances _____
   1. Visual Notification Devices _____
   2. Audible Notification Devices _____
   3. Voice Evacuation Systems _____
   4. Signal Considerations _____

Session IV. Communications and Monitoring; General Installation Guidelines

A. Communications and Monitoring _____
   1. Monitoring Options _____
   2. Digital Communicators _____
   3. Cellular Backup _____

B. General Installation Guidelines _____
   1. General Wiring Requirements _____
   2. Workmanship _____
   3. Access to Equipment _____
   4. Fire Alarm Circuit Identification _____
   5. Power-Limited Circuits in Raceways _____
   6. Mounting of Detectors _____
   7. Outdoor Wiring _____
   8. Fire Seals _____
   9. Wiring in Air Handling Spaces _____
   10. Wiring in Hazardous Locations _____
   11. Remote Control Signaling Circuits _____
   12. Cables Running Floor to Floor _____
   13. Cables Running in Raceways _____
   14. Cable Spacing _____
   15. Elevator Shafts _____
   16. Terminal Wiring Methods _____
   17. Conventional Initiation Device Circuits _____
   18. Notification Appliance Circuits _____
   19. Primary Power Requirements _____
   20. Secondary Power Requirements _____

Session V. Total Premises Fire Alarm System Installation Guidelines; Fire Alarm-Related Systems and Installation Guidelines; Troubleshooting

A. Total Premises Fire Alarm System Installation Guidelines _____
   1. Manual Fire Alarm Box (Pull Station) Installation _____
   2. Flame Detector Installation _____
   3. Smoke Chamber Definition, Smoke Spread Phenomena, and Stratification Phenomena _____
   4. General Precautions for Detector Installation _____
   5. Spot Detector Installations on Flat, Smooth Ceilings _____
   6. Photoelectric Beam Smoke Detector Installations on Flat, Smooth Ceilings _____
   7. Spot Detector Installations on Irregular Ceilings _____
   8. Notification Appliance Installation _____
   9. Fire Alarm Control Panel Installation Guidelines _____

B. Fire Alarm-Related Systems and Installation Guidelines _____
   1. Ancillary Control Relay Installation Guidelines _____
   2. Duct Smoke Detectors _____
   3. Elevator Recall _____
   4. Special Door Locking Arrangements _____
   5. Suppression System Supervision _____
   6. Supervision of Suppression Systems _____

C. Troubleshooting _____
   1. Alarm System Troubleshooting Guidelines _____
   2. Addressable System Troubleshooting Guidelines _____

D. Laboratory _____

   Have the trainees practice connecting selected fire alarm systems. This laboratory corresponds to Performance Task 1.

Session VI. Review; Testing

A. Review _____

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

C. Performance Testing _____
   1. Trainees must perform each task to the satisfaction of the instructor to receive recognition from 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 various heat tracing systems along with their applications and installation requirements.

PREREQUISITES

Prior to training with this module, it is recommended that the trainee shall have successfully completed *Core Curriculum; Electrical Level One*; *Electrical Level Two; Electrical Level Three;* and *Electrical Level Four,* Modules 26401-08 through 26408-08.

OBJECTIVES

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

1. Identify and describe the purpose of electric heat tracing equipment used with pipelines and vessels.
2. Select, size, and install electric heat tracing equipment on selected pipelines and vessels in accordance with the manufacturer's instructions and *National Electrical Code®* (*NEC®*) requirements.
3. Identify and describe the purpose of electric heating equipment used with roof, gutter, and downspout de-icing systems.
4. Select, size, and install selected roof, gutter, and downspout de-icing systems in accordance with the manufacturer's instructions and *NEC®* requirements.
5. Identify and describe the purpose of electric heating equipment used with snow-melting and anti-icing systems.
6. Select, size, and install selected snow-melting and anti-icing systems in accordance with the manufacturer's instructions and *NEC®* requirements.
7. Identify and describe the purpose of electric heat tracing equipment used with domestic hot-water temperature maintenance systems.
8. Select, size, and install selected electric heat traced domestic hot-water systems in accordance with the manufacturer's instructions and *NEC®* requirements.
9. Identify and describe the purpose of electric floor heating/warming systems.
10. Select, size, and install selected electric floor heating/warming systems in accordance with the manufacturer's instructions and *NEC®* requirements.

PERFORMANCE TASKS

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

1. Prepare and connect heat tracing cable in a power connection box or splice box.

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
Self-regulating cables
Power-limiting cables
Mineral-insulated cables
Manufacturer's application/design guides
Components used in pipeline heat tracing systems
Components used in roof, gutter, and downspout de-icing systems
Components used in snow-melting and anti-icing systems
Electric heating mats and cables
TV with DVD or VHS player (optional)
Trade Terms Quiz*
Module Examinations**
Performance Profile Sheets**

*Located in the back of this module.

**Located in the Test Booklet.

SAFETY CONSIDERATIONS

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

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.

