Brazosport College
Center for Business/Industry Training

INSTRUMENTATION

Applied Instrumentation

Course Listing and Delivery Schedule

In light of the increasing need for instrumentation technician training, the Center for Business/Industry Training (CBIT) of Brazosport College has developed Applied Instrumentation instructor-led courses for entry-level Instrument & Electrical Technicians and related occupational jobs (Process Control Technicians, Control and Valves Installer and Repairer, Electro-Mechanical Technicians, Electrical and Electronic Engineering Technicians, and Maintenance and Repair Workers, etc.) who preferably have a two-year instrumentation degree or equivalent. Following is the list of Applied Instrumentation courses, along with the projected delivery schedule.

Basic Level

This module will enable the participant to learn fundamental principles of level measurement, terminology and concepts. New level measuring techniques, devices and applications incorporated into this module will enhance the skills learned through the hands-on exercises.

Learning Objectives

Trainees will be able to:

- Learn how instruments measure level and transmit this information to a controller, computer, or other readout
- Complete hands-on demonstrations of actual instrument calibration, installation, replacement, and troubleshooting
- Learn appropriate communication and terminology

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Basic Flow

This module will enable participants to learn fundamental principles of flow measurement, flow indicators, flow control and related process variable regulation. Various flow measurement technologies will be discussed, including differential pressure, flow transmitters and indicators, mass, magnetic, vortex, turbine, variable area, target, and ultrasonic. Terminology, concepts, and calculations will be an integral part of this module.

Learning Objectives

Trainees will be able to:

- Learn fundamental principles of flow measurement and how this information is transmitted to a controller, computer, or other readout
- Learn new flow measuring techniques/devices and the appropriate application
- Complete hands-on demonstrations of actual instrument calibration, installation, replacement, and troubleshooting; and learn appropriate communication and terminology
- Apply skills learned through demonstrations and hands-on exercises with actual instrument calibration, installation, replacement, and troubleshooting.

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Basic Valves

This module will allow the participant to learn terminology, principles and concepts of valve & pneumatic systems, and will include the following technologies: final elements, air supply, rising stem valves, rotary valves, on/off valves, and control valves.

Learning Objectives

Trainees will be able to:

- Learn fundamental principles of valve operation
- Identify and describe different type of valves, their components, their functions and the advantages and disadvantages of different types of valves
- Complete hands-on demonstrations of actual valve tuning, configuration, installation, replacement and troubleshooting
- Identify actuators and how they function
- Apply skills learned through hands-on demonstrations of actual valve installation, maintenance, replacement and troubleshooting

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Basic Electronic Instrumentation

This course will allow participants to display an understanding of the scientific principles of operation and application of the data from varied electronic instruments to process control, plant efficiency or safety of an operating chemical plant. These include a weigh cell system, vibration sensor, RPM sensor, and analyzers. Analyzers include flame and gas detection as well as analytical instrumentation, such as gas chromatographs. Various environmental instruments such as air quality, toxic and flammable gas analysis, pH, conductivity, and dissolved oxygen are also covered.

Learning Objectives

Trainees will be able to:

- Identify and describe the components of a weigh cell system (e.g., Wheatstone bridge, summing board, excitation voltage, load cell, indicator).
- Describe the functionality of a vibration sensor and its applications.
- Describe the principles of operation of a RPM sensor.
- Describe the basic concepts of process analyzers (e.g., gas chromatograph, liquid chromatograph, infrared).
- Describe the basic concepts of sample systems to assure that the sample is properly extracted, transported, and conditioned.
- Explain the operation, and purpose of major air and water quality analyzers.
- Describe the functionality of the area monitor.
- Perform calibration, commissioning and start-up on electronic instruments.

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Basic Transmitters

This course will allow participants to gain an understanding of the fundamental principles associated with industrial applications of transmitters and their many uses. Concepts relating to transmitter use will include: common transmitter signal types, smart versus non-smart transmitters, flow measurement, pressure measurement, level measurement, specialty level measurement, temperature measurement, weigh cells, revolutions per minute (RPM) sensors/rotational speed sensors, vibration sensors, air quality (safety and monitoring), flammable gas detection, flame sensors, and water quality.

