Module One (12110-15) reviews the characteristics of four key process variables: temperature, pressure, level, and flow. It describes the basic features and principles of operation of various instruments that are used to measure these variables. It also explains how to work with mathematical formulas that are associated with temperature, pressure, level, and flow measurement.

Objectives

Learning Objective 1
- Describe the process of measuring temperature.
  a. Identify various units of measure for temperature.
  b. Describe instruments and methods used to measure temperature.

Learning Objective 2
- Describe the process of measuring pressure.
  a. Identify various units of measure for pressure.
  b. Describe instruments and methods used to measure pressure.
  c. Describe conditions that can damage pressure-measuring instruments and the devices used to protect the instruments from these conditions.

Learning Objective 3
- Describe the process of measuring levels.
  a. Describe instruments and methods used to measure levels directly.
  b. Describe instruments and methods used to measure levels indirectly.
  c. Explain how levels can be determined based on pressure.
  d. Describe instruments and methods used to measure levels based on pressure.

Learning Objective 4
- Describe the process of measuring flow.
  a. Identify various units of measure for flow.
  b. Explain how friction and other flow characteristics affect flow rates.
  c. Describe instruments and methods used to measure flow rates through differential pressure.
  d. Describe instruments and methods used to measure flow rates by means other than differential pressure.

Performance Task

Performance Task 1
(Learning Objectives 1, 2, 3, and 4)
- Identify specific measurement devices, state the variable that each device measures, and describe the principles of operation for each selected device.

Teaching Time: 15 hours
(Six 2.5-Hour Sessions)
Session time may be adjusted to accommodate your class size, schedule, and teaching style.

Prerequisites
Core Curriculum; Instrumentation Level One.

Before You Begin
As you prepare for each session, allow sufficient time to review the course objectives, content, visual aids (including the PowerPoint® presentation), and these lesson plans, and to gather the required equipment and materials. Consider time required for demonstrations, laboratories, field trips, and testing.

Using your access code, download the Module Examinations and Performance Profile Sheets from www.nccerirc.com. The passing score for submission into NCCER’s Registry is 70% or above for the written examination; performance testing is graded pass or fail.
**Safety Considerations**

This module may require trainees to work in the vicinity of functioning equipment. Electrical and mechanical safety must be emphasized at all times. Trainees should be carefully observed to ensure that they wear the proper PPE, follow safe practices, and give due respect to the hazards of energized and operating systems. Any work performed on or in the vicinity of functioning equipment must be completed under the direct supervision of the instructor.

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**Classroom Equipment and Materials**

- Whiteboard and markers
- Pencils and paper
- *Instrumentation Level Two*
- PowerPoint® Presentation Slides
- DVD player
- LCD projector and screen
- Computer
- Internet access during class (optional)
- Review Questions answer key
- Copies of the Module Examination and Performance Profile Sheets
- One or more types of thermocouples
- A complete temperature-measuring assembly of thermocouple, thermowell, and junction block
- One or more examples of RTDs
- One or more examples of thermistors
- A handheld IR pyrometer
- Various types of manometers
- A liquid-filled pressure gauge
- One or more styles of pressure gauge isolators
- One or more styles of snubbers
- Various direct level measuring instruments, such as sight glasses and displacers
- Various indirect level measuring instruments, such as magnetic float, capacitance-based, and radar units
- Various types of differential-pressure based flow measuring instruments, such as orifice plates, flow nozzles, and pitot tubes
- Various other types of flow measuring instruments, such as turbine flowmeters and coriolis flowmeters

**Equipment and Materials for Laboratories and Performance Testing**

- Photographs and/or line drawings of instruments from this module, manufacturer catalogs, and similar sources
- Actual instruments that are available for the instructor to tag and lay out on a table in a shop or classroom setting
- Instruments that are installed in a plant where instructors are able to escort the trainees through to conduct the session
- Instructor-prepared handout with blanks corresponding to numbers identifying each instrument that is selected for the Performance Task

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


There are a number of on-line resources available for trainees who would like more information on devices for measuring temperature, pressure, level, and flow. A search for additional information may be assigned as homework to interested trainees.

Instructors should view any videos that may be identified in the lesson plan to ensure their suitability before using them. The videos can provide teachable moments in both proper and improper work processes and behaviors. Be prepared to stop the videos at appropriate times to point out and discuss both proper and improper conduct and techniques.

Instructors are also encouraged to locate additional audiovisual aids available on the internet, make personal videos, and take still pictures related to the subject matter and add them to the PowerPoint® presentations throughout the program.
Session Outline for 12110-15

TEMPERATURE, PRESSURE, LEVEL, AND FLOW

The Lesson Plan for this module is divided into six 2.5-hour sessions. This time includes 10 minutes for administrative tasks and a 10-minute break per session.

SESSION ONE

Session One describes units, instruments, and methods used in the process of measuring temperature. This session covers all of Section 1.0.0.

1. Show the Session One PowerPoint® presentation.
2. Use the Kickoff Activity to encourage trainees to consider the importance of accurately measuring temperature in various types of process applications.
3. Explain what thermal equilibrium is and how it is used in measuring temperature.
4. Describe the four scales for measuring temperature.
5. Explain how to convert from one temperature scale to another.
6. Describe the features and principles of operation for the following temperature-measuring devices: bimetallic thermometers, thermocouples, resistance temperature detectors (RTDs), thermistors, and infrared (IR) pyrometers.

SESSION TWO

Session Two describes units, instruments, and methods used in the process of measuring pressure. This session covers all of Section 2.0.0.

1. Show the Session Two PowerPoint® presentation.
2. Use the Kickoff Activity to encourage trainees to consider the factor of pressure and the need to measure this process variable accurately.
3. Explain what pressure is and how it is expressed mathematically.
4. Describe how force, weight, and area are used to determine pressure.
5. Identify common units of measurement for pressure.
6. Define absolute pressure, gauge pressure, and atmospheric pressure.
7. Explain how to convert from one type of pressure measurement unit to another.
8. Explain what differential pressure is and how it is calculated.
9. Describe the features and principles of operation for the following pressure-measuring devices: manometers, bellows-type pressure sensors, Bourdon tubes, and diaphragms.
10. Describe three conditions that can damage pressure-measuring instruments and identify devices that are used to protect the instruments from these conditions.
Session Three describes units, instruments, and methods used in the process of measuring levels. This session covers all of Section 3.0.0.

1. Show the Session Three PowerPoint® presentation.

2. Use the Kickoff Activity to encourage trainees to think about why a variety of different types of level-measuring devices are used in process systems.

3. Explain what level is and the basic ways of measuring level.

4. Describe the features and principles of operation for the following devices that measure level directly: dipsticks and lead lines, sight glasses, float-cable arrangements, and displacers.

5. Describe the features and principles of operation for the following devices that measure level indirectly: magnetic float system, conductance devices, capacitance devices, ultrasonic level measurement systems, guided wave radar (GWR) detectors, and non-contact radar detectors.

6. Describe how measurements of head pressure and specific gravity are used to determine level.

7. Explain how to use formulas to calculate the height of a volume of water and determine the level of liquids at atmospheric pressure.

8. Explain how to use formulas to calculate the height of a volume of liquid other than water and determine the level of the liquid at atmospheric pressure.

9. Describe the features and principles of operation for the following devices that measure level based on pressure: hydrostatic head devices and bubbler systems.

Session Four describes units, instruments, and methods used in the process of measuring flow. This session covers all of Section 4.0.0.

1. Show the Session Four PowerPoint® presentation.

2. Use the Kickoff Activity to encourage trainees to consider how flow measurement differs from simply detecting the presence of flow.

3. Define flow and describe the three basic types of fluid flow.

4. Talk about how flow-measuring instruments are normally mounted and the additional devices that are commonly used to protect the instruments from conditions in the process that is being measured.

5. Identify common units of measurement for flow and explain how flow is described in terms of velocity, volume, and mass.

6. Explain how to use the formula for calculating volumetric flow rate.

7. Explain how to use the formula for calculating mass flow rate.

8. Talk about the differences between volumetric flow rate and mass flow rate.

9. Describe the relationship between differential pressure and flow and explain how to use the mathematical formula that expresses this relationship.

10. Describe the features and principles of operation for the following devices that use differential pressure to measure flow: orifice plates, flow nozzles, venturi tubes, and pitot tubes.

11. Describe the features and principles of operation for the following flow-measuring devices: target flowmeters, electromagnetic flowmeters, turbine flowmeters, vortex flowmeters, variable area flowmeters (rotameters), and coriolis meters.
**SESSION FIVE**

Session Five is a laboratory devoted to Performance Task 1.

1. Note that there is no PowerPoint® presentation associated with this session.
2. Demonstrate identifying a specific measurement device, stating the variable that the device measures and describing its principles of operation.
3. Have trainees practice and/or complete the tasks associated with Performance Task 1.

**SESSION SIX**

Session Six is a review and testing session. Have trainees complete the module Review Questions. Alternatively, this may be assigned as homework at the end of Session Five. Go over the answers to the Review Questions in class prior to the exam and answer any questions that the trainees may have.

1. Have trainees complete the written examination. Any outstanding performance testing must be completed during this session as well.
2. Record the testing results on the Registration of Training Modules form, and submit the report to your Training Program Sponsor.
## Equipment and Materials

<table>
<thead>
<tr>
<th>Equipment and Materials</th>
<th>One or more types of thermocouples</th>
<th>A complete temperature-measuring assembly of thermocouple, thermowell, and junction block</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal protective equipment: None</td>
<td>One or more examples of RTDs</td>
<td>One or more examples of thermistors</td>
</tr>
<tr>
<td>Whiteboard and markers</td>
<td>A handheld IR pyrometer</td>
<td>Various types of manometers</td>
</tr>
<tr>
<td>Pencils and paper</td>
<td>A liquid-filled pressure gauge</td>
<td>One or more styles of pressure gauge isolators</td>
</tr>
<tr>
<td>Instrumentation Level Two PowerPoint® Presentation Slides</td>
<td>One or more styles of snubbers</td>
<td>Various direct level measuring instruments, such as sight glasses and displacers</td>
</tr>
<tr>
<td>DVD player</td>
<td>Various indirect level measuring instruments, such as magnetic float, capacitance-based, and radar units</td>
<td>Various types of differential-pressure based flow measuring instruments, such as orifice plates, flow nozzles, and pitot tubes</td>
</tr>
<tr>
<td>Computer</td>
<td>Various other types of flow measuring instruments, such as turbine flowmeters and coriolis flowmeters</td>
<td>Photographs and/or line drawings of instruments from this module, manufacturer catalogs, and similar sources</td>
</tr>
<tr>
<td>Internet access during class (optional)</td>
<td>Actual instruments that are available for the instructor to tag and lay out on a table in a shop or classroom setting</td>
<td>Instruments that are installed in a plant where instructors are able to escort the trainees through to conduct the session</td>
</tr>
<tr>
<td>Review Questions answer key</td>
<td>Instructor-prepared handout with blanks corresponding to numbers identifying each instrument that is selected for the Performance Task</td>
<td></td>
</tr>
<tr>
<td>Copies of the Module Examination and Performance Profile Sheets</td>
<td></td>
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</tr>
</tbody>
</table>

To the extent possible, and as required for performance testing, provide a selection of the tools listed for each session; alternatively, photos may be used to teach tool identification.
Module Two (12301-15) presents the basics of geometry, algebra, and trigonometry that are applied in what is known in the instrumentation environment as fitter’s math. The module focuses on how instrument fitters can use fitter’s math to make accurate, efficient offsets in tubing installations even when complex combinations of several back-to-back bends are required.

