Instrument Fitter's Math
Annotated Instructor's Guide

Module 12301-03

MODULE OVERVIEW

This module covers the mathematics necessary to complete conduit and tubing installations.

PREREQUISITES

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

Core Curriculum; Instrumentation Levels One and Two.

OBJECTIVES

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

1. Identify a right triangle and the angles in a right triangle.
2. Calculate the unknown side length in a right triangle when the two other side lengths are known.
3. Find the sine, cosine, or tangent in decimal form of any right triangle when side lengths are known, using either longhand math or a standard calculator.
4. Find the length of an unknown side in a right triangle when one other side length and the associated angle are known, using the proper calculator.
5. Find the angle in a right triangle when two associated sides are known, using the proper calculator.
6. Apply fitter's math to tubing and conduit installations.

PERFORMANCE TASKS

There are no performance tasks for this module.

MATERIALS AND EQUIPMENT LIST

Overhead projector and screen
Transparencies
Whiteboard/chalkboard
Markers/chalk
Blank acetate sheets
Transparency pens
Pencils and scratch paper
Appropriate personal protective equipment
Scientific calculator
Various types of benders used to bend copper and stainless steel tubing
Copper tubing
Digital readout angle finder
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 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.

Math to Build on: A Book for Those Who Build. Johnny E. Hamilton and Margaret S. Hamilton. Clinton, NC: Construction Trades Press.

Pipe Fitter's Math. Johnny E. Hamilton. Clinton, NC: Construction Trades Press.

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 *Instrument Fitter's Math*. 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; Angles; Polygons; Triangles	
A. Introduction	_____
B. Angles	_____
C. Polygons	_____
D. Triangles	_____
Session II. Right Triangles	
A. Relationship of Line Segment Lengths to Each Other	_____
B. Ratios of Line Segment Lengths to Angles	_____
C. Using Tables to Convert Sine, Cosine, or Tangent Values to Angles	_____
Session III. Right Triangles, Continued	
A. Using a Scientific Calculator to Convert Sine, Cosine, or Tangent Values to Angles	_____
B. Summary of Trigonometric Functions	_____
Session IV. Applying Fitter's Math to Bending Tubing or Conduit	
A. Determining the Angles When Side Lengths Are Known	_____
Session V Applying Fitter's Math to Bending Tubing or Conduit, Continued	
A. Determining the Length of Travel	_____
Session VI. Applying Fitter's Math to Bending Tubing or Conduit, Continued	
A. Determining the Side Lengths When the Angle Is Known	_____
Session VII. Using the Proper Tubing Benders	
A. Using the Proper Tubing Benders	_____
Session VIII. Review; Module Examination	
A. Review	_____
B. Module Examination	_____
1. Trainees must score 70% or higher to receive recognition from the NCCER.	
2. Record the testing results on Craft Training Report Form 200 and submit the results to the Training Program Sponsor.	

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

Module 12302-03

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

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

Core Curriculum; Instrumentation Levels One and Two; Instrumentation Level Three, Module 12301-03.

OBJECTIVES

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

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 tubing fittings
   - Compression tubing fittings
   - Threaded pipe fittings
   - Pipe flanges

PERFORMANCE TASKS

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

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
Whiteboard/chalkboard
Markers/chalk
Blank acetate sheets
Transparency pens
Pencils and scratch paper
Appropriate personal protective equipment
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
Hand benders
Various hangers and supports
Snubber
Flanges and flange bolts
Torque wrenches
Compression fittings
Flared fittings and flaring tool
Module Examinations*
Performance Profile Sheets*

* Located in the Test Booklet.

SAFETY CONSIDERATIONS

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

Piping and Pipe Support Systems—Design and Engineering. Paul R. Smith P.E. and Thomas J. Van Laan P.E. New York: McGraw-Hill Higher Education.

The Pipe Fitter's and Pipe Welder's Handbook. Thomas W. Frankland. New York: Glencoe McGraw-Hill.

Marks' Standard Handbook for Mechanical Engineers. Eugene A. Avallone and Theodore Baumeister, III. New York: McGraw-Hill Professional.

Piping Handbook. Mohinder L. Nayyar. New York: McGraw-Hill Professional.