Learning Objectives

Trainees will be able to:

- Develop an understanding of the common transmitter signal methods ranging from a typical transmitter to a control device.
- Demonstrate and explain the common practices used in wiring a typical transmitter to a controller (internal vs. external loop power).
- Define and use calibration, transmitter failure modes, and configuration practices in a lab environment.
- Understand and explain the effects of dampening on a transmitter signal.
- Understand and explain the difference between instrument transmitter span and range.
- Understand and explain the difference between a transmitter and a transducer.
- Identify, troubleshoot, repair, replace, calibrate and test various types of transmitters incorporating appropriate safety procedures.
- Define and demonstrate the use of HART communicators and the appropriate calibration test equipment.
- Explain the difference between a smart and non-smart transmitter, and demonstrate the ability to use and configure various smart devices.
- Perform five point calibration on a transmitter (e.g., five point calibration check, accuracy, repeatability, hysteresis) using calibration graphs and document findings.
- Understand and explain principles of transmitter signals converted or conditioned to signals sent to the distributive control system (e.g., voltage to milliamp, repeaters, voltage to voltage, voltage to current, current to current, analog to digital).
- Understand and describe the functionality of a Fieldbus device.

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Basic Electricity

This course will allow participants to demonstrate understanding of electricity basics, calculations, and procedures related to various electrical components and test instruments. Concepts presented will include: electrical theory, lighting, conductors, raceways, motors, motor controls, uninterruptible power supply (UPS). Hands-on exercises will involve series and parallel circuits, conduit bending, lighting circuits, motor starters and motor control circuits.

Learning Objectives

Trainees will be able to:

- Identify and describe electrical/electronic terms, symbols and definitions, various discrete electronic components, applications of magnetic devices, functionality of certain semiconductor devices, signal wire shielding practices, and computer cable installation.
- Use Ohm's law and circuit analysis on series and parallel alternating and/or direct current circuits, describe grounding techniques, cathodic protection, and usage of GFIs.
- Describe the use of seals and purges in junction boxes and field junction boxes.

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Basic Process Theory A

This course will allow participants to demonstrate understanding of basic process science principles used in common chemical processing operations, major components and functionality of heat exchangers, cooling towers, refrigeration, compressors, distillation, and other common unit operations, basic control strategies for process systems, and basic troubleshooting methods for process and instrument problems.

Concepts presented will include:

- Basic Process Plant Sciences
  - Heat transfer
  - Conductivity
  - Temperature and pressure relationships
  - Understanding pH
- Process Systems and Control
  - Continuous
- Process Unit Operations
  - Heat transfer (exchangers, cooling towers)
  - Distillation towers
- Compressors/turbines
  - Utilities (steam, water, fuel, nitrogen, electricity)
- Introduction to Troubleshooting Methodology

Learning Objectives

Trainees will be able to:

- Describe process systems, specifically continuous
- Identify the pieces of equipment that create a process system and define the boundaries
- Describe a simple processing unit in a given plant
- Identify and describe a simple control system design (e.g., primary sensing element, controlling element and a final controlled element).
- Describe and explain a distillation process
- Perform start-up, operation and shutdown of a processing unit in a Lab.

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Basic Process Plant Science

This course includes the concepts and terminology associated with process instrumentation and its application in various process operations including distillation, heat exchangers, pumps, refrigeration, fired equipment and compressor functionality, and the science and theory behind these concepts.

Learning Objectives

Trainees will be able to:

- Understand the operation of common process equipment and how instrumentation is used to control and troubleshoot process operations
- Learn the application of the general gas law, heat transfer, and categories of chemical reactions with expected instrumentation action
- Understand acid/base chemistry and its impact on plant equipment life and instrumentation specification
- Understand the impact of process startup and shutdown conditions on instrumentation designed for steady state operations
- Determine the safety and hazardous characteristics of a chemical from a Material Safety Data Sheet and
- National Fire Protection Agency symbols and the impact of these characteristics upon instrumentation
- performance and specification, including lab work covering troubleshooting instrumentation problems caused by changes in chemical properties (e.g., density, vapor pressure)

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Basic Process Theory B

This course will allow participants to demonstrate understanding of basic process science principles used in common chemical processing operations, major components and functionality of pumps, solids handling, boilers and furnaces, reactors and other common unit operations, basic control strategies for process systems, and basic troubleshooting methods for process and instrument problems.