<table>
<thead>
<tr>
<th>Objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning Objective 1</td>
</tr>
<tr>
<td>• Identify and describe various types of angles, polygons, and triangles.</td>
</tr>
<tr>
<td>a. Identify and describe line segments and various types of angles.</td>
</tr>
<tr>
<td>b. Identify and describe various regular and irregular polygons.</td>
</tr>
<tr>
<td>c. Identify and describe various types of triangles.</td>
</tr>
<tr>
<td>Learning Objective 2</td>
</tr>
<tr>
<td>• Explain how to determine characteristics of right triangles using algebraic functions.</td>
</tr>
<tr>
<td>a. Identify right triangles and explain how to use the Pythagorean theorem.</td>
</tr>
<tr>
<td>b. Describe and determine the mathematical ratio between line segments in right triangles.</td>
</tr>
<tr>
<td>Learning Objective 3</td>
</tr>
<tr>
<td>• Explain how to determine characteristics of right triangles using trigonometric functions.</td>
</tr>
<tr>
<td>a. Define the sine, cosine, and tangent of an angle and their relationships to each other.</td>
</tr>
<tr>
<td>b. Explain how to use tables and calculators to determine the sine, cosine, and tangent of an angle.</td>
</tr>
<tr>
<td>Learning Objective 4</td>
</tr>
<tr>
<td>• Explain how to apply fitter’s math to bending tubing.</td>
</tr>
<tr>
<td>a. Explain how to determine an angle when the line segment lengths are known.</td>
</tr>
<tr>
<td>b. Determine the length of travel of a piping offset.</td>
</tr>
<tr>
<td>c. Explain how to determine line segment lengths when the angle is known.</td>
</tr>
</tbody>
</table>

| Performance Tasks |
| This is a knowledge-based module; there are no Performance Tasks. |

Teaching Time: 12.5 hours  
(Five 2.5-Hour Sessions)
Session time may be adjusted to accommodate your class size, schedule, and teaching style.

Prerequisites
Core Curriculum; Instrumentation Level One.

Before You Begin
As you prepare for each session, allow sufficient time to review the course objectives, content, visual aids, and these lesson plans, and to gather the required equipment and materials. Consider time required for demonstrations, laboratories, field trips, and testing.

Using your access code, download the Module Examinations from www.nccerirc.com. The passing score for submission into NCCER’s Registry is 70% or above for the written examination.
**Safety Considerations**
This module will likely be taught exclusively in the classroom environment. However, instructors may teach or demonstrate portions of it in the shop or in the vicinity of functioning equipment. Electrical and mechanical safety must be emphasized at all times. Trainees should be carefully observed to ensure that they wear the proper PPE, follow safe practices, and give due respect to the hazards of energized and operating systems. Any work performed on functioning equipment must be completed under the direct supervision of the instructor.

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**Classroom Equipment and Materials**

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whiteboard</td>
<td>Multiple 10” to 12” (25 to 30 cm)</td>
</tr>
<tr>
<td>Markers</td>
<td>Lengths of solid wire or soft copper tubing</td>
</tr>
<tr>
<td>Pencils and paper</td>
<td>Multiple 4.25” x 5.5” (11 cm x 14 cm) paper rectangles for drawing and folding exercise</td>
</tr>
<tr>
<td><em>Instrumentation Level Two</em> PowerPoint presentation</td>
<td>Multiple 4.25” (11 cm) paper squares for folding exercise</td>
</tr>
<tr>
<td>DVD player or a computer with a DVD drive</td>
<td>Multiple 4” (10 cm) paper circles for folding exercise</td>
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<td>LCD projector and screen</td>
<td>48-inch (1.2 m) length of solid wire or soft copper tubing</td>
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<tr>
<td>Computer with Internet access</td>
<td>Straight edges or rulers</td>
</tr>
<tr>
<td>Review Questions answer key</td>
<td>Scientific calculators</td>
</tr>
<tr>
<td>Copies of the Module Examination</td>
<td>Measuring tapes</td>
</tr>
<tr>
<td>Multiple copies of a paper template for at least two offset bends in a tubing installation (optional exercise)</td>
<td></td>
</tr>
</tbody>
</table>

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


There are a number of on-line resources available for trainees who would like more information on instrument fitter’s math specifically, or the more general fields of geometry, algebra, and trigonometry. Math resources of all types, including video, handouts, and practice problems, are readily accessible. A search for additional information may be assigned as homework to interested trainees.

Instructors should view any videos that may be identified in the lesson plan to ensure their suitability before using them. The videos can provide teachable moments in both proper and improper work processes and behaviors. Be prepared to stop the videos at appropriate times to point out and discuss both proper and improper conduct and techniques.

Instructors are also encouraged to locate additional audiovisual aids available on the Internet, make personal videos, and take still pictures related to the subject matter and add them to the PowerPoint® presentations throughout the program.
Session Outline for 12301-15

INSTRUMENT FITTER’S MATH

The Lesson Plan for this module is divided into five 2.5-hour sessions. This time includes 10 minutes for administrative tasks and a 10-minute break per session.

**Session One**

Session One reviews basic geometric terminology and concepts that relate to the instrument fitter trade. This session covers all of Section 1.0.0.

1. Show the Session One PowerPoint® presentation.

2. Use the Kickoff Activity to introduce trainees to the range of mathematical concepts that are employed in fitter’s math.

3. Review the standards that fitters must meet when installing tubing, and identify the types of mathematics that fitters use.

4. Review the characteristics of a circle; explain how angles are formed; and talk about how instrument fitters use the relationships between the degrees of interior angles and the lengths of line segments.

5. Review the various types of polygons and describe the formula for finding the sum of the interior angles of a polygon.

6. Review the various types of triangles and explain why instrument fitters need to understand the relationships between the sides and the angles of right triangles.

**Session Two**

Session Two explains how to apply the rules of algebra to manipulate the Pythagorean theorem. It also describes how fitters make use of the ratios between the line segments of right triangles. This session covers all of Section 2.0.0.

1. Show the Session Two PowerPoint® presentation.

2. Use the Kickoff Activity to introduce the prevalence and importance of right triangles in instrument fitter’s math.

3. Review the characteristics of right triangles and the conventions for identifying their different line segments.

4. Describe the Pythagorean theorem and the formula that is used to express this theorem as an equation.

5. Review how to apply basic rules of algebra to solve the equation for the Pythagorean theorem for any one of the three line segments of a right triangle.

6. Describe the steps for using a scientific calculator, including the use of the square root and square keys, to solve the equation for the Pythagorean theorem.

7. Explain how a rectangle or a square can be divided into two right triangles.

8. Review the bulleted list of key points about right triangles.

9. Describe the ratios between the line segments of a right triangle and explain how the ratios relate to each other. Identify the various ways to express a ratio.

10. Describe how the sizes of angles in right triangles are affected by changes in the lengths of the line segments.

11. Use peer instruction to review practice problems from Section 2.1.1.
**Session Outline for 12301-15**

**INSTRUMENT FITTER’S MATH**

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**SESSION THREE**

Session Three introduces the basic trigonometric functions of sine, cosine, and tangent and explains how these functions are used in fitter’s math. It also describes how to use tables and scientific calculators to determine the sine, cosine, and tangent of an angle. This session covers all of Section 3.0.0.

1. Show the Session Three PowerPoint® presentation.
2. Use the Kickoff Activity to introduce trigonometry as the subject that will be covered in this session.
3. Explain what trigonometry is and how fitters can use it when bending and routing tubing.
4. Explain what the sine, cosine, and tangent of an angle are and how to calculate these functions. Describe the relationships between the sine and cosine of an angle.
5. Explain how to find the sine, cosine, and tangent of the two complementary angles of a right triangle.
6. Summarize the key points that have been made about trigonometric functions and describe how fitters can make use of these functions when bending tubing.
7. Talk about using conversion tables or scientific calculators as aids for determining sines, cosines, and tangents.
8. Describe how to use a scientific calculator to convert sine, cosine, or tangent values to angles.
9. Use peer instruction to review practice problems from Section 3.1.0.

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**SESSION FOUR**

Session Four describes how to apply fitter’s math to make offset bends in tubing installations.

1. Show the Session Four PowerPoint® presentation. This session covers all of Section 4.0.0.
2. Use the Kickoff Activity to generate a discussion about why it is important for fitters to be able to use fitter’s math.
3. Explain why one of the most frequent uses of fitter’s math is for making offset bends.
4. Describe offset angles for pipe and tubing.
5. Explain how sine, cosine, and tangent ratios can be applied to calculate the required angle for an offset bend.
6. Review the steps for using a scientific calculator to determine the degrees for angle T in the example provided.
7. Explain how to mark the location of the first bend on the tubing. Stress the importance of always following the “measure, mark, bend” order when making bends in tubing.
8. Define length of travel and explain how it is determined.
9. Introduce an example of determining length of travel based on the measurement of an angle.
10. Describe the basic procedure for determining side lengths when the angle and only one of the side lengths is known.
11. Describe the steps for one method of installing tubing in an example installation.
SESSION FIVE

Session Five is a review and testing session. Have trainees complete the module Review Questions. Alternatively, this may be assigned as homework at the end of Session Four. Go over the Review Questions answers in class prior to the exam and answer any questions that the trainees may have.

1. Have trainees complete the module examination.

2. Record the testing results on the Registration of Training Modules form, and submit the report to your Training Program Sponsor.
# Materials Checklist for Module 12301-15, Instrument Fitter’s Math

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<td>Scientific calculators</td>
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<td>Whiteboard/chalkboard</td>
<td>Measuring tapes</td>
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<td>Markers/chalk</td>
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<td><strong>Review Questions answer key</strong></td>
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<tr>
<td><strong>Copies of the Module Examination</strong></td>
<td></td>
</tr>
</tbody>
</table>

To the extent possible, and as required for performance testing, provide a selection of the tools listed for each session; alternatively, photos may be used to teach tool identification.
Module Three (12202-15) introduces the range of diagrams and drawings that instrumentation installers and technicians use on the job. It focuses on how to select the appropriate diagram or drawing for a given purpose and how to read and correctly interpret diagrams and drawings.

**Objectives**

**Learning Objective 1**
- Identify and interpret various standardized drawing elements, such as symbols and numbering systems.
  - Identify and interpret various instrumentation drawing components, such as symbols and data sheets.
  - Identify and interpret various electrical symbols.

**Learning Objective 2**
- Identify and interpret various types of electrical drawings.
  - Identify and interpret single- and three-line diagrams.
  - Identify and interpret various types of wiring diagrams.
  - Identify and interpret raceway drawings.

**Learning Objective 3**
- Identify and interpret various types of instrumentation drawings.
  - Identify and interpret piping and instrumentation drawings (P&IDs).
  - Identify and interpret loop sheets.
  - Identify and interpret ladder diagrams.
  - Identify and interpret equipment location and installation detail drawings.
  - Identify and interpret flow drawings.
  - Explain how to apply various drawings in the instrumentation trade environment.

**Performance Tasks**

**Performance Task 1**
(Learning Objectives 1 and 2)
- Trace the circuit flow on a one-line diagram.

**Performance Task 2**
(Learning Objectives 1 and 2)
- Read and interpret an electrical raceway drawing.

**Performance Task 3**
(Learning Objectives 1 and 3)
- Read and interpret a loop sheet.

**Teaching Time: 17.5 hours**
(Seven 2.5-Hour Sessions)

Session time may be adjusted to accommodate your class size, schedule, and teaching style.

**Prerequisites**
*Core Curriculum; Instrumentation Level One.*

**Before You Begin**

As you prepare for each session, allow sufficient time to review the course objectives, content, visual aids including the PowerPoint® presentation, and these lesson plans, and to gather the required equipment and materials. Consider time required for demonstrations, laboratories, field trips, and testing.

Using your access code, download the Module Examinations and performance profile sheets from [www.nccerirc.com](http://www.nccerirc.com). The passing score for submission into NCCER’s Registry is 70% or above for the written examination; performance testing is graded pass or fail.
**Additional Resources**

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


There are a number of on-line resources available for trainees who would like more information on instrumentation drawings and project specifications. A search for additional information may be assigned as homework to interested trainees.

Instructors should view any videos that may be identified in the lesson plan to ensure their suitability before using them. The videos can provide teachable moments in both proper and improper work processes and behaviors. Be prepared to stop the videos at appropriate times to point out and discuss both proper and improper conduct and techniques.

One suggestion is the work of Robert Cook, who has generated a five-part video series in reading instrumentation drawings. The series can be found at the website of CHEnected ([http://chenected.aiche.org/](http://chenected.aiche.org/)), an organization and website dedicated to chemical engineers. At the home page, use the Search feature to find the works of Robert Cook.

