

TEMPERATURE, PRESSURE, LEVEL, AND FLOW

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.

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

Additional Resources

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

Industrial & Process Instrumentation: Process, Flow, Level, Temperature, 2006. Michigan City, IN: Dwyer Instruments, Inc.

Instrument Engineers' Handbook, Volume 1: Process Measurement and Analysis, Bela G. Liptak. 2003. Boca Raton, FL: CRC Press.

Instrument Engineers' Handbook, Volume 2: Process Control and Optimization, Bela G. Liptak. Fourth Edition. 2005. Boca Raton, FL: CRC Press.

Instrumentation Reference Book, Edited by Walt Boyes. Fourth Edition. 2009. Burlington, MA: Butterworth-Heinemann.

Omega Flow, Level, and Environmental Handbook and Encyclopedia, Latest Edition. Stamford, CT: Omega Engineering, Inc.

Omega Temperature Measurement Handbook and Encyclopedia, Latest Edition. Stamford, CT: Omega Engineering, Inc.

Omega Complete Pressure, Strain, and Force Measurement Handbook and Encyclopedia, Latest Edition. Stamford, CT: Omega Engineering, Inc.

Purdy's Instrument Handbook, Ralph G. Dewey. Latest Edition. Deer Park, TX: Glen Enterprises.

The Engineer's Guide to Level Measurement, Latest Edition. Chanhassen, MN: Rosemount Inc.

Industrial Pressure, Level & Density Measurement, Donald R. Gillum. Second Edition. 2008. Research Triangle Park, NC: International Society of Automation (ISA).

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.



TEMPERATURE, PRESSURE, LEVEL, AND FLOW

SESSION THREE

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

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.

TEMPERATURE, PRESSURE, LEVEL, AND FLOW

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.

Materials Checklist for Module 12110-15, Temperature, Pressure, Level, and Flow

Equipment and Materials					
Personal protective equipment:		One or more types of thermocouples		A complete temperature-measuring assembly of thermocouple, thermowell, and junction block	
None		One or more examples of RTDs		One or more examples of thermistors	
Whiteboard and markers		A handheld IR pyrometer		Various types of manometers	
Pencils and paper		A liquid-filled pressure gauge		One or more styles of pressure gauge isolators	
<i>Instrumentation Level Two</i> PowerPoint® Presentation Slides		One or more styles of snubbers		Various direct level measuring instruments, such as sight glasses and displacers	
DVD player		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	
Computer		Various other types of flow measuring instruments, such as turbine flowmeters and coriolis flowmeters		Photographs and/or line drawings of instruments from this module, manufacturer catalogs, and similar sources	
Internet access during class (<i>optional</i>)		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	
Review Questions answer key		Instructor-prepared handout with blanks corresponding to numbers identifying each instrument that is selected for the Performance Task			
Copies of the 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.