Concepts presented will include:

- Basic Process Plant Sciences
  - Chemical reactions and rates
- Process Systems and Control
  - Batch
  - Continuous
- Process Unit Operations
  - Pumps
  - Reactor Systems
  - Boilers and furnaces
- Compressors/turbines
  - Utilities (steam, water, fuel, nitrogen, electricity)
  - Solids Handling: screw feeders, belt feeder, load cells
- Introduction to Troubleshooting Methodology

Learning Objectives

Trainees will be able to:

- Explain basic process chemistry principles (e.g., acid, base, pH. etc.)
- Describe process systems, including batch and continuous
- Identify the pieces of equipment that create a process system and define the boundaries
- Describe a simple processing unit in a given plant
- Identify and describe a simple control system design (e.g., primary sensing element, controlling element and a final controlled element).

Perform start-up, operation and shutdown of a processing unit in a Lab.

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Basic Test Equipment, Safety Instrumented Systems and Safety/Environmental Processes

This course will allow participants to learn about test equipment used in the daily activities of I/E and specialized test equipment that is used to support Safety and Environmental Processes. Test equipment safety, administration, operation, and application of various test equipment will be emphasized. The proper calibration technique for pneumatic and electronic instruments will be examined and demonstrated.

A significant portion of this course will deal with Safety Instrumented Systems (SIS) and Safety/Environmental Processes. A history of some of the major environmental regulations, how they came about, and how they have impacted the chemical industry will serve as a lead-in to Safety Instrumented Systems, followed by examination of the Most Effective Technology (MET) practices for various process systems. As part of the safety and environmental portion of the course, participants will examine specific instrumentation and test equipment that supports these areas, for example: area monitors, fugitive emission monitors, radiation monitors, and noise monitors.

Test Equipment Learning Objectives

Trainees will be able to:

- Describe Test Equipment Administration - Identification of Instruments, Classification, Calibration and Repair Procedures, Test Equipment Technical Documentation, Stickers, and Storing and Handling.
- Understand and demonstrate Test Equipment Safety - Working on Energized and De-Energized Circuits.
- Demonstrate instrument calibration and use of a Hart communicator (or comparable device).
- Describe basic measurements - Voltage and Current Measurements, Resistance Measurements, Capacitance Measurements, and Inductance Measurements.
- Explain the operation and purpose of instrument air.
- Describe the functionality of the multimeters and types of measurement they are used for.
- Perform hands-on calibrations using various test equipment (multimeters, communicators, calibrators, etc).

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Safety Instrumented Systems Learning Objectives

Trainees will be able to:

- Review incidents where SIS was not installed, failed or disabled
- Examine and discuss factory certifications
- Understand how the logic for SIS instrumentation works
- Examine and evaluate a safety instrument system loop that has process interlocks and discuss how coordination with plant operations is critical
- Understand the fundamental principles of a safety instrumented system per industry MET
- Understand the importance of maintaining a repair history per workplace standards and what should be done
- Perform installation of a level transmitter in accordance with hazardous areas classification and MET practices

Safety/Environment Processes Learning Objectives

Trainees will be able to:

- Review and understand why the Clean Air Act was implemented and its impact on the chemical industry
- Understand fundamental principles of area monitoring instruments
- Review and understand why the Clean Water Act was implemented and its impact on the chemical industry
- Understand fundamental principles of water monitoring systems
- Review and understand why ANSI/ISA84/IEC61511 regulations were implemented and their impact on the chemical industry
- Understand fundamental principles of fugitive emissions monitoring
- Review and understand why the Emergency Planning and the Community Right-to-Know Act came about and its impact on the chemical industry
- Understand Environmental Inspections, Enforcement, and Liability and their impact on the chemical industry
- Understand the portions of OSHA that affect I&E and their impact on the chemical industry
- Understand fundamental principles of noise monitoring devices (Sound Level Meters, Dosimeters, Octave Band Analyzers, and Sound Intensity Analyzers), Non-ionizing Radiation, Infrared Point Sensors, and Explosimeters

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Basic Control Theory

In this course, the basics of control theory will be covered with an emphasis on the use of distributed control systems (DCS) and programmable logic controllers (PLC), but will also include manual, auto, cascade (master/slave), and ratio control. Tuning control loops, reading logic diagrams, and learning to use truth tables and cause& effect tables will also be part of this module.