Instructors are also encouraged to locate additional audiovisual aids available on the Internet, make personal videos, and take still pictures related to the subject matter and add them to the presentations throughout the program.
Session Outline for 12202-15

**Instrument Drawings and Documents, Part Two**

The Lesson Plan for this module is divided into seven 2.5-hour sessions. This time includes 10 minutes for administrative tasks and a 10-minute break per session.

**Session One**

Session One describes common standardized drawing elements and explains how to interpret them. It covers various instrumentation drawing elements as well as electrical symbols.

1. Show the Session One PowerPoint® presentation.
2. Use the Kickoff Activity to introduce the importance of using standardized symbols and abbreviations on drawings.
3. Explain why many different types of diagrams and drawings are used in the instrumentation trade.
4. Talk about ISA standard formats for instrumentation diagrams.
5. Describe how to use and interpret the following instrumentation drawing elements: symbols, number systems, instrument data sheets, and notes on P&IDs.
6. Describe how to read and interpret electrical symbols and the standardized abbreviations associated with the symbols.

**Session Two**

Session Two explains how to read and interpret various types of electrical drawings.

1. Show the Session Two PowerPoint® presentation.
2. Use the Kickoff Activity to introduce the various electrical diagrams that will be covered in the session.
3. Describe the features and uses of single-, three-line, and block diagrams.
4. Describe internal and external wiring diagrams and the information they provide.
5. Describe the following methods for illustrating wiring connection layouts of systems and explain how each method is used: point-to-point method, cable method, baseline method, and lineless method.
6. Describe schematic diagrams and explain how to read and interpret them.
7. Describe raceway drawings and explain how to read and interpret them.
### Session Three

Session Three begins the discussion of instrumentation drawings. It focuses on P&IDs and loop sheets.

1. Show the Session Three PowerPoint® presentation.
2. Use the Kickoff Activity to engage trainees in thinking about the use of diagrams to obtain information that is specifically associated with system instrumentation.
3. Describe how to read and interpret P&IDs.
4. Explain what loop sheets are and the information they provide.
5. Explain how to interpret the information provided by the five parts of an instrument tag number.
6. Describe the information provided by and the uses of the following sections of a loop sheet: location and connection section, calibration and specification section, and field checklist.

### Session Four

Session Four concludes the discussion of instrumentation drawings. It also examines how instrument installers and technicians can apply diagrams to solve problems on the job.

1. Show the Session Four PowerPoint® presentation.
2. Use the Kickoff Activity to introduce the remaining types of instrumentation diagrams that will be covered in the session.
3. Describe ladder diagrams, the information they contain, how they can be used for troubleshooting, and how they can be used to express ladder logic.
4. Explain what bills of material are and the information they provide.
5. Describe two basic ways of drawing flow diagrams and explain why flow diagrams are typically used in conjunction with P&IDs.
6. Talk about how instrument installers and technicians can use various types of diagrams and drawings to troubleshoot problems on the job.
**SESSIONS FIVE AND SIX**

Sessions Five and Six are devoted to laboratories and Performance Tasks 1, 2, and 3.

1. Note that there is no PowerPoint® presentation associated with these sessions.

2. Demonstrate how to trace the circuit flow on a one-line diagram; how to read and interpret an electrical raceway drawing; and how to read and interpret a loop sheet.

3. Trainees practice and/or complete the tasks associated with Performance Tasks 1, 2, and 3 in two practical sessions.

**SESSION SEVEN**

Session Seven is a review and testing session. Have trainees complete the module Review Questions. Alternatively, these may be assigned as homework at the end of Session Six. Go over the answers to the Review Questions in class prior to the exam and answer any questions that the trainees may have.

1. Have trainees complete the written examination. Any outstanding performance testing must be completed during this session as well.

2. Record the testing results on the Registration of Training Modules form, and submit the report to your Training Program Sponsor.
<table>
<thead>
<tr>
<th>Equipment and Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Personal protective equipment:</strong></td>
</tr>
<tr>
<td>None</td>
</tr>
<tr>
<td>Whiteboard/chalkboard</td>
</tr>
<tr>
<td>Markers/chalk</td>
</tr>
<tr>
<td>Pencils and paper</td>
</tr>
<tr>
<td><em>Instrumentation Level Two</em></td>
</tr>
<tr>
<td><em>PowerPoint® Presentation</em></td>
</tr>
<tr>
<td><em>Slides</em></td>
</tr>
<tr>
<td>DVD player</td>
</tr>
<tr>
<td>LCD projector and screen</td>
</tr>
<tr>
<td>Computer with Internet access</td>
</tr>
<tr>
<td>Review Questions answer key</td>
</tr>
<tr>
<td>Copies of the Module Examination and Performance Profile sheets</td>
</tr>
<tr>
<td>One or more examples of a flow diagram incorporated into a P&amp;ID</td>
</tr>
</tbody>
</table>

To the extent possible, and as required for performance testing, provide a selection of the tools listed for each session; alternatively, photos may be used to teach tool identification.
Module Overview
This module describes the selection, inspection, use, and maintenance of the analog and digital meters used in the installation and checkout of electronic systems.

Prerequisites
Prior to training with this module, it is recommended that the trainee shall have successfully completed Core Curriculum; Instrumentation Level One.

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

1. Describe and explain the operation of the following pieces of test equipment:
   - Ammeter
   - Voltmeter
   - Ohmmeter
   - Multimeter
   - Continuity tester
   - Voltage tester
   - Electrical outlet tester
2. Explain the operation and use of specialized test equipment used in the checkout and troubleshooting of electronic equipment, cables, and cabling systems.
3. Select the correct item of test equipment to be used in specific situations.
4. Describe how to measure and generate various waveforms.
5. Set up and use selected cable testers to check out cables and evaluate the performance of copper and optical fiber cable.

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

1. Measure AC/DC voltage, current, and resistance using a multimeter.
2. Set up and use selected cable testers to check out cables and evaluate the performance of copper and optical fiber cable.

Materials and Equipment
- Markers/chalk
- Whiteboard/chalkboard
- Pencils and scratch paper
- Instrumentation Level Two PowerPoint® Presentation Slides can be downloaded (with your access code) from www.nccerirc.com
- Multimedia projector and screen
- Computer
- Appropriate personal protective equipment
- Grounding strap
- Power supplies, circuit boards, or equipment used as a source of test voltages and currents
- Signal or function generator, or other source of test waveforms
- Batteries
- Resistors
- Components and wire to connect basic test circuits
- Assortment of cables for test purposes
- Various test instruments and their operation manuals, including:
  - Ammeter
  - Voltmeter
  - Ohmmeter
  - Multimeter (analog and digital)
  - Continuity tester
  - Voltage tester
  - Oscilloscope

(continued)
Safety Considerations

Ensure that the trainees are equipped with appropriate personal protective equipment and know how to use it properly. This module requires the trainees to test electronic circuits with various electrical instruments. Ensure that trainees are briefed on basic electrical safety and shop safety policies. Review safety guidelines for all test instruments used, especially the megohmmeter.

Additional Resources

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


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

<table>
<thead>
<tr>
<th>Topic</th>
<th>Planned Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Session I. Introduction; Types of Meters</td>
<td></td>
</tr>
<tr>
<td>A. Introduction</td>
<td></td>
</tr>
<tr>
<td>B. Meters</td>
<td></td>
</tr>
<tr>
<td>C. Ammeters</td>
<td></td>
</tr>
<tr>
<td>D. Voltmeters</td>
<td></td>
</tr>
<tr>
<td>E. Ohmmeters</td>
<td></td>
</tr>
<tr>
<td>F. Multimeters</td>
<td></td>
</tr>
<tr>
<td>G. Digital Meters</td>
<td></td>
</tr>
<tr>
<td>H. PT/Laboratory</td>
<td></td>
</tr>
</tbody>
</table>

Have trainees measure AC/DC voltage, current, and resistance using a multimeter. This laboratory corresponds with Performance Task 1.
Session II. Continuity and Voltage Testers; Oscilloscopes

A. Continuity Testers
B. Voltage Testers
C. Oscilloscopes

Session III. Wattmeters; Meggers; Line, Cable, and Signal Meters

A. Wattmeters
B. Megohmmeters (Meggers)
C. Line Frequency Meters
D. Power Factor Meters
E. Recording Instruments
F. Lineman’s Test Set
G. Cable Toners
H. Cable Certification Testers
I. Sound Pressure Level Meters
J. RF Power Meters
K. Signal Level Meters
L. Time-Domain Reflectometers
M. Spectrum Analyzers
N. Signal Generators
O. Category Ratings
P. Testing and Troubleshooting
Q. Safety
R. PT/Laboratory
   Have trainees set up and use selected cable testing equipment to check out cables and evaluate the performance of copper and optical fiber links. This laboratory corresponds with Performance Task 2.

Session IV. Review and Testing

A. Module Review
B. Module Examination
   1. Trainees must score 70 percent or higher to receive recognition from NCCER.
   2. Record the testing results on the Registration of Training Modules form, 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 the Registration of Training Modules form, and submit the results to the Training Program Sponsor.
Module Five (12212-15) introduces the trainees to the methods and procedures needed to construct reliable instrument panels. Trainees will receive an overview of the symbols, tools, and procedures involved in panel layout and construction. They will also learn how to develop and apply a template, cut mounting holes in the panel, and install the instrument.

Objectives

Learning Objective 1
• Describe the factors to consider and tools required to lay out an instrument panel.
  a. Identify factors related to instrument panel planning and layout.
  b. Identify and describe tools used to lay out and fabricate an instrument panel.

Learning Objective 2
• Describe the instrument panel layout process.
  a. Describe an instrument panel template and how to prepare it for the layout process.
  b. Explain how to apply a template and lay out an instrument panel.

Performance Tasks

Performance Task 1
(Learning Objectives 1 and 2)
• Lay out an instrument panel.

Performance Task 2
(Learning Objectives 1 and 2)
• Install an instrument in a panel.

Teaching Time: 10 hours
(Four 2.5-Hour Sessions)
Session time may be adjusted to accommodate your class size, schedule, and teaching style.

Prerequisites
Core Curriculum; Instrumentation Level One.

Before You Begin
As you prepare for each session, allow sufficient time to review the course objectives, content, visual aids, including the PowerPoint® presentation, and these lesson plans, and to gather the required equipment and materials. Consider the time required for demonstrations, laboratories, field trips, and testing.

Using your access code, download the Module Examinations and Performance Profile Sheets from www.nccerirc.com. The passing score for submission into NCCER’s Registry is 70% or above for the written examination; performance testing is graded pass or fail.
**Safety Considerations**
This module requires that trainees work with power tools and electrically energized equipment. Safety must be emphasized at all times. Trainees should be carefully observed to ensure that they wear the proper PPE, follow safe practices, and give due respect to unseen hazards related to the installation of panel-mounted instruments. Any deficiencies must be corrected to ensure future trainee safety. All practice sessions and Performance Tasks must be completed under your direct supervision.

**Classroom Equipment and Materials**
- Whiteboard
- Markers
- Pencils and paper

**Equipment and Materials for Laboratories and Performance Testing**
- Appropriate personal protective equipment:
  - Safety glasses
  - Work gloves
  - Proper footwear as designated by the instructor or training facility provider
  - Hearing protection as designated by the instructor or training facility provider
  - Hard hat as designated by the instructor or training facility provider
- Drill and bits
- Saber saws
- Power shears
- Nibblers and/or cutters
- Knockout punch set
- Hole saw set
- Tape measure or steel rules

**Classroom Equipment and Materials**
- Whiteboard
- Markers
- Pencils and paper

**Instrumentation Level Two**
- PowerPoint® Presentation
- DVD player or a computer with a DVD drive
- LCD projector and screen
- Computer with Internet access
- Review Questions answer key
- Copies of the Module Examination and Performance Profile Sheets

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


Instructors are also encouraged to locate additional audiovisual aids available on the Internet, make personal videos, and take still pictures related to the subject matter and add them to the PowerPoint® presentations throughout the program.
Session One

Session One introduces trainees to basic panel layout and fabrication. Instruction covers layout guidelines, instrument symbols, appropriate tools, and the use of templates. Trainees learn how to transfer the template to the panel, cut instrument openings, and install the instrument. This session covers Sections 1.0.0 through 2.2.0.