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 45 hours are suggested to cover *Layout and Installation of Tubing and Piping 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 to Layout	
A. Introduction	_____
B. Layout	_____
1. Layout Preparation	_____
2. Considerations in the Layout of a Piping System	_____
3. Developing an Isometric Sketch	_____
Session II. Laboratory	
A. 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 III. Measuring and Bending Tubing and Piping	
A. Determine Initial Bend Position and Angle	_____
B. Locate Bend Position on Tubing	_____
C. Pipe and Tube Cutting Tools	_____
D. Selection of Benders	_____
E. Using a Compression Tube Bender	_____
Sessions IV–XI. Laboratory	
A. Laboratory (8 Sessions) – Trainees measure and bend the tubing sections for a loop per an isometric drawing. This laboratory corresponds to Performance Task 2.	_____
Session XII. Supporting Tubing and Piping	
A. Support Spacing	_____
B. Variable Spring Hangers	_____
C. Constant Supports	_____
D. Rigid Hangers and Supports	_____
E. Snubbers	_____
F. Supporting Tubing	_____
Session XIII. Laboratory	
A. Laboratory – Trainees identify the types and locations of support devices required for an example tubing installation. This laboratory corresponds to Performance Task 3.	_____
Session XIV. Supporting Tubing and Piping, Continued	
A. Flanged Connections	_____
B. Compression Tubing Fittings	_____
Session XV. Laboratory	
A. Laboratory – Trainees install compression fittings on tubing. This laboratory corresponds to Performance Task 4.	_____

Session XVI. Supporting Tubing and Piping, Continued

A. Flared Connectors _____

Session XVII. Review; Module Examination

A. Review _____

B. Module Examination _____

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

Session XVIII. Performance Testing

A. Performance Testing _____

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

Clean, Purge, and Test Tubing and Piping Systems Annotated Instructor's Guide

Module 12303-03

MODULE OVERVIEW

This module covers the equipment and procedures used to clean and purge piping and tubing systems. It also reviews general procedures for performing pressure leak testing.

PREREQUISITES

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

Core Curriculum; Instrumentation Levels One and Two; Instrumentation Level Three, Modules 12301-03 and 12302-03.

OBJECTIVES

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

1. Identify cleaning, flushing, and purging procedures.
2. Describe the general cleaning and purging requirements for piping and tubing.
3. Perform the appropriate cleaning and flushing methods until required cleanliness has been achieved.
4. Describe and select pressure and leak testing methods for piping/tubing systems.
5. Identify precautions associated with testing piping/tubing systems.
6. Perform pressure leak tests per approved procedures.
7. Prepare required test documentation.

PERFORMANCE TASKS

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

1. Set up and perform a pressure leak test.
2. Inspect the system to verify there is no leakage.
3. Document the test results.

MATERIALS AND EQUIPMENT LIST

Overhead projector and screen
Transparencies
Whiteboard/chalkboard
Markers/chalk
Blank acetate sheets
Transparency pens
Pencils and scratch paper
Appropriate personal protective equipment
Basic hand tools
Bubbler leak tester
Snoop®
Portable air-driven pump
Air hose and fittings
Clear plastic hose
Low-pressure air supply
Demineralized water supply
Hydrostatic test pump
Module Examinations*
Performance Profile Sheets*

* Located in the Test Booklet.

SAFETY CONSIDERATIONS

Ensure that the trainees are equipped with appropriate personal protective equipment. Emphasize the safety precautions required when working with pressurized systems.

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.

CFR (Code of Federal Regulations) 29 Subparts H and Z, Hazardous and Toxic Substances.

Machinery Component Maintenance and Repair, Second Edition, Gulf Publishing Co., 1990.

ASTM/ANSI B31.1: Power Piping.

ASTM/ANSI B31.3: Process Piping.

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 *Clean, Purge, and Test Tubing and Piping 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; Cleaning and Purging

A. Introduction _____

B. Cleaning and Purging _____

1. General Cleaning Requirements for Tubing and Piping _____
2. Cleaning, Flushing, and Purging Methods _____
3. Applicable Records and Documentation _____

Session II. Pressure and Leak Testing

A. ANSI, ASME, and ISO 9000 Standards for Piping Systems/Tubing Systems _____

B. Selection Criteria for Testing Methods _____

C. Description of Testing Methods _____

D. Testing Precautions _____

E. General Test Procedures _____

F. Testing Documentation _____

Session III. Laboratory

A. Laboratory – Trainees perform the following tasks:

- Set up and perform a pressure leak test. _____
- Inspect the system to verify there is no leakage. _____
- Document the test results. _____

This laboratory corresponds to Performance Tasks 1, 2, and 3.