Learning Objectives

Trainees will be able to:

- Describe the basic concepts of feed forward, feedback control, and basic block function of a feed back control system
- Explain the components of a block diagram
- Define Accuracy, Precision, and Sensitivity
- Explain proportional band gain, reset, integral, rate, and derivative
- Compare and contrast proportional band to gain, reset to integral, and rate to derivative
- Explain the basic modifications to a standard PID control
- Explain the differences between basic process control and a safety-critical system
- Explain the operation of a cascade control system
- Explain the operation of a ratio control
- Describe the operation of control loop adjustments and analysis
- Explain the difference between open loop and closed loop control
- Explain the difference between analog/digital control
- Explain the difference between manual/automatic control
- Explain the difference between on/off control
- Demonstrate how to tune a control loop (temperature, pressure, flow, and level)

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Basic Instrument Documentation and Process Control System Interface

This course is comprise of two (2) important overall objectives. The first one is a review of basic instrumentation documentation. The course will cover the terminology and symbols used in P&ID's, control logic, loop and wiring diagrams. The participant will identify and interpret common instrumentation documentation and examine/discuss hazardous area classification. Change management requires that documentation must be updated after a repair or alteration. Electronic processes used for updating this critical information are company/industry dependent. The capabilities of these information systems will be examined and a demonstration of a common system will be examined.

The second objective will cover a basic overview of process control systems and how the I/E participant will interface. The basic process control system will be reviewed with emphasis on user application and interface. The participant will review the components of a control system. The control systems that will be examined include PLC's and DCS's. Various types of these control systems will be investigated and the functionality of each reviewed. The participant will demonstrate their knowledge of these control systems by implementing control logic they developed.

Instrument Document Learning Objectives

Trainees will be able to:

- Demonstrate how to read a P&ID to determine the control problem
- Identify and interpret ISA instrumentation symbols and diagrams
- Produce a P&ID and a corresponding loop diagram of a selected process.
- Read and interpret process flow diagrams, P&ID's and wiring diagrams
- Identify and interpret common instrumentation documentation (specification sheets, manufacturer's manuals and procedures)
- Know the various types of documentation required for troubleshooting and when their use is applicable
- Define the class and division of hazardous areas
- Update a P&ID and loop diagram to reflect a change in instrumentation

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Process Control System Interface Learning Objectives

Trainees will be able to:

- Understand the role of I/E with in the process control system
- Review and demonstrate digital logic in a programming application.
- Identify and describe how the environment affects the components of the process control system
- Learn and demonstrate controller redundancy
- Compare analog and digital I/O
- Describe the components of a safety instrumented system and control loop
- Understand the trouble shooting process for investigating a SIS loop
- Describe how a human machine interface system functions
- Describe how a distributed control system (DCS) operates and communicates.
- Identify the components and functionality of a DCS
- Describe how a programmable logic controller (PLC) operates and communicates.
- Identify the components and functionality of a PLC
- Compare DCS and PLC process control systems
- Design a control scheme using ladder logic and demonstrate its functionality
- Describe the different types of control loop schemes (feedback, feedforward, ratio, cascade, etc.)
- Demonstrate how to trouble shoot a process control problem
- Install, configure, tune and trouble shoot a single loop controller
- Learn and demonstrate how to do a diagnostic check on a process control system (DCS or PLC)
- Given a live instrumentation and control system, troubleshoot control system and components by using a systematic approach, historical data, information gathered from relevant personnel, process of elimination, cause and effect, isolation of problem to unit operation, drawings, and knowledge of how electrical components work by successfully identifying the source of the problem within a reasonable period time frame

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Projected Course Schedule

Please note that course schedule is subject to change.

Week of…	Module
9/21-25/2009	Basic Level
1/11-15/2010	Basic Flow
4/19-23/2010	Basic Valves
10/18-22/2010	Basic Electronic Instrumentation
11/1-5/2010	Basic Transmitters
2/7-10/2011	Basic Electricity
5/16-20/2011	Basic Process Theory A
5/23-26/2011	Basic Process Plant Science
8/22-26/2011	Basic Process Theory B
8/29-9/1/2011	Basic Test Equipment, SIS and Safety/Environmental Processes
11/28-12/2/2011	Basic Control Theory
12/5-8/2011	Basic Instrumentation Documentation and Process Control System Interface

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