1. Show the Session One PowerPoint® presentation.
2. Use the Kickoff Activity to get trainees engaged and give them an idea of what they will learn from this module.
3. Review panel layout considerations, safety, and instrument symbols.
4. Discuss appropriate tools for laying out and fabricating instrument panels.
5. Introduce template preparation and transferring the layout to the panel.
6. Overview making the panel cutout and installing the instrument.

Session Four

Session Four is a review and testing session. Have the trainees complete the module Review Questions. Alternatively, these may be assigned as homework at the end of Session Three. Go over the answers to the Review Questions in class prior to the exam and answer any questions that the trainees may have.

1. Have trainees complete the written examination. Any outstanding performance testing must be completed during this session as well.
2. Record the testing results on the Registration of Training Modules form, and submit the report to your Training Program Sponsor.

Sessions Two and Three

Sessions Two and Three are laboratory sessions that provide an opportunity to practice and/or complete the Performance Tasks associated with panel-mounted instrument installation.

1. Note that no PowerPoint® presentation is associated with these laboratory sessions.
2. Demonstrate how to properly complete a layout using various layout tools and templates.
3. Demonstrate how to properly and safely make the panel cutout and install the instrument.
4. Trainees practice and/or complete the requirements of Performance Tasks 1 and 2.
<table>
<thead>
<tr>
<th>Equipment and Materials</th>
<th>Drill and bits</th>
<th>Hole saw set</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Personal protective equipment:</strong></td>
<td>Safety glasses</td>
<td>Common hand tools</td>
</tr>
<tr>
<td><strong>Work gloves</strong></td>
<td>Work gloves</td>
<td>Straightedges</td>
</tr>
<tr>
<td><strong>Proper footwear as designated by the instructor or training facility provider</strong></td>
<td>Proper footwear as designated by the instructor or training facility provider</td>
<td>P&amp;ID related to panel-mounted instruments</td>
</tr>
<tr>
<td><strong>Hearing protection as designated by the instructor or training facility provider</strong></td>
<td>Hearing protection as designated by the instructor or training facility provider</td>
<td>Scrap metal plate 1/16” to 1/8” (2 to 3 mm) thick, mild steel</td>
</tr>
<tr>
<td><strong>Hard hat as designated by the instructor or training facility provider</strong></td>
<td>Hard hat as designated by the instructor or training facility provider</td>
<td>Power shears</td>
</tr>
<tr>
<td>Whiteboard/chalkboard</td>
<td>Whiteboard/chalkboard</td>
<td>Nibblers and/or cutters</td>
</tr>
<tr>
<td>Markers/chalk</td>
<td>Markers/chalk</td>
<td>Knockout punch set</td>
</tr>
<tr>
<td>Pencils and paper</td>
<td>Pencils and paper</td>
<td>Dividers and/or trammel points</td>
</tr>
<tr>
<td>Instrumentation Level Two PowerPoint® Presentation Slides</td>
<td>Instrumentation Level Two PowerPoint® Presentation Slides</td>
<td>Toolmaker’s hammers</td>
</tr>
<tr>
<td>DVD player or computer with a DVD drive</td>
<td>DVD player or computer with a DVD drive</td>
<td>LCD projector and screen</td>
</tr>
<tr>
<td>Computer with Internet access</td>
<td>Computer with Internet access</td>
<td>Review Questions answer key</td>
</tr>
<tr>
<td>Copies of the Module Examination and Performance Profile Sheets</td>
<td>Copies of the Module Examination and Performance Profile Sheets</td>
<td></td>
</tr>
</tbody>
</table>

To the extent possible, and as required for performance testing, provide a selection of the tools listed for each session; alternatively, photos may be used to teach tool identification.
Module Six (12213-15) covers installation equipment and guidelines associated with field-mounted instruments. It explains how to fabricate instrument stands and mount an instrument to the stand. The basic operating principles of various field-mounted instruments are discussed. The module describes how to mount in-line, vessel-mounted, surface-mounted, and inserted instruments. Finally, it examines manifold valve assemblies and the various types of flanges used with field instruments.

**Objectives**

**Learning Objective 1**
- Explain how to fabricate instrument stands and install the intended instrument.
  a. Identify various stand mounting approaches.
  b. Explain how to fabricate an instrument stand.
  c. Describe how to secure an instrument stand to concrete floors or metal grating.
  d. Explain how to mount an instrument to a stand.

**Learning Objective 2**
- Explain how to install various types of in-line instruments.
  a. Explain how to mount differential-pressure flowmeters.
  b. Explain how to mount velocity flowmeters.
  c. Explain how to mount volumetric flowmeters.
  d. Explain how to mount mass flowmeters.
  e. Explain how to mount variable-area flowmeters.
  f. Explain how to mount density meters.

**Learning Objective 3**
- Explain how to install various types of vessel-mounted instruments.
  a. Explain how to mount probe-type level instruments.
  b. Explain how to mount displacer-type level instruments.
  c. Explain how to install strap-mounted instruments.
  d. Describe the mounting of radiation meters for level and density measurement.

**Learning Objective 4**
- Explain how to install surface-mounted and inserted instruments.
  a. Identify and describe the installation of surface-mounted temperature sensors.
  b. Identify and describe the installation of thermowells and connector heads.
  c. Identify and describe the installation of resistance temperature detectors (RTDs) and extension wiring.

**Learning Objective 5**
- Identify and describe manifold valve assemblies and various types of flanges.
  a. Identify various types of manifold valve assemblies.
  b. Identify and describe the common types of seats in manifold assemblies.
  c. Describe how to install a manifold valve assembly.
  d. Describe common flange types and their characteristics.

**Performance Tasks**

**Performance Task 1 (Learning Objective 2)**
- Using a P&ID, properly orient an orifice plate between two pipe flanges and identify the direction of flow.

**Performance Task 2 (Learning Objective 4)**
- Assemble and install a thermocouple in a thermowell into a section of process piping.

**Performance Task 3 (Learning Objective 5)**
- Match the appropriate manifold to a differential-pressure device and make the necessary piping connections.

**Performance Task 4 (Learning Objective 5)**
- Identify selected pipe flange facings.

**Teaching Time: 25 hours**
(Ten 2.5-Hour Sessions)
Session time may be adjusted to accommodate your class size, schedule, and teaching style.

**Prerequisites**
*Core Curriculum; Instrumentation Level One.*
Before You Begin
As you prepare for each session, allow sufficient time to review the course objectives, content, visual aids, including the PowerPoint® presentation, and these lesson plans, and to gather the required equipment and materials. Consider time required for demonstrations, laboratories, field trips, and testing.

Using your access code, download the Module Examinations and Performance Profile Sheets from www.nccerirc.com. The passing score for submission into NCCER’s Registry is 70% or above for the written examination; performance testing is graded pass or fail.

Safety Considerations
This module requires trainees to work with electrically energized equipment and various types of field-mounted instruments and associated hardware. Trainees should be carefully observed to ensure that they wear the proper PPE, follow safe practices, and give due respect to any hazards that may be present. Any deficiencies must be corrected to ensure future trainee safety. All practice exercises and Performance Tasks must be done under the direct supervision of the instructor.

Classroom Equipment and Materials

| Whiteboard | Oval-gear flowmeter |
| Markers | Nutating-disc flowmeter |
| Pencils and paper | Coriolis flowmeter |
| Instrumentation Level Two | Rotameter |
| PowerPoint® Presentation | Hydrometer |
| DVD player or a computer with a DVD drive | Capacitance probe |
| LCD projector and screen | Line-sensing thermostat |
| Computer with Internet access | Thermowell assembly (including pipe nipples, threaded unions, and a standard connection head) |
| Review Questions answer key | Industrial RTD |
| Copies of the Module | Thermocouple extension wire |
| Examination and Performance Profile Sheets | Single-valve manifold |
| Prefabricated floor-mounted pipe stand | Two-valve manifold |
| Prefabricated wall-mounted pipe stand | Three-valve equalizing manifold |
| One or more wedge anchors | Five-valve equalizing manifold |
| One or more sleeve-type anchors | Five-valve blowdown manifold |
| One or more orifice plates | Futbol |
| Flow nozzle | Rod-out tool |
| Venturi tube | Hard valve seats |
| Turbine flowmeter | Soft valve seats |
| Vortex flowmeter | Raised-face flange |
| Magnetic flowmeter | Male-and-female flange |
| Ultrasonic flowmeter | Flat-face flange |
| Rotary-vane flowmeter | Tongue-and-groove flange |

Equipment and Materials for Laboratories and Performance Testing

Appropriate personal protective equipment:
- Safety glasses
- Work gloves
- Proper footwear as designated by the instructor or training facility provider
- Hearing protection as designated by the instructor or training facility provider
- Hard hat as designated by the instructor or training facility provider

A P&ID showing an orifice plate installed in a process pipe
Orifice plates
Pipe flanges
Thermocouple and thermowell assembly components
Section of process piping
Appropriate manifold
Differential-pressure device
Selection of pipe flange facings
Specific tools necessary to install an orifice plate between two flanges, assemble and install a thermocouple in a thermowell assembly into a section of process piping, and match an appropriate manifold to a differential-pressure device and make the necessary piping connections.
Additional Resources
This module presents thorough resources for task training. The following resource material is suggested for further study.


www.dwyer-inst.com
www.marlinmfg.com
www.omega.com
www.pipingtech.com

There are a number of on-line resources available for trainees who would like more information on the installation of field-mounted instruments. A search for additional information may be assigned as homework to interested trainees.

Instructors should view any videos that may be identified in the lesson plan to ensure their suitability before using them. The videos can provide teachable moments in both proper and improper work processes and behaviors. Be prepared to stop the videos at appropriate times to point out and discuss both proper and improper conduct and techniques.

Instructors are also encouraged to locate additional audiovisual aids available on the Internet, make personal videos, and take still pictures related to the subject matter and add them to the PowerPoint® presentations throughout the program.
Session Outline for 12213-15

INSTALLING FIELD-MOUNTED INSTRUMENTS

The Lesson Plan for this module is divided into ten 2.5-hour sessions. This time includes 10 minutes for administrative tasks and a 10-minute break per session.

SESSION ONE

Session One describes the importance of properly mounting field instruments and explains how most field instruments are mounted on pipe stands. It describes different stand-mounting techniques and explains how to fabricate a typical two-instrument floor stand. Floor-mounting techniques are addressed, as well as how to mount the instrument on the stand. This session covers Sections 1.0.0 through 1.4.0.

1. Show the Session One PowerPoint® presentation.

2. Use the Kickoff Activity to introduce the subjects that will be covered in this module and stimulate trainee interest in the material to be covered.

3. Describe the common types of instrument pipe stands that are used for instrument mounting.

4. Examine the tools, materials, and procedures needed to fabricate a typical two-instrument floor stand.

5. Describe how to secure an instrument stand to concrete flooring and metal grating flooring.

6. Examine various ways to mount an instrument to an instrument stand.

SESSION TWO

Session Two describes the basic operation and the proper way to mount two common types of in-line instruments: differential-pressure flowmeters and velocity flowmeters. This session covers Sections 2.0.0 through 2.2.4.

1. Show the Session Two PowerPoint® presentation.

2. Use the Kickoff Activity to provide a visual sense of how differential-pressure flowmeters measure flow.

3. Identify common types of differential-pressure flowmeters, describe their basic operation, and examine how they are mounted.

4. Identify common types of velocity flowmeters, describe their basic operation, and examine how they are mounted.

SESSION THREE

Session Three describes the basic operation and proper way to mount common volumetric, mass, and variable-area flowmeters. Density meter operation and mounting are also covered. This session covers Sections 2.3.0 through 2.6.3.

1. Show the Session Three PowerPoint® presentation.

2. Use the Kickoff Activity to provide a visual sense of how Coriolis effect flowmeters operate.

3. Identify common types of volumetric flowmeters. Describe their basic operation, and examine how they are mounted.

4. Identify common types of mass flowmeters, describe their basic operation, and examine how they are mounted.

5. Identify common types of variable-area flowmeters, describe their basic operation, and examine how they are mounted.

6. Identify common types of density meters, describe their basic operation, and examine how they are mounted.
**Session Outline for 12213-15**

**Installing Field-Mounted Instruments**

---

### Session Four

Session Four describes the basic operation and the proper way to install various types of vessel-mounted instruments. This session covers Sections 3.0.0 through 3.4.0.