Session IV. Review; Module Examination; Performance Testing

A. Review _____

B. Module Examination _____

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

C. Performance Testing _____

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

Receive, Inspect, Handle, and Store Instrumentation
Annotated Instructor's Guide

Module 12304-03

MODULE OVERVIEW

This module discusses standard procedures for receiving, storing, inspecting, and handling instruments.

PREREQUISITES

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

Core Curriculum; Instrumentation Levels One and Two; Instrumentation Level Three, Modules 12301-03 through 12303-03.

OBJECTIVES

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

1. Inspect a carton or container for physical damage.
2. Identify special handling requirements for a carton or container.
3. Describe the safety requirements for lifting.
4. Inspect received items for damage and complete required paperwork.
5. Compare received instrumentation to instrument data sheet specifications.
6. Describe considerations for storage of instruments or components.

PERFORMANCE TASKS

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

1. Inspect a carton or container for damage.
2. Inspect a received item for physical damage and compliance to purchase order.
3. Select the proper level of storage required for a received item.

MATERIALS AND EQUIPMENT LIST

Overhead projector and screen
Transparencies
Whiteboard/chalkboard
Markers/chalk
Blank acetate sheets
Transparency pens
Pencils and scratch paper
Appropriate personal protective equipment
Damaged cartons and containers
Various instruments for inspection
Module Examinations*
Performance Profile Sheets*

* Located in the Test Booklet.

SAFETY CONSIDERATIONS

Ensure that the trainees are equipped with appropriate personal protective equipment. Emphasize the importance of following proper lifting procedures.

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.

Marks' Standard Handbook for Mechanical Engineers. Eugene A. Avallone and Theodore Baumeister, III. New York: McGraw-Hill Professional.

Standard Handbook of Plant Engineering. Robert Rosaler. New York: McGraw Hill Professional.

Instrument Maintenance Manager's Sourcebook. Joseph Patton. Research Triangle Park, NC: Instrument Society of America.

TEACHING TIME FOR THIS MODULE

An outline for use in developing your lesson plan is presented below. Approximately 2½ hours are suggested to cover *Receive, Inspect, Handle, and Store Instrumentation*. This includes 10 minutes at the beginning of the session for administrative tasks and one 10-minute break. You may need to adjust the time required for hands-on activities 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. Receive, Inspect, Handle, and Store Instrumentation; Review; Module Examination and Performance Testing	
A. Introduction	_____
B. Instrument Tag Number	_____
C. Inspection of a Carton or Container for Physical Damage	_____
1. Laboratory – Supply the trainees with damaged cartons and containers. Have them use Transparency 3 (Figure 1) to identify the types of damage. This laboratory corresponds to Performance Task 1.	_____
D. Special Handling Instructions for Cartons or Containers	_____
E. Safety Requirements for Lifting	_____
F. Inspection of the Received Item for Damage	_____
1. Laboratory – Supply the trainees with damaged instrumentation. Have them use Transparency 4 (Figure 2) to identify the types of damage. This laboratory corresponds to Performance Task 2.	_____
G. Comparison of Received Instrumentation to Instrument Data Sheet Specifications	_____
1. Receiving from Storage	_____
H. Considerations for Storage of Instruments or Components	_____
1. Level A	_____
2. Level B	_____
3. Level C	_____
4. Level D	_____
5. Laboratory – Provide the trainees with a list of materials and equipment and have them determine the level of storage required for each item. This laboratory corresponds to Performance Task 3.	_____
6. Additional Glass Protection Considerations	_____
I. Review	_____

J. Module Examination _____

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

K. Performance Testing _____

1. Trainees must perform each task to the satisfaction of the instructor to receive recognition from the 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 characteristics and terminology associated with various types of circuits. It also discusses the calculations required to determine voltage, current, and resistance.

PREREQUISITES

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

Core Curriculum; Instrumentation Levels One and Two; Instrumentation Level Three, Modules 12301-03 through 12304-03.