American Electrician's Handbook, Terrell Croft and Wilfred I. Summers. New York, NY: McGraw-Hill, 1996.

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

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 *Heat Tracing and Freeze Protection.* 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; Pipeline Heat Tracing Applications; Pipeline Electric Heat Tracing Systems; Equipment Selection and Installation for Pipe Heat Tracing Systems

A. Introduction _____
B. Pipeline Heat Tracing Applications _____
C. Pipeline Electric Heat Tracing Systems _____
   1. Heat Tracing System Power Distribution _____
   2. Heat Tracing System Cables _____
   3. Heat Tracing System Control _____
   4. Heat Tracing System Monitoring _____
   5. Typical Heat Tracing System Operation _____
D. Equipment Selection and Installation for Pipe Heat Tracing Systems _____
   1. Installation Guidelines _____

Session II. Roof, Gutter, and Downspout De-Icing Systems; Component Selection and Installation for Roof, Gutter, and Downspout De-Icing Systems; Snow-Melting and Anti-Icing Systems; Component Selection and Installation for Snow-Melting and Anti-Icing Systems

A. Roof, Gutter, and Downspout De-Icing Systems _____
B. Component Selection and Installation for Roof, Gutter, and Downspout De-Icing Systems _____
   1. Installation Guidelines _____
C. Snow-Melting and Anti-Icing Systems _____
D. Component Selection and Installation for Snow-Melting and Anti-Icing Systems _____
   1. Installation Guidelines _____

Session III. Domestic Hot-Water Temperature Maintenance Systems; Component Selection and Installation for Domestic Hot-Water Temperature Maintenance Systems; Floor Heating and Warming Systems; Component Selection and Installation for Floor Heating Systems

A. Domestic Hot-Water Temperature Maintenance Systems _____

B. Component Selection and Installation for Domestic Hot-Water Temperature Maintenance Systems _____

   1. Installation _____
   2. *NEC*® Requirements _____

C. Floor Heating and Warming Systems _____

D. Component Selection and Installation for Floor Heating Systems _____

   1. *NEC*® Requirements _____

E. Laboratory _____

   Have the trainees practice preparing and connecting heat tracing cable in a power connection box or splice box. This laboratory corresponds to Performance Task 1.

Session IV. Review; Testing

A. Review _____

B. Module Examination _____

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

C. Performance Testing _____

   1. Trainees must perform each task to the satisfaction of the instructor to receive recognition from 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.

Standby and Emergency Systems
Annotated Instructor's Guide

Module 40401-09

MODULE OVERVIEW

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

PREREQUISITES

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

OBJECTIVES

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

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

PERFORMANCE TASKS

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

MATERIALS AND EQUIPMENT LIST

Overhead projector and screen

Transparencies

Blank acetate sheets

Transparency pens

Whiteboard/chalkboard

Markers/chalk

Pencils and scratch paper

Appropriate personal protective equipment

Engine-driven AC generator

Transfer switches

Storage batteries

Tools to perform resistance and capacity checks on batteries

Module Examinations*

* Located in the Test Booklet

SAFETY CONSIDERATIONS

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

ADDITIONAL RESOURCES

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

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

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

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

TEACHING TIME FOR THIS MODULE

An outline for use in developing your lesson plan is presented below. Note that each Roman numeral in the outline equates to one session of instruction. Each session has a suggested time period of 2½ hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 12½ hours are suggested to cover *Standby and Emergency Systems*. You will need to adjust the time required for hands-on activity and testing based on your class size and resources.

Topic	**Planned Time**
Session I. Introduction; Emergency and Standby Power System Components	
A. Introduction	_____
B. Emergency and Standby Power System Components	_____
1. Engine-Driven Generator Sets	_____
2. Transfer Switches	_____
3. Automatic Sequential Paralleling Emergency/Standby System	_____
Session II. Storage Batteries; Static Uninterruptible Power Supply	
A. Storage Batteries	_____
1. Lead-Acid Batteries	_____
2. Nickel Cadmium Batteries	_____
3. Battery Maintenance	_____
4. Battery and Battery Charger Operation	_____
B. Static Uninterruptible Power Supply	_____
1. Double-Conversion UPS Systems	_____
2. Single-Conversion UPS Systems	_____
Session III. *NEC*® Requirements for Emergency Systems	
A. *NEC*® Requirements for Emergency Systems	_____
1. Legally Required Standby Systems	_____
2. Sources of Power	_____
Session IV. Emergency System Circuits for Light and Power	
A. Emergency System Circuits for Light and Power	_____
1. Health Care Facilities	_____
2. Battery-Powered Emergency Lighting	_____
3. Emergency Lighting Units	_____
4. Places of Assembly	_____
Session V. Review and Testing	
A. Module Review	_____
B. Module Examination	_____
1. Trainees must score 70 percent or higher to receive recognition from NCCER.	
2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.	