1. Show the Session Four PowerPoint® presentation.
2. Use the Kickoff Activity to encourage trainees to think about the possible ways that the liquid level in a tank can be measured.
3. Describe how probe-type instruments work and are mounted.
4. Describe how displacer-type level instruments work and are mounted.
5. Describe how strap-mounted instruments are installed.
6. Describe how radiation meters used for level and density measurement work and are mounted.

### Session Six

Session Six examines various types of manifold valves, valve seats, and flanges. This session covers Sections 5.0.0 through 5.4.3.

1. Show the Session Six PowerPoint® presentation.
2. Use the Kickoff Activity to help trainees see the reasons for manifold valves in instrumentation settings.
3. Identify various types of manifold valve assemblies.
4. Identify and describe the common types of seats in manifold assemblies.
5. Describe how to install a manifold valve assembly.
6. Describe common flange types and their characteristics.

### Sessions Seven Through Nine

Sessions Seven through Nine are laboratory sessions devoted to the practice and completion of Performance Tasks 1 through 4.

1. Note that no PowerPoint® presentations are associated with these laboratory sessions.
2. Demonstrate how to use a P&ID to properly orient an orifice plate between two pipe flanges and identify the direction of flow.
3. Demonstrate how to assemble and install a thermocouple in a thermowell into a section of process piping.
4. Demonstrate how to match the appropriate manifold to a differential-pressure device and make the necessary piping connections.
5. Demonstrate how to identify selected pipe flange facings.
6. Trainees practice and/or complete the tasks associated with Performance Tasks 1, 2, 3, and 4 in these hands-on sessions.
Session Ten is a review and testing session. Have trainees complete the module Review Questions. Alternatively, these may be assigned as homework at the end of Session Nine. Go over the answers to the Review Questions in class prior to the exam and answer any questions that the trainees may have.

1. Have trainees complete the written examination. Any outstanding performance testing must be completed during this session as well.

2. Record the testing results on the Registration of Training Modules form, and submit the report to your Training Program Sponsor.
<table>
<thead>
<tr>
<th>Equipment and Materials</th>
<th>Vortex flowmeter</th>
<th>Magnetic flowmeter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal protective equipment:</td>
<td>Safety glasses</td>
<td>Ultrasonic flowmeter</td>
</tr>
<tr>
<td></td>
<td>Work gloves</td>
<td>Magnetic flowmeter</td>
</tr>
<tr>
<td></td>
<td>Proper footwear</td>
<td>Capacitance probe</td>
</tr>
<tr>
<td></td>
<td>Hearing protection</td>
<td>Raised-face flange</td>
</tr>
<tr>
<td></td>
<td>Hard hat</td>
<td>Hard valve seats</td>
</tr>
<tr>
<td></td>
<td>Whiteboard/chalkboard</td>
<td>Hydrometer</td>
</tr>
<tr>
<td></td>
<td>Markers/chalk</td>
<td>Five-valve blowdown manifold</td>
</tr>
<tr>
<td></td>
<td>Pencils and paper</td>
<td>Industrial RTD</td>
</tr>
<tr>
<td></td>
<td>Instrumentation Level Two</td>
<td>Tongue-and-groove flange</td>
</tr>
<tr>
<td></td>
<td>PowerPoint® Presentation Slides</td>
<td>P&amp;ID showing an orifice plate installed in a process pipe</td>
</tr>
<tr>
<td></td>
<td>DVD player or computer with DVD drive</td>
<td>Five-valve equalizing manifold</td>
</tr>
<tr>
<td></td>
<td>Computer with Internet access</td>
<td>Coriolis flowmeter</td>
</tr>
<tr>
<td></td>
<td>Review Question answer key</td>
<td>Rotameter</td>
</tr>
<tr>
<td></td>
<td>Copies of Module Examination and Performance Profile Sheets</td>
<td>Selection of pipe flange facings</td>
</tr>
<tr>
<td></td>
<td>A prefabricated floor-mounted pipe stand</td>
<td>Single-valve manifold</td>
</tr>
<tr>
<td></td>
<td>A prefabricated wall-mounted pipe stand</td>
<td>Two-valve manifold</td>
</tr>
<tr>
<td></td>
<td>One or more wedge anchors</td>
<td>Line-sensing thermostat</td>
</tr>
<tr>
<td></td>
<td>One or more sleeve-type anchors</td>
<td>Soft valve seats</td>
</tr>
<tr>
<td></td>
<td>One or more orifice plates</td>
<td>Male-and-female flange</td>
</tr>
<tr>
<td></td>
<td>Flow nozzle</td>
<td>Flat-face flange</td>
</tr>
<tr>
<td></td>
<td>Venturi tube</td>
<td>Turbine flowmeter</td>
</tr>
</tbody>
</table>

| Specific tools needed to install an orifice plate between two flanges |
| Specific tools needed to assemble and install a thermocouple in a thermowell assembly into a section of process piping |
| Specific tools needed to match an appropriate manifold to a differential-pressure device and make the necessary piping connections |

To the extent possible, and as required for performance testing, provide a selection of the tools listed for each session; alternatively, photos may be used to teach tool identification.
Module Seven (12214-15) introduces methods and procedures related to raceway systems and fittings in the instrumentation environment. It provides an overview of various types of conduit, fittings, and supports. The basic steps for cutting, deburring, threading, and joining conduit are also reviewed, and trainees practice simple conduit threading and assembly skills.

Objectives

Learning Objective 1
- Identify various types of conduit, fittings, and supports used in the instrumentation trade.
  a. Identify various types of metal conduit and their related fittings.
  b. Identify various types of nonmetallic conduit and their related fittings.
  c. Identify various types of conduit support hardware.

Learning Objective 2
- Explain how to prepare and assemble various types of conduit.
  a. Explain how to cut various types of conduit.
  b. Explain how to deburr various types of conduit.
  c. Explain how to thread conduit using manual threading equipment.
  d. Explain how to join conduit with fittings.

Learning Objective 3
- Identify and describe various raceways and their related fittings and supports.
  a. Identify and describe metal wireways and their basic installation considerations.
  b. Identify and describe various types of wireway fittings.
  c. Identify and describe common wireway support components.
  d. Identify and describe nonmetallic surface-mounted wireways.
  e. Identify and describe cable trays, their related fittings, and support methods.
  f. Describe how to properly handle and store raceway materials.

Performance Tasks

Performance Task 1
(Learning Objectives 1 and 2)
- Cut, thread, and ream conduit.

Performance Task 2
(Learning Objectives 1 and 2)
- Connect and support conduit to a box or device using liquidtight flexible metal conduit and fittings.

Teaching Time: 17.5 hours
(Seven 2.5-Hour Sessions)
Session time may be adjusted to accommodate your class size, schedule, and teaching style.

Prerequisites
Core Curriculum; Instrumentation Level One.

Before You Begin
As you prepare for each session, allow sufficient time to review the course objectives, content, visual aids including the PowerPoint® presentation, and these lesson plans, and to gather the required equipment and materials. Consider the time required for demonstrations, laboratories, field trips, and testing.

Using your access code, download the Module Examinations and Performance Profile Sheets from www.nccerirc.com. The passing score for submission into NCCER's Registry is 70% or above for the written examination; performance testing is graded pass or fail.
### Equipment and Materials for Laboratories and Performance Testing

**Appropriate personal protective equipment:**
- Safety glasses
- Work gloves
- Proper footwear as designated by the instructor or training facility provider
- Hearing protection as designated by the instructor or training facility provider
- Hard hat as designated by the instructor or training facility provider

**Common hand tools**
- Hacksaw and/or portable band saw
- Hacksaw and/or band saw blades appropriate for cutting RMC

**Additional Resources**

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


There are a number of online resources available for trainees who would like more information on raceways used for instrumentation. A search for additional information may be assigned as homework to interested trainees. Instructors should view any videos that may be identified in the lesson plan to ensure their suitability before using them. The videos can provide teachable moments in both proper and improper work processes and behaviors. Be prepared to stop the videos at appropriate times to point out and discuss both proper and improper conduct and techniques.

There are also numerous videos available on the Internet related to raceways and wireways. These can be located by searching for raceways, wireways or similar terms and using the Video tab on the results page of your preferred search engine.

Instructors are also encouraged to locate additional audiovisual aids available on the Internet, make personal videos, and take still pictures related to the subject matter and add them to the PowerPoint® presentations throughout the program.
Session Outline for 12214-15

RACEWAYS FOR INSTRUMENTATION

The Lesson Plan for this module is divided into seven 2.5-hour sessions. This time includes 10 minutes for administrative tasks and a 10-minute break per session.

**SESSION ONE**

Session One introduces trainees to various types of conduit and the related fittings and supports. This session covers Sections 1.0.0 through 1.3.4.

1. Show the Session One PowerPoint® presentation.
2. Use the Kickoff Activity to get trainees engaged and give them an idea of what they will learn from this module.
3. Present and describe the various types of rigid conduit and related fittings.
4. Describe how to identify the various types of nonmetallic conduit and related fittings.
5. Discuss the types of hardware used to support conduit systems.

**SESSION TWO**

Session Two presents the preparation of conduit for installation. This session covers Sections 2.0.0 through 2.4.2

1. Show the Session Two PowerPoint® presentation.
2. Use the Kickoff Activity to review the information presented in the previous session.
3. Describe how to cut various types of conduit using several different tools.
4. Describe how to deburr conduit.
5. Explain how to thread conduit using manual threading equipment.
6. Explain how threaded conduit is assembled and identify the fittings required.

**SESSION THREE**

Session Three introduces raceways and their associated fittings and supports. This session covers Sections 3.0.0 through 3.6.2

1. Show the Session Three PowerPoint® presentation.
2. Use the Kickoff Activity to briefly introduce wireway products to the trainees.
3. Describe metal wireways and their basic installation considerations.
4. Describe various types of wireway fittings and common support components.
5. Describe non-metallic surface-mounted wireway components and how they are applied.
6. Describe cable trays, their related fittings, and methods of support.
7. Explain how raceway components are properly handled and stored prior to installation.
Session Outline for 12214-15

RACEWAYS FOR INSTRUMENTATION

SESSIONS FOUR THROUGH SIX

Sessions Four through Six are laboratory sessions that provide an opportunity to practice and/or complete the Performance Tasks required for completion of this module.

1. Note that no PowerPoint® presentation is associated with these sessions.
2. Demonstrate how to properly cut, thread, and ream conduit.
3. Demonstrate how to connect rigid conduit to a box or device using liquidtight flexible metal conduit and fittings, and how the components should be supported.
4. Trainees practice and/or complete the requirements of Performance Tasks 1 and 2.

SESSION SEVEN

Session Seven is a review and testing session. Have trainees complete the module Review Questions. Alternatively, this may be assigned as homework at the end of Session Six. Go over the answers to the Review Questions in class prior to the exam and answer any questions that the trainees may have.