OBJECTIVES

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

1. Explain the basic characteristics of series circuits, parallel circuits, and series-parallel circuits.
2. Analyze series, parallel, and series-parallel circuits.
3. Find the total resistance in series, parallel, and series-parallel circuits.
4. Determine the frequency and period for a given AC sine wave.
5. Calculate the peak, effective (rms), and average voltage or current values for an AC sine wave.
6. Describe the voltage and current phase relationship in a resistive AC circuit.
7. Define inductive reactance and state how it is affected by frequency.
8. Define capacitive reactance and state how it is affected by frequency.
9. Explain the terms true power, apparent power, reactive power, and power factor.
10. Explain why a 4–20mA signal is typically transmitted in a loop instead of a 1–5V signal.
11. Describe the characteristics of a digital signal.
12. Calculate the unknown resistance value in a resistance temperature detector (RTD) bridge circuit.

PERFORMANCE TASKS

There are no Performance Tasks for this module.

MATERIALS AND EQUIPMENT LIST

Overhead projector and screen
Transparencies
Whiteboard/chalkboard
Markers/chalk
Blank acetate sheets
Transparency pens
Pencils and scratch paper
Appropriate personal protective equipment
Scientific 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 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 Electricians' Handbook. New York, NY: McGraw-Hill.

Electronics Fundamentals. Thomas L. Floyd. New York, NY: Prentice Hall.

Introduction to Electric Circuits. Richard C. Dorf and James A. Sroboda. New York, NY: Prentice Hall.

Principles of Electric Circuits. Thomas L. Floyd. New York, NY: Prentice Hall.

TEACHING TIME FOR THIS MODULE

An outline for use in developing your lesson plan is presented below. Note that each Roman numeral in the outline equates to one session of instruction. Each session has a suggested time period of 2½ hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 25 hours are suggested to cover *Instrumentation Electrical Circuitry*. 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; Resistive Circuits	
A. Introduction	_____
B. Resistive Circuits	_____
1. Resistances in Series	_____
2. Resistances in Parallel	_____
3. Series-Parallel Circuits	_____
Session II. Applying Ohm's Law	
A. Applying Ohm's Law in Series Circuits	_____
B. Applying Ohm's Law in Parallel Circuits	_____
C. Applying Ohm's Law in Series-Parallel Circuits	_____
Session III. Kirchoff's Laws	
A. Kirchoff's Current Law	_____
B. Kirchoff's Voltage Law	_____
C. Loop Equations	_____
Session IV. Introduction to Alternating Current	
A. Sine Wave Generation	_____
B. Sine Wave Terminology	_____
Session V. AC Phase Relationships; Resistance in AC Circuits	
A. AC Phase Relationships	_____
B. Resistance in AC Circuits	_____
Session VI. Inductance in AC Circuits; Capacitance	
A. Inductance in AC Circuits	_____
B. Capacitance	_____
1. Calculating Equivalent Capacitance	_____
2. Voltage Rating	_____
3. Leak Resistance	_____
4. Capacitive Reactance	_____

Session VII. Power in AC Circuits; Electronic Instrumentation Signals

A. Power in AC Circuits _____

B. Electronic Instrumentation Signals _____

1. Analog Signals (4–20mA and 1–5V) _____
2. Digital Signals _____

Session VIII. Introduction to PLCs

A. Discrete Input/Output _____

B. Analog Input/Output _____

Session IX. Applications of Instrumentation Circuitry

A. Temperature (RTD Bridge) _____

B. Pressure (Strain Gauge Bridge) _____

C. Remote Level Indication _____

Session X. Review; Module Examination

A. Review _____

B. Module Examination _____

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

Grounding and Shielding of Instrumentation Wiring
Annotated Instructor's Guide

Module 12306-03

MODULE OVERVIEW

This module provides an overview of the grounding requirements for electrical systems. It also discusses the methods used to identify and minimize electrical noise in instrumentation systems.

PREREQUISITES

Please refer to the Course Map in the Trainee Module. Prior to training with this module, it is recommended that the trainee shall have successfully completed the following: Core Curriculum; Instrumentation Levels One and Two; Instrumentation Level Three, Modules 12301-03 through 12305-03.

OBJECTIVES

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

1. Define electrical system grounding.
2. List the reasons electrical systems are grounded.
3. Describe methods used to ground electrical systems.
4. Define noise in instrumentation systems.
5. Describe types of noise in instrumentation systems.
6. Identify sources of noise in instrumentation systems.
7. Apply shielding methods to reduce noise.