1. Have trainees complete the module examination. Any outstanding performance testing must be completed during this session as well.
2. Record the testing results on the Registration of Training Modules form, and submit the report to your Training Program Sponsor.
## Materials Checklist for Module 12214-15, Raceways for Instrumentation

<table>
<thead>
<tr>
<th>Equipment and Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Personal protective equipment:</strong></td>
</tr>
<tr>
<td>- Common hand tools</td>
</tr>
<tr>
<td>- Pipe vises</td>
</tr>
<tr>
<td>Safety glasses</td>
</tr>
<tr>
<td>- Deburring tools</td>
</tr>
<tr>
<td>- Tape measures</td>
</tr>
<tr>
<td>Work gloves</td>
</tr>
<tr>
<td>- Pipe cutter</td>
</tr>
<tr>
<td>- Threading lubricant</td>
</tr>
<tr>
<td>Proper footwear as designated by instructor or training facility provider</td>
</tr>
<tr>
<td>- RMC conduit</td>
</tr>
<tr>
<td>- Hacksaw and/or portable band saw</td>
</tr>
<tr>
<td>Hearing protection as designated by instructor or training facility provider</td>
</tr>
<tr>
<td>- Hacksaw and/or band saw blades appropriate for cutting RMC</td>
</tr>
<tr>
<td>- One or more electrical junction boxes suitable for RMC</td>
</tr>
<tr>
<td>Hard hat as designated by instructor or training facility provider</td>
</tr>
<tr>
<td>- Half-round files and/or accessory reamers for screwdrivers</td>
</tr>
<tr>
<td>- Threading dies and teeth for the conduit size to be threaded</td>
</tr>
<tr>
<td>Whiteboard/chalkboard</td>
</tr>
<tr>
<td>- Assorted RMC fittings and hardware</td>
</tr>
<tr>
<td>- Liquidtight flexible conduit and compatible fittings</td>
</tr>
<tr>
<td>Markers/chalk</td>
</tr>
<tr>
<td>- Threading die head and handle</td>
</tr>
<tr>
<td>Pencils and paper</td>
</tr>
<tr>
<td><em>Instrumentation Level Two</em> PowerPoint® Presentation Slides</td>
</tr>
<tr>
<td>DVD player or computer with DVD drive</td>
</tr>
<tr>
<td>LCD projector and screen</td>
</tr>
<tr>
<td>Computer with internet access</td>
</tr>
<tr>
<td>Review Questions answer key</td>
</tr>
<tr>
<td>Copies of the Module Examination and Performance Profile Sheets</td>
</tr>
<tr>
<td>Samples of various types of conduit</td>
</tr>
<tr>
<td>Samples of various fittings, boxes, and adapters used to assemble conduit</td>
</tr>
<tr>
<td>Samples of supporting hardware</td>
</tr>
<tr>
<td>Thread dies and teeth</td>
</tr>
<tr>
<td>Thread die heads and handle</td>
</tr>
<tr>
<td>Portable power threader (optional)</td>
</tr>
</tbody>
</table>

To the extent possible, and as required for performance testing, provide a selection of the tools listed for each session; alternatively, photos may be used to teach tool identification.
Module Eight (12303-15) examines the processes of cleaning, purging, and testing piping and tubing systems. It describes typical steps and safety precautions for conducting pneumatic and hydrostatic testing. It explains how to document the performance of leak testing. It also describes how to repair minor leaks in piping and tubing assemblies.

### Objectives

**Learning Objective 1**
- Describe the cleaning and purging process and the methods used to complete the task.
  a. Describe the cleaning and purging process.
  b. Describe various methods used to clean and purge tubing and piping systems.

**Learning Objective 2**
- Describe the piping and tubing testing process and explain how it is accomplished.
  a. Describe the testing process and basic precautions.
  b. Identify and describe common test methods.
  c. Explain how to conduct low-pressure pneumatic and hydrostatic testing.
  d. Explain how to complete minor leak repairs.

### Performance Tasks

**Performance Task 1**
(Learning Objective 2)
- Set up and perform a pneumatic or hydrostatic leak test.

**Performance Task 2**
(Learning Objective 2)
- Inspect the tested system to verify the absence of leaks.

**Performance Task 3**
(Learning Objective 2)
- Document the results of the leak test.

### Teaching Time: 10 hours

(Four 2.5-Hour Sessions)

Session time may be adjusted to accommodate your class size, schedule, and teaching style.

### Prerequisites

*Core Curriculum; Instrumentation Level One.*

### Before You Begin

As you prepare for each session, allow sufficient time to review the course objectives, content, visual aids, including the PowerPoint® presentation, and these lesson plans, and to gather the required equipment and materials. Consider time required for demonstrations, laboratories, field trips, and testing.

Using your access code, download the Module Examinations and Performance Profile Sheets from [www.nccerirc.com](http://www.nccerirc.com). The passing score for submission into NCCER’s Registry is 70% or above for the written examination; performance testing is graded pass or fail.
**Safety Considerations**

This module requires that trainees work with and in the vicinity of functioning equipment and use potentially hazardous tools, equipment, and materials. Electrical, mechanical, and chemical safety must be emphasized at all times. Trainees should be carefully observed to ensure that they wear the proper PPE, follow safe practices, and give due respect to the hazards associated with the energy sources, tools, equipment, and materials that they are using. Any work performed on functioning equipment must be done under the direct supervision of the instructor.

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**Classroom Equipment and Materials**

- Whiteboard
- Markers
- Pencils and paper
- Instrumentation Level Two
- PowerPoint® Presentation
- DVD player or a computer with a DVD drive
- LCD projector and screen
- Computer with Internet access
- Review Questions answer key
- Copies of the Module Examination and Performance Profile Sheets
- A portable turbidimeter
- One or more copies of articles of the ASME codes that apply to the testing limitations for piping and tubing systems
- One or more containers of a standard liquid leak detection solution, such as Snoop®
- A bubbler leak tester (optional)
- One or more types of hydrostatic test pump
- One or more examples of a written leak testing procedure
- One or more examples of a completed leak testing report
- An orifice plate with pipe flanges that are designed specifically for orifice plates

**Equipment and Materials for Laboratories and Performance Testing**

- Appropriate personal protective equipment:
  - Safety glasses
  - Face shields as designated by the instructor or training facility provider
  - Work gloves
  - Chemical-resistant gloves as designated by the instructor or training facility provider
  - Proper footwear as designated by the instructor or training facility provider
  - Hearing protection as designated by the instructor or training facility provider
  - Hard hat as designated by the instructor or training facility provider
- Common hand tools
- Lockout/tagout (LOTO) tags
- Caps to seal tubing ends and/or jumpers to maintain continuity where instruments are removed

- Blank leak test report forms for documenting test results
- The following materials and equipment are required specifically for pneumatic leak testing:
  - Regulated compressed gas supply (air, nitrogen, argon, or other gas as specified)
  - Test pressure gauges, pressure relief valve, and hand valve to install on the supply line to the instrument system
  - Standard liquid leak detection solution (Snoop®)
- The following materials and equipment are required specifically for hydrostatic leak testing:
  - Test medium (Grade A, B, or C water, as specified)
  - Hydrostatic test pump (manual or electric)
  - Test pressure gauges and pressure relief valve to install on the supply line to the instrument system

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**Additional Resources**

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


Instructors are also encouraged to locate additional audiovisual aids available on the Internet, make personal videos, and take still pictures related to the subject matter and add them to the PowerPoint® presentations throughout the program.
Session Outline for 12303-15
CLEAN, PURGE, AND TEST TUBING AND PIPING SYSTEMS

The Lesson Plan for this module is divided into four 2.5-hour sessions. This time includes 10 minutes for administrative tasks and a 10-minute break per session.

**SESSION ONE**

Session One explains why tubing and piping systems must be cleaned and purged. It reviews general cleaning requirements and describes common cleaning and purging methods. This session covers Section 1.0.0 in its entirety.

1. Show the Session One PowerPoint® presentation.
2. Use the Kickoff Activity to introduce the subjects that will be covered in this module and stimulate trainee interest in the material to be covered.
3. Discuss general cleaning requirements and the overall manufacturer’s process for cleaning tubing and piping systems.
4. Describe the common cleaning and purging methods used with tubing and piping systems.

**SESSION TWO**

Session Two explains how to perform leak testing for tubing and piping systems. It discusses the criteria for selecting test methods and reviews the testing precautions that must be followed. It identifies common testing methods and describes typical steps for these test procedures. It also reviews how to document leak testing and explains how to repair minor leaks in tubing and piping assemblies. This session covers Section 2.0.0 in its entirety.

1. Show the Session Two PowerPoint® presentation.
2. Use the Kickoff Activity to encourage trainees to consider the importance of inspecting for and repairing leaks in process tubing and piping systems.
3. Explain the selection criteria and safety precautions that apply to tubing and piping leak testing.
4. Describe the major testing methods.
5. Describe the typical steps for performing a pneumatic leak test using liquid leak detector solutions.
6. Describe the typical steps for performing a hydrostatic leak test.
7. Discuss the proper documentation procedures for leak testing.
8. Explain how to repair minor leaks in tubing and piping assemblies.
Session Three is a laboratory session devoted to the practice and completion of Performance Tasks 1, 2, and 3.

1. Note that no PowerPoint® presentation is associated with this laboratory session.
2. Demonstrate how to set up and perform a pneumatic or hydrostatic leak test.
3. Demonstrate how to inspect the tested system to verify the absence of leaks.
4. Demonstrate how to document the results of the leak test.
5. Trainees practice and/or complete the tasks associated with Performance Tasks 1, 2, and 3 in these hands-on sessions.

Session Four is a review and testing session. Have the trainees complete the module Review Questions. Alternatively, these may be assigned as homework at the end of Session Three. Go over the answers to the Review Questions in class prior to the exam and answer any questions that the trainees may have.

1. Have trainees complete the written examination. Any outstanding performance testing must be completed during this session as well.
2. Record the testing results on the Registration of Training Modules form, and submit the report to your Training Program Sponsor.
# Materials Checklist for Module 12303-15, Clean, Purge, and Test Tubing and Piping Systems

## Equipment and Materials

<table>
<thead>
<tr>
<th>Personal protective equipment:</th>
<th>Equipment and Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety glasses</td>
<td>Common hand tools</td>
</tr>
<tr>
<td>Work gloves</td>
<td>A portable turbidimeter</td>
</tr>
<tr>
<td>Face shields as designated by the instructor or training facility provider</td>
<td>Regulated compressed gas supply for pneumatic leak testing (air, nitrogen, argon, or other gas as specified)</td>
</tr>
<tr>
<td>Chemical-resistant gloves as designated by the instructor or training facility provider</td>
<td>Test pressure gauges, pressure relief valve, and hand valve to install on the supply line to the instrument system (for pneumatic leak testing)</td>
</tr>
<tr>
<td>Proper footwear as designated by the instructor or training facility provider</td>
<td>Standard liquid leak detection solution (Snoop®) for pneumatic leak testing</td>
</tr>
<tr>
<td>Hearing protection as designated by the instructor or training facility provider</td>
<td>One or more copies of articles of the ASME codes that apply to the testing limitations for piping and tubing systems</td>
</tr>
<tr>
<td>Hard hat as designated by the instructor or training facility provider</td>
<td>One or more containers of a standard liquid leak detection solution, such as Snoop®</td>
</tr>
<tr>
<td>Whiteboard/chalkboard</td>
<td>One or more examples of a completed leak testing report</td>
</tr>
<tr>
<td>Markers/chalk</td>
<td>Blank leak test report forms for documenting test results</td>
</tr>
<tr>
<td>Pencils and paper</td>
<td></td>
</tr>
<tr>
<td>Instrumentation Level Two PowerPoint® Presentation Slides</td>
<td></td>
</tr>
<tr>
<td>DVD player or computer with DVD drive</td>
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<tr>
<td>LCD projector and screen</td>
<td></td>
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<tr>
<td>Computer with Internet access</td>
<td></td>
</tr>
<tr>
<td>Review Questions answer key</td>
<td></td>
</tr>
<tr>
<td>Copies of the Module Examination and Performance Profile Sheets</td>
<td></td>
</tr>
</tbody>
</table>

To the extent possible, and as required for performance testing, provide a selection of the tools listed for each session; alternatively, photos may be used to teach tool identification.
Lesson Plans for 12308-15

**PROTECTIVE MEASURES FOR INSTRUMENTATION**

Module Nine (12308-15) introduces trainees to various protective measures commonly used to safeguard instrumentation and piping systems from freezing conditions, or to maintain the contents of system at a given temperature. Presented examples include the use of electrical and steam heat tracing, chemical antifreeze solutions, and insulating materials designed to preserve heat and prevent freezing.