PERFORMANCE TASKS

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

1. Identify and explain the function of an equipment ground in a given drawing.
2. Draw an example of a ground loop.
3. Identify and explain the function of an equipment shield in a given drawing.

MATERIALS AND EQUIPMENT LIST

Overhead projector and screen
Transparencies
Whiteboard/chalkboard
Markers/chalk
Blank acetate sheets
Transparency pens
Latest edition of the *National Electrical Code®*
Pencils and scratch paper
Sample drawings
Appropriate personal protective 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 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.

Grounding and Shielding in Instrumentation. Ralph Morrison. New York: John Wiley & Sons.

Grounding and Shielding in Facilities. Ralph Morrison. New York: John Wiley & Sons.

National Electrical Code®, 2002. 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 10 hours are suggested to cover *Grounding and Shielding of Instrumentation Wiring*. 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; Overview of Electrical System Grounding	
A. Introduction	_____
B. Overview of Electrical System Grounding	_____
1. Grounding System Terminology	_____
2. General NEC Grounding Requirements	_____
3. System and Equipment Grounding	_____
4. Laboratory – Trainees identify and explain the function of an equipment ground in a given drawing. This laboratory corresponds to Performance Task 1.	
Session II. Direct Current Power; Noise/Electromagnetic Interference	
A. Direct Current Power	_____
1. DC Power Supplies	_____
B. Noise/Electromagnetic Interference	_____
1. Capacitive-Coupled Noise	_____
2. Inductive-Coupled Noise	_____
3. Directly Coupled Noise	_____
Session III. Cable Shielding and Grounding Techniques Used to Minimize EMI; Practical Instrument Shielding	
A. Cable Shielding and Grounding Techniques Used to Minimize EMI	_____
1. Cable Shields	_____
2. Preventing Ground Loops	_____
3. Laboratory – Trainees draw an example of a ground loop. This laboratory corresponds to Performance Task 2.	
4. Shield Termination	_____
5. Use of Multiple Shields	_____
6. Signal Cable Types	_____

B. Practical Instrument Shielding _____

1. Reducing Noise by Shielding _____
2. Laboratory – Trainees identify and explain the function of an equipment shield in a given drawing. This laboratory corresponds to Performance Task 3. _____
3. Installing Twisted Pair Shielded Wire _____

Session IV. Review; Module Examination; Performance Testing

A. Review _____

B. Module Examination _____

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

C. Performance Testing _____

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

Terminating Conductors
Annotated Instructor's Guide

Module 12307-03

MODULE OVERVIEW

This module covers various types of cables and their applications. It also discusses the equipment and procedures used to terminate these conductors as well as procedures for inspecting splices and terminations.

PREREQUISITES

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

Core Curriculum; Instrumentation Levels One and Two; Instrumentation Level Three, Modules 12301-03 through 12306-03.

OBJECTIVES

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

1. Identify types of low-voltage and fiber-optic cable.
2. Install and terminate various types of crimp connectors.
3. Terminate shielded cable to provide maximum EMI protection.
4. Install and terminate coaxial cable connectors.
5. Describe fiber-optic splices and terminations.
6. Perform continuity checks on cable installations.
7. Explain causes of cable failure.

PERFORMANCE TASKS

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

1. Physically distinguish between various types of cable, including:
   - Twisted pair
   - Non-twisted pair
   - Coaxial
   - Fiber optic
2. Install and terminate crimp connectors.
3. Terminate shielded cable.
4. Install a coaxial connector onto coaxial cable.
5. Ring out a cable using phones.
6. Inspect a cable for defects and identify the classifications of defects found, if any.

MATERIALS AND EQUIPMENT LIST

Overhead projector and screen
Transparencies
Whiteboard/chalkboard
Markers/chalk
Blank acetate sheets
Transparency pens
Pencils and scratch paper
Latest Edition of the *National Electrical Code®*
Appropriate personal protective equipment
Various types of cable and patch cords
Punch down blocks
Wire strippers
Wire cutters
Various cable connectors and associated tools
Terminal blocks
Multimeter
Telephone test set
Low-voltage power source
Defective cable for examination
Module Examinations*
Performance Profile Sheets*

* Located in the Test Booklet.