<table>
<thead>
<tr>
<th>Objectives</th>
<th>Learning Objective 1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Describe the operation of electrical heat tracing and explain how it is installed.</td>
</tr>
<tr>
<td></td>
<td>a. Describe the application of electrical heat tracing on pipelines and their components.</td>
</tr>
<tr>
<td></td>
<td>b. Describe the power requirements and distribution for electrical heat tracing systems.</td>
</tr>
<tr>
<td></td>
<td>c. Identify and describe electrical heat tracing cable products and components.</td>
</tr>
<tr>
<td></td>
<td>d. Describe electrical heat tracing system control components and their operation.</td>
</tr>
<tr>
<td></td>
<td>e. Describe the approaches to monitoring electrical heat tracing system operation.</td>
</tr>
<tr>
<td></td>
<td>f. Identify and describe the basic installation guidelines for electrical heat tracing systems.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Learning Objective 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Describe other protection schemes for pipelines and their components.</td>
</tr>
<tr>
<td>a. Describe steam heat tracing systems.</td>
</tr>
<tr>
<td>b. Describe chemical-based burst and freeze protection.</td>
</tr>
<tr>
<td>c. Identify and describe various types of insulation materials and installation precautions.</td>
</tr>
<tr>
<td>d. Identify miscellaneous system protection devices and approaches to protecting instrumentation from physical damage.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Learning Objective 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Describe the need for blowdown and how to properly blow down instrument air and signal lines.</td>
</tr>
<tr>
<td>a. Explain why blowdown is required and what systems and components require blowdown.</td>
</tr>
<tr>
<td>b. Explain how to properly blow down instrument air and signal lines.</td>
</tr>
</tbody>
</table>

**Performance Tasks**

**Performance Task 1** (Learning Objective 1)
- Install electric heat tracing on a short section of piping.

**Performance Task 2** (Learning Objective 1)
- Install electric heat tracing on a control valve.

**Performance Task 3** (Learning Objective 2)
- Install a section of steam tracing according to a set of instructor-provided specifications.

**Performance Task 4** (Learning Objective 3)
- Perform a blowdown on a transmitter, following specific sequences to open and close the manifold valve to protect the instrument.

**Teaching Time: 20.0 hours**
(Eight 2.5-Hour Sessions)

Session time may be adjusted to accommodate your class size, schedule, and teaching style.

**Prerequisites**
*Core Curriculum; Instrumentation Level One.*

**Before You Begin**
As you prepare for each session, allow sufficient time to review the course objectives, content, visual aids (including the PowerPoint® presentation), and these lesson plans, and to gather the required equipment and materials. Consider the time required for demonstrations, laboratories, field trips, and testing.

Using your access code, download the Module Examinations and Performance Profile Sheets from www.nccerirc.com. The passing score for submission into NCCER's Registry is 70% or above for the module examination; performance testing is graded pass or fail.
Safety Considerations
This module requires that trainees work with hand tools, power tools, and various types of electrical and steam heat tracing, chemical antifreeze solutions, and insulating materials. Safety must be emphasized at all times. Emphasize safety precautions when blowing down instrument lines. Ensure all trainees wear the proper PPE, follow safe practices, and give due respect to unseen hazards related to the module content. Any deficiencies must be corrected to ensure future trainee safety. All practice sessions and Performance Tasks must be completed under your direct supervision.

Classroom Equipment and Materials
Whiteboard
Markers
Pencils and paper
Instrumentation Level Two
PowerPoint® Presentation
DVD player or a computer with a DVD drive
LCD projector and screen
Computer with Internet access
Review Questions answer key
Copies of the Module Examination and Performance Profile Sheet
Short sections of various electric heating cable products
Samples of various pipe insulation materials
Examples of pigtail siphons, dampeners, and/or snubbers

Equipment and Materials for Laboratories and Performance Testing
Appropriate personal protective equipment:
- Safety glasses and/or face shields
- Work gloves
- Proper footwear as designated by the instructor or training facility provider
- Hearing protection as designated by the instructor or training facility provider
- Hard hat as designated by the instructor or training facility provider
- Transmitter connected into a common configuration with an appropriate manifold valve for blowdown

Compressed air source with necessary hose and fittings
Tape measures
Connected piping and valve assemblies to heat trace
Steam heat tracing material of choice with manufacturer’s installation instructions
Electrical heat-trace material of choice with manufacturer’s installation instructions
Electrical heat-trace accessories required for splices and/or terminations
Wire, clips, and/or fiberglass tape as called for by the material manufacturers

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


There are a number of online resources available for trainees who would like more information on protective measures related to the instrumentation trade. A search for additional information may be assigned as homework to interested trainees.

Instructors should view any videos that may be identified in the lesson plan to ensure their suitability before using them. The videos can provide teachable moments in both proper and improper work processes and behaviors. Be prepared to stop the videos at appropriate times to point out and discuss both proper and improper conduct and techniques.
Session One introduces trainees to piping and process protection through electrical heat tracing. This session covers Sections 1.0.0 through 1.6.0.

1. Show the Session One PowerPoint® presentation.
2. Use the Kickoff Activity to get trainees engaged and give them an idea of what they will learn from this session.
3. Identify applications of electrical heat trace products of piping and components.
4. Discuss power requirements and power distribution schemes.
5. Explain how electrical heat trace systems are controlled and monitored.
6. Identify and describe the basic installation guidelines for electrical heat trace products.

Session Two reviews other kinds of freeze protection strategies, chemicals, and equipment. This session covers Sections 2.0.0 through 2.4.4.

1. Show the Session Two PowerPoint® presentation.
2. Use the Kickoff Activity to show how different materials perform as insulators.
3. Describe how steam heat tracing systems are applied and installed.
4. Introduce chemical-based burst and freeze protection strategies and the chemicals typically used.
5. Identify various types of insulation materials and their installation considerations.
6. Identify various device protection devices used to protect individual instruments from damage.

Session Three introduces the process of blowing down instrument air and signal lines. This session covers Sections 3.0.0 through 3.2.2.

1. Show the Session Three PowerPoint® presentation.
2. Use the Kickoff Activity to review trainee knowledge of compressed air and moisture content.
3. Identify the components and systems that require blowdown and why it is required.
4. Review the proper blowdown procedures for instrument air lines and signal lines.
5. Demonstrate how to properly and safely blowdown an instrument transmitter.
6. Trainees practice and/or complete the requirements of Performance Task 4.
Session Outline for 12308-15

PROTECTIVE MEASURES FOR INSTRUMENTATION

**Sessions Four through Seven**

Sessions Four through Seven are laboratory sessions that provide an opportunity to practice and/or complete the Performance Tasks associated with protective measures for instrumentation.

1. Demonstrate how to install electric heat trace on a short section of piping.
2. Demonstrate how to install electric heat trace on a control valve.
3. Demonstrate how to install a section of steam tracing according to a set of instructor-provided specifications.
4. Trainees practice and/or complete the requirements of Performance Tasks 1 through 3.

**Session Eight**

Session Eight is a review and testing session. Have the trainees complete the module Review Questions. Alternatively, these may be assigned as homework at the end of Session Seven. Go over the answers to the Review Questions in class prior to the exam and answer any questions that the trainees may have.

1. Have trainees complete the module examination. Any outstanding performance testing must be completed during this session as well.
2. Record the testing results on the Registration of Training Modules form, and submit the report to your Training Program Sponsor.
### Equipment and Materials

<table>
<thead>
<tr>
<th>Personal protective equipment:</th>
<th>Equipment and Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety glasses and/or face shields</td>
<td>Samples of various pipe insulation materials</td>
</tr>
<tr>
<td>Work gloves</td>
<td>Examples of pigtail siphons, dampeners, and/or snubbers</td>
</tr>
<tr>
<td>Proper footwear as designated by the instructor or training facility provider</td>
<td>Steam heat tracing material of choice with manufacturer’s installation instructions</td>
</tr>
<tr>
<td>Hearing protection as designated by the instructor or training facility provider</td>
<td>Transmitter connected into a common configuration with an appropriate manifold valve for blowdown</td>
</tr>
<tr>
<td>Hard hat as designated by the instructor or training facility provider</td>
<td>Compressed air source with necessary hose and fittings</td>
</tr>
<tr>
<td>Whiteboard/chalkboard</td>
<td>Tape measures</td>
</tr>
<tr>
<td>Markers/chalk</td>
<td></td>
</tr>
<tr>
<td>Pencils and paper</td>
<td></td>
</tr>
<tr>
<td><em>Instrumentation Level Two</em> PowerPoint® Presentation Slides</td>
<td></td>
</tr>
<tr>
<td>DVD player or computer with DVD drive</td>
<td></td>
</tr>
<tr>
<td>LCD projector and screen</td>
<td></td>
</tr>
<tr>
<td>Computer with Internet access</td>
<td></td>
</tr>
<tr>
<td>Review Questions answer key</td>
<td></td>
</tr>
<tr>
<td>Copies of Module Examination and Performance Profile Sheets</td>
<td></td>
</tr>
</tbody>
</table>

To the extent possible, and as required for performance testing, provide a selection of the tools listed for each session; alternatively, photos may be used to teach tool identification.
Module Ten (12302-15) introduces the trainees to three major tasks that instrument fitters must be able to perform: laying out piping and tubing systems; measuring and bending tubing or piping; and installing and properly supporting tubing or piping systems. Through this module, trainees will become familiar with these systems and techniques.

### Objectives

#### Learning Objective 1
- Identify and describe the factors related to the layout of instrument tubing or piping systems.
  - a. Identify the factors related to the initial planning of instrument tubing or piping installations.
  - b. Identify and describe considerations in the final layout of instrument tubing or piping systems.
  - c. Explain how to develop an isometric sketch of instrument tubing or piping installations.
  - d. Describe the contents of a bill of materials for the installation of an instrument and its process connections.

#### Learning Objective 2
- Explain how to properly measure and bend tubing.
  - a. Explain how to measure for bending.
  - b. Identify and explain how to use a hand-operated, lever-type tubing bender.

### Performance Tasks

#### Performance Task 1 (Learning Objective 1)
- Given a set of instructor-provided drawings, create a bill of materials for the installation of the instrument and its process connections.

#### Performance Task 2 (Learning Objective 2)
- Measure, bend, and install tubing according to the drawings used for Performance Task 1.

#### Performance Task 3 (Learning Objective 3)
- Indicate the types and locations of support needed for the tubing installation shown in the drawings used in Performance Task 1.

### Prerequisites

Core Curriculum; Instrumentation Level One.

### Before You Begin

As you prepare for each session, allow sufficient time to review the course objectives, content, visual aids, including the PowerPoint® presentation, and these lesson plans, and to gather the required equipment and materials. Consider the time required for demonstrations, laboratories, field trips, and testing.

Using your access code, download the Module Examinations and Performance Profile Sheets from www.nccerirc.com. The passing score for submission into NCCER's Registry is 70% or above for the module examination; Performance Tasks are graded pass or fail.
Safety Considerations
This module requires that trainees work with hand tools, power tools, and various types of piping, tubing and support systems. Safety must be emphasized at all times. Ensure that all trainees wear the proper PPE, follow safe practices, and give due respect to all hazards related to the layout and installation of tubing and piping arrangements. Any deficiencies must be corrected to ensure future trainee safety. All practice sessions and performance tasks must be completed under your direct supervision.

Classroom Equipment and Materials
- Whiteboard
- Markers
- Pencils and paper
- Instrumentation Level Two PowerPoint® presentation
- DVD player or a computer with a DVD drive
- LCD projector and screen
- Computer with Internet access
- Review Questions answer key
- Copies of the Module Examination and Performance Profile Sheets
- Simple and complex sets of loop drawings and specifications
- Graph paper
- Protractor
- Straightedge
- 45-degree triangle
- Scientific calculator
- Copies of or online access to the current ASME Boiler and Pressure Vessel Code

Equipment and Materials for Laboratories and Performance Testing
- Appropriate personal protective equipment as designated by the instructor or training facility provider:
  - Safety glasses
  - Work gloves
  - Proper footwear
  - Hearing protection
  - Hard hat
- One or more sets of loop drawings and specifications that trainees will use a guide for installation practice
- Instruments and related devices for installation practice
- Common hand tools
- Tape measure or steel rule
- Hand-operated tube benders
- Electric drill and assorted bits
- Tubing cutters suitable for the material in use
- Reamers
- Flaring tools
- Torque wrenches
- Copper or stainless steel tubing
- Appropriate compression fittings
- Various hangers and supports

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


*Plastics Pipe Institute, Inc.* [plasticpipe.org](http://plasticpipe.org)


Instructors are also encouraged to locate additional audiovisual aids available on the Internet, make personal videos, and take still pictures related to the subject matter and add them to the PowerPoint® presentations throughout the program.
Session Outline for 12302-15

LAYOUT AND INSTALLATION OF TUBING AND PIPING SYSTEMS

The Lesson Plan for this module is divided into fourteen 2.5-hour sessions. This time includes 10 minutes for administrative tasks and a 10-minute break per session.