SAFETY CONSIDERATIONS

Ensure that the trainees are equipped with appropriate personal protective equipment. Emphasize the safety precautions required when using test 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.

LAN and Internetworking Design Manual. Tampa, FL: BICSI, www.bicsi.org.

Mike's Basic Guide to Cabling. Mike Gorman. Highland Park, CO: Prairie Wind Communications.

Telecommunications Cabling Installation Manual. Tampa, FL: BICSI, www.bicsi.org.

Telecommunications Distribution Methods Manual. Tampa, FL: BICSI, www.bicsi.org.

TAI/EIA Telecommunications Building Wiring Standards, Latest Edition. Englewood, CO: Global Engineering Documents.

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 *Terminating Conductors*. 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; Types of Low-Voltage and Optical Fiber Cables	
A. Introduction	_____
B. Types of Low-Voltage and Optical Fiber Cables	_____
1. NEC Classifications and Ratings	_____
2. PTLC, Fire Alarm, and Class 2/3 Cable Styles and Construction	_____
3. Communication Cable Styles and Construction	_____
4. Laboratory – Trainees identify various types of cable. This laboratory corresponds to Performance Task 1.	_____
Session II. Electromagnetic Interference; Working with Fiber Optics	
A. Electromagnetic Interference	_____
1. EMI Guidelines	_____
B. Working with Fiber Optics	_____
1. Installation	_____
Session III. Low-Voltage Connectors and Terminals	
A. Crimp Connectors for Screw Terminals	_____
B. Coaxial Cable, Video, and Audio Connectors	_____
Session IV. Low-Voltage Cable/Conductor Termination Procedures	
A. Termination of Conductors/Cables to Solderless Connectors	_____
B. Laboratory – Under your supervision, have the trainees install and terminate crimp connectors. This laboratory corresponds to Performance Task 2.	_____
C. Termination of Coaxial or Shielded Cable	_____
D. Laboratory – Trainees terminate coaxial and shielded cable. This laboratory corresponds to Performance Tasks 3 and 4.	_____
E. Terminating Fiber-Optic Cable	_____

Session V. Testing and Troubleshooting

A. Test Equipment _____
B. Test Parameters _____
C. Troubleshooting _____
D. Laboratory – Trainees ring out conductors using a telephone test set. This laboratory corresponds to Performance Task 5. _____

Session VI. Fiber-Optic Testing

A. Optical Power Tests _____
B. Fiber Loss Measurements _____
C. Insertion Loss Tests _____

Session VII. Cable Failures and Their Analysis

A. Mechanical Failures _____
B. Sheath Corrosion _____
C. Surges _____
D. Electrical Puncture _____
E. Inherent Causes (Workmanship) _____
F. Non-Intrinsic Causes (Environmental) _____
G. Laboratory – Trainees inspect a cable for defects and identify the classifications of defects found, if any. This laboratory corresponds to Performance Task 6. _____

Session VIII. Review; Module Examination; Performance Testing

A. Review _____
B. Module Examination _____
   1. Trainees must score 70% or higher to receive recognition from the NCCER.
   2. Record the testing results on Craft Training Report Form 200 and submit the results to the Training Program Sponsor.
C. Performance Testing _____
   1. Trainees must perform each task to the satisfaction of the instructor to receive recognition from the NCCER. 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.

Protective Measures for Instrumentation
Annotated Instructor's Guide

Module 12308-03

MODULE OVERVIEW

This module covers the heat tracing methods, chemicals, and insulation used to maintain process fluids at the desired temperature and protect piping from freezing and bursting. It also discusses the procedure for system blowdown.

PREREQUISITES

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

Core Curriculum; Instrumentation Levels One and Two; Instrumentation Level Three, Modules 12301-03 through 12307-03.

OBJECTIVES

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

1. Identify applications that require heat tracing.
2. Describe the elements of a heat tracing system, including:
   - Power distribution
   - Cables
   - Controls
   - Monitoring
3. Install heat tracing systems.
4. Explain steam tracing.
5. Describe types of chemical protection, their purposes, and specific applications.
6. Identify and install types of piping and device insulation.
7. Perform blowdown on instrument air and signal lines.