**SESSION ONE**

Session One introduces trainees to the factors and procedures related to laying out instrument tubing or piping systems. This session covers Sections 1.0.0 through 1.4.0.

1. Show the Session One PowerPoint® presentation.
2. Use the Kickoff Activity to introduce the subjects that will be covered in this module and stimulate trainee interest in the material to be covered.
3. Identify the various factors involved in the initial planning of instrument tubing or piping installations.
4. Describe issues associated with the final layout of instrument tubing or piping installations.
5. Develop isometric sketches to better communicate instrument tubing or piping installations.
6. Describe a bill of materials for the installation of an instrument and its process connections and explain how it can be used.

**SESSION TWO**

Session Two addresses the process of measuring and bending tubing. Trainees will learn how to properly measure tubing so that bends will be accurate. They will also learn how to use a hand-operated bender and become acquainted with potential problems. This session covers Sections 2.0.0 through 2.2.2.

1. Show the Session Two PowerPoint® presentation.
2. Use the Kickoff Activity to review how tubing is bent using a hand bender.
3. Describe the measuring process and explain how it relates to a successful bend.
4. Explain the procedure and issues involved with using a hand-operated, lever-type tubing bender.

**SESSION THREE**

Session Three introduces the topic of tubing and piping support systems. Trainees will learn piping system support guidelines and review the various components used for support. This session covers Section 3.0.0 through 3.2.2.

1. Show the Session Three PowerPoint® presentation.
2. Use the Kickoff Activity to acquaint trainees with the ASME Boiler and Pressure Vessel Code, as well as the mindset behind codes in general.
3. Describe the overall guidelines for supporting piping systems, including rules of thumb and the general strategies used in common settings.
4. Identify and explain the use of different support components, including both constant and rigid devices.
5. Discuss the differences between supporting piping and supporting tubing.
Session Outline for 12302-15

LAYOUT AND INSTALLATION OF TUBING AND PIPING SYSTEMS

SESSIONS FOUR THROUGH THIRTEEN

Sessions Four through Thirteen are laboratory sessions devoted to the practice and completion of Performance Tasks 1, 2, and 3.

1. Note that no PowerPoint® presentation is associated with these laboratory sessions.

2. Demonstrate how to use a set of instructor-provided drawings to create a bill of materials for the installation of the instrument and its process connections.

3. Demonstrate how to measure, bend, and install tubing according to the instructor-provided drawings.

4. Demonstrate how to select, locate, and install the proper supports for the tubing installation shown in the instructor-provided drawings.

5. Trainees practice and/or complete the tasks associated with Performance Tasks 1, 2, and 3 in these hands-on sessions.

SESSION FOURTEEN

Session Fourteen is a review and testing session. Have trainees complete the module Review Questions. Alternatively, these may be assigned as homework at the end of Session Thirteen. Go over the answers to the Review Questions in class prior to the exam and answer any questions that the trainees may have.

1. Have trainees complete the module examination. Any outstanding performance testing must be completed during this session as well.

2. Record the testing results on the Registration of Training Modules form, and submit the report to your Training Program Sponsor.
## Materials Checklist for Module 12302-15, Layout and Installation of Tubing and Piping Systems

<table>
<thead>
<tr>
<th>Equipment and Materials</th>
<th>Protractor</th>
<th>Straightedge</th>
<th>Protractor</th>
<th>Straightedge</th>
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</thead>
<tbody>
<tr>
<td><strong>Personal protective equipment:</strong></td>
<td></td>
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<tr>
<td>Safety glasses</td>
<td>45-degree triangle</td>
<td>Scientific calculator</td>
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<tr>
<td>Work gloves</td>
<td>Tape measure or steel rule</td>
<td>Common hand tools</td>
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<tr>
<td>Proper footwear as designated by the instructor or training facility provider</td>
<td>One or more sets of loop drawings and specifications that trainees will use a guide for installation practice</td>
<td>Copies of or online access to the current ASME Boiler and Pressure Vessel Code</td>
<td></td>
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</tr>
<tr>
<td>Hearing protection as designated by instructor or training facility provider</td>
<td>Instruments and related devices for installation practice</td>
<td>Hand-operated tube benders</td>
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</tr>
<tr>
<td>Hard hat as designated by instructor or training facility provider</td>
<td>Tubing cutters suitable for the material in use</td>
<td>Electric drill and assorted bits</td>
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</tr>
<tr>
<td>Whiteboard/chalkboard</td>
<td>Copper or stainless steel tubing</td>
<td>Appropriate compression fittings</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Markers/chalk</td>
<td>Reamers</td>
<td>Flaring tools</td>
<td></td>
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</tr>
<tr>
<td>Pencils and paper</td>
<td>Torque wrenches</td>
<td>Various hangers and supports</td>
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<td><strong>Instrumentation Level Two PowerPoint® Presentation Slides</strong></td>
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<td>Computer with Internet access</td>
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<td>Copies of the Module Examination and Performance Profile Sheets</td>
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</tr>
<tr>
<td>Simple and complex sets of loop drawings and specifications</td>
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<tr>
<td>Graph paper</td>
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</tbody>
</table>

To the extent possible, and as required for performance testing, provide a selection of the tools listed for each session; alternatively, photos may be used to teach tool identification.
Module Eleven (12210-15) introduces filters commonly used for instrument air applications, regulators, and dryers. These share a common element as they all contribute to the quality and reliability of crucial compressed air supplies and possibly other gases. It is very common to see all three devices used and installed together on a system. This module will introduce trainees to these components and their primary functions.

Objectives

Learning Objective 1
• Identify compressed air quality classes and describe common air filtration materials.
  a. Explain the need for clean air and identify compressed air quality classes relevant to instrumentation air systems.
  b. Describe common air filtration materials and characteristics.

Learning Objective 2
• Identify and describe various types of pneumatic regulators.
  a. Identify and describe direct-operated regulators.
  b. Identify and describe pilot-operated regulators.
  c. Describe the general guidelines for selecting a pressure regulator.

Learning Objective 3
• Identify and describe various types of dryers.
  a. Identify and describe absorbent dryers.
  b. Identify and describe refrigerated dryers.
  c. Identify and describe adsorptive desiccant dryers.
  d. Describe the general guidelines for selecting a dryer system.

Performance Tasks

Performance Task 1 (Learning Objectives 1 and 2)
• Identify the components of filters and regulators.

Performance Task 2 (Learning Objective 1)
• Select the appropriate filter for a given application.

Performance Task 3 (Learning Objective 2)
• Disassemble and reassemble a pressure regulator.

Performance Task 4 (Learning Objective 3)
• Select the appropriate dryer for a given application.

Teaching Time: 7.5 hours
(Three 2.5-Hour Sessions)

Session times may be adjusted to accommodate your class size, schedule, and teaching style.

Prerequisites
Core Curriculum; Instrumentation Level One.

Before You Begin

As you prepare for each session, allow sufficient time to review the course objectives, content, visual aids including the PowerPoint® presentation, and these lesson plans, and to gather the required equipment and materials. Consider time required for demonstrations, laboratories, field trips, and testing.

Using your access code, download the Module Examinations and Performance Profile Sheets from www.nccerirc.com. The passing score for submission into NCCER’s Registry is 70% or above for the written examination; performance testing is graded pass or fail.
**Safety Considerations**

This module is primarily delivered in the classroom environment. However, some activities are likely to be conducted in shop areas and require trainees to work with common hand tools. Safety must be emphasized at all times. Trainees should be carefully observed to ensure that they wear the proper PPE, follow safe practices, and give due respect to unseen hazards. Any deficiencies must be corrected to ensure future trainee safety.

**Classroom Equipment and Materials**

- Whiteboard
- Markers
- Pencils and paper
- *Instrumentation Level Two* PowerPoint® Presentation
- DVD player or a computer with a DVD drive
- LCD projector and screen
- Computer with Internet access
- Review Questions answer key
- Copies of the Module Examination and Performance Profile Sheets
- Filter element selection resources (catalog data, compatibility charts)
- An assortment of compressed air filter assemblies and filter elements
- Direct- and/or pilot-operated regulator for disassembly
- Samples of desiccant materials
- Performance charts for one or more regulators, showing the pressure drop at various flow rates
- Air dryer selection resources (catalog data, performance charts, selection guides) for various absorbent, refrigerated, and adsorptive dryers

**Equipment and Materials for Laboratories and Performance Testing**

- Safety glasses
- An assortment of compressed air filter assemblies and filter elements
- Filter element selection resources (catalog data, compatibility charts)
- Direct- and/or pilot-operated regulators for disassembly
- Air dryer selection resources (catalog data, performance charts, selection guides) for various absorbent, refrigerated, and adsorptive dryers

**Additional Resources**

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


There are a number of online resources available for trainees who would like more information on this topic. A search for additional information may be assigned as homework to interested trainees.

Instructors should view any videos that may be identified in the lesson plan to ensure their suitability before using them. The videos can provide teachable moments in both proper and improper work processes and behaviors. Be prepared to stop the videos at appropriate times to point out and discuss both proper and improper conduct and techniques. Instructors may find useful videos related to compressed air filtration and dryers at www.airdryers.com under the Blog tab found on the home page. In addition, videos related to various air dryers and desiccants can be found at www.vanairsystems.com under the Video tab found on the home page.

Instructors are also encouraged to locate additional audiovisual aids available on the Internet, make personal videos, and take still pictures related to the instrumentation trade and add them to the PowerPoint® presentations throughout the program.
Session One covers all three objectives listed for this module. The trainees will be able to explain the interrelationship of these devices and the guidelines for selecting the appropriate devices for particular applications.

1. Show the Session One PowerPoint presentation.
2. Use the Kickoff Activity to engage trainees and give them an idea of what they will learn from this session.
3. Discuss the need for clean, dry air and the air quality classes as defined by ISO.
4. Review compressed air filter types and selection considerations.
5. Describe and point out the differences between direct- and pilot-operated regulators.
6. Describe and point out the differences between absorbent, refrigerated, and adsorptive desiccant dryers.

Session Two is a laboratory session that provides an opportunity to practice and/or complete the Performance Tasks associated with filters, regulators, and dryers presented in this module.

1. Note that no PowerPoint presentation is associated with this session.
2. Demonstrate filter selection, regulator disassembly and assembly, and dryer selection as required.
3. Trainees practice and/or complete the tasks associated with Performance Tasks 1 through 4.

Session Three is a review and testing session. Have trainees complete the module Review Questions. Alternatively, this may be assigned as homework at the end of Session Two. Go over the answers to the Review Questions in class prior to the exam and answer any questions that the trainees may have.

1. Have trainees complete the written examination. Any outstanding performance testing must be completed during this session as well.
2. Record the testing results on the Registration of Training Modules form, and submit the report to your Training Program Sponsor.
## Materials Checklist for Module 12210-15, Instrument Air Filters, Regulators, and Dryers

<table>
<thead>
<tr>
<th>Equipment and Materials</th>
<th>Direct- and/or pilot-operated regulator for disassembly</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Personal protective equipment:</strong></td>
<td>Samples of desiccant materials</td>
</tr>
<tr>
<td>Safety glasses</td>
<td>Filter element selection resources (catalog data, compatibility charts)</td>
</tr>
<tr>
<td>Whiteboard/chalkboard</td>
<td>Filter element selection resources (catalog data, compatibility charts)</td>
</tr>
<tr>
<td>Markers/chalk</td>
<td>Air dryer selection resources (catalog data, performance charts, selection guides) for various absorbent, refrigerated, and adsorptive dryers</td>
</tr>
<tr>
<td>Pencils and paper</td>
<td>Performance charts for one or more regulators, showing the pressure drop at various flow rates</td>
</tr>
</tbody>
</table>

### Instrumentation Level Two PowerPoint® Presentation Slides

- Performance charts for one or more regulators, showing the pressure drop at various flow rates
- Air dryer selection resources (catalog data, performance charts, selection guides) for various absorbent, refrigerated, and adsorptive dryers

- DVD player or computer with DVD drive
- Computer with Internet access
- Review Questions answer key
- Copies of Module Examination and Performance Profile Sheets

To the extent possible, and as required for performance testing, provide a selection of the tools listed for each session; alternatively, photos may be used to teach tool identification.