PERFORMANCE TASKS

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

1. Install electric heat tracing on a short section of piping.
2. Install electric heat tracing on a control valve.
3. Install a section of steam tracing according to a set of specifications provided.
4. Install an insulation blanket on a control valve.
5. Install insulation blankets on a section of piping.
6. Perform blowdown on a transmitter, following specific sequences to open and close the manifold valve to protect the instrument.

MATERIALS AND EQUIPMENT LIST

Overhead projector and screen
Transparencies
Whiteboard/chalkboard
Markers/chalk
Blank acetate sheets
Transparency pens
Pencils and scratch paper
Appropriate personal protective equipment
Sample job specifications
Piping and valve mock-up
Wrench set
Multimeter
Steam heat tracing material
Electrical heat tracing material and thermostats
Wire, clips, and/or fiberglass tape for attaching heat tracers and insulation
Winterization chemicals and test kits
Piping mockup for the addition of chemicals
Mixing container for winterization chemicals
Various insulating blankets
Operating system with manifold valve for blowdown
Module Examinations*
Performance Profile Sheets*

* Located in the Test Booklet.

SAFETY CONSIDERATIONS

Ensure that the trainees are equipped with appropriate personal protective equipment. Stress the importance of fall protection when installing heat tracing on overhead lines. Also emphasize the special safety precautions necessary when blowing down instrument lines.

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.

LAN and Internetworking Design Manual. Tampa, FL: BICSI, www.bicsi.org.

Mike's Basic Guide to Cabling. Mike Gorman. Highland Park, CO: Prairie Wind Communications.

Piping Handbook. Mohinder L. Nayyar. New York: McGraw-Hill Professional.

Standard Handbook of Plant Engineering. Robert Rosaler. New York: McGraw Hill Professional.

Telecommunications Cabling Installation Manual. Tampa, FL: BICSI, www.bicsi.org.

Telecommunications Distribution Methods Manual. Tampa, FL: BICSI, www.bicsi.org.

TAI/EIA Telecommunications Building Wiring Standards, Latest Edition. Englewood, CO: Global Engineering Documents.

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 *Protective Measures for Instrumentation*. 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 Heat Tracing	
A. Introduction	_____
B. Electrical Heat Tracing	_____
1. Pipeline Heat Tracing Applications	_____
2. Heat Tracing System Power Distribution	_____
3. Heat Tracing System Cables	_____
4. Heat Tracing System Control	_____
5. Heat Tracing System Monitoring	_____
6. Typical Heat Tracing System Operation	_____
7. Installation Guidelines	_____
8. Laboratory – Trainees install electric heat tracing on piping and associated system components. This laboratory corresponds to Performance Tasks 1 and 2.	_____
Session II. Steam Heat Tracing	
A. Jacket and Externally Mounted Convection Steam Tracing Systems	_____
B. Conduction Tracing Using Heat Transfer Compound	_____
C. Steam Tracing Today	_____
D. Accessories for Modern Steam Tracing Systems	_____
E. Laboratory – Trainees install a section of steam tracing according to a set of specifications provided. This laboratory corresponds to Performance Task 3.	_____
Session III. Chemical Protection	
A. Burst Protection Versus Freeze Protection	_____
B. Preparing a System for Chemical Addition	_____
C. Addition of Chemicals	_____
D. Maintaining Chemical Concentration	_____
Session IV. Insulation	
A. Types of Insulation	_____
C. Identifying Lines and Devices Requiring Insulation from Drawings	_____
D. Insulation Installation Precautions	_____
E. Thermal Insulation Used with Heat Tracing Systems	_____
F. Laboratory – Trainees install insulation blankets on piping and other system components. This laboratory corresponds to Performance Tasks 4 and 5.	_____
Session V. Miscellaneous Protection	
A. Pigtail Pressure Gauge Siphons	_____
B. Dampeners or Snubbers	_____
C. Chemical Seals	_____

Session VI. Blowdown of Instrument Air Lines

A. Systems Requiring Moisture Removal _____

B. Blowing Down Instrument Air Lines _____

Session VII. Blowdown of Instrument Signal Lines

A. Blowing Down Instrument Signal Lines _____

B. Laboratory – Trainees perform a blowdown on a transmitter. This laboratory corresponds to Performance Task 6.

Session VIII. Review; Module Examination; Performance Testing

A. Review _____

B. Module Examination _____

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

C. Performance Testing _____

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