

IICTA

CORE CURRICULUM

Introduction to Instrumentation Technology

An introductory course that may be taught in local high schools and may provide test out option for semi-experienced industry personnel. Pre-requisites: None.

Description

An introductory course providing the concepts of automatic control, occupational analysis of job descriptions, working conditions, employment opportunities, professional certification requirements, and safety considerations in the class and for those employed in the field of industrial instrumentation. Process characteristics, control applications and an introduction to standard instrument symbology, terminology, P&IDs and loop drawings will be presented. Topics include pneumatic, electronic, digital and mechanical devices and systems.

Minimum Learning Outcome

Demonstrate knowledge of the role and responsibility of an instrumentation technician; describe the applications involved with industrial process control, apply principles of instrumentation and use standard instrument system drawings.

Competency:

1. Describe the occupation of an instrument technician.

Objectives:

- a. Explain why automatic control is necessary in process control.
- b. Describe the tasks of an instrumentation technician.
- c. Identify the working conditions associated with instrumentation technicians.
- d. Identify the earnings and work hours of an instrumentation technician.
- e. Identify personal requirements of an instrumentation technician.
- f. Identify personal requirements of an instrumentation technician (technical, interpersonal skills, and effective work planning.)
- g. Explain intolerance of sexual harassment in the workplace.
- h. Explain intolerance of agitation in the workplace.
- i. Explain the need for teamwork in the workplace
- j. Explain intolerance of drugs, firearms and espionage in the workplace.
- k. List the various industries where job opportunities may exist.
- l. List trade publications and organizations.
- m. List career development possibilities.

Competency:

2. Describe measurement devices and symbols used in instrumentation.

Objectives:

- a. Identify various measurement devices and instrument symbols.
- b. Describe the purpose for measurement devices.
- c. Explain the appropriate times for using each device.
- d. Identify instrumentation systems.
- e. Describe the purposes and functions of instrumentation system components.
- f. Recognize standard symbology.
- g. Identify P&IDs for instrument systems.
- h. Identify instrument loop drawings.
- i. Identify instrumentation terminology.
- j. Identify the symbols used in instrumentation documentation.
- k. Identify control system strategies.
- l. Identify a control loop.
- m. Recognize the components of a loop.
- n. Identify information on an instrument drawing.

- o. Recognize the symbols on an instrument drawing.
- p. Describe the use of instrument drawings.
- q. Interpret an instrument drawing.

Competency:

- 3. Describe control devices.

Objectives:

- a. Identify various control devices.
- b. Describe the uses of control devices.

Competency:

- 4. Describe process control loops.

Objectives:

- a. Define terms associated with control loops.
- b. Identify types of control loops.
- c. Describe the application of control loops.

Competency:

- 5. Apply safety procedures in the class and for those employed in the field.

Objectives:

- a. Define safety in industrial workplace context.
- b. Describe the issues involved in personal safety
- c. Explain community safety issues

Competency:

- 6. Utilize safety equipment to ensure a safe workplace

Objectives:

- a. List the types of personal protection equipment (e.g. safety glasses, side shields, safety shoes, gloves, hardhats and FRCs)
- b. Explain the use of personal safety tools
- c. Explain the operation of portable explosimeters
- d. Identify the difference between “continuous” and “spot” explosive measurements
- e. Recognize the role of instrument enclosure purging.

Competency:

- 7. Explain the importance of communications in providing a safe workplace

Objectives:

- a. Define the importance of HAZCOM
- b. Define the methods used for safe communications

Competency:

- 8. Define the concept of safety management in the workplace

Objectives:

- a. Define the importance of PSM
- b. Identify the importance of medical record tracking
- c. Describe the use of evacuation drills to ensure safety in the workplace
- d. Identify the role of the rescue team and fire brigade.

Competency:

9. Recognize the importance of regulatory agencies and tools related to safety in the workplace

Objectives:

- a. Identify the impact of the Occupational Safety and Health Act
- b. Explain the purpose of OSHA
- c. Recognize hazardous area classifications for Class I, II, III, Division 1 and 2
- d. Recognize the purpose of explosion proof equipment
- e. Describe the relationship between explosion proof and intrinsically safe systems
- f. Explain HAZMAT and the format used to convey hazardous material information. (e.g. MSDS (Material Safety Data Sheet))

Competency:

10. Assess typical workplace safety procedures

Objectives:

- a. Explain plant requirement for safety orientation
- b. Identify general procedure and explain safety issues for lockout/tag out
- c. Identify general procedure and explain safety issues for opening and blinding
- d. Identify general procedure for first aid
- e. Identify general procedure for man down
- f. Identify general procedure and explain safety issues for product leakage
- g. Identify general procedure for hurricanes
- h. Identify general procedure for fires
- i. Identify general procedure for evacuation
- j. Identify general procedure and explain safety issues for fall protection
- k. Identify general procedure and explain safety issues for confined space entry
- l. Identify general procedure and explain safety issues for use of respirators
- m. Identify general procedure and explain safety issues for use of breathing air

Competency:

11. Select and use proper hand tools used in the instrumentation technology workplace

Objectives:

- a. Identify hand tools used in instrumentation
- b. Inspect the condition of tools
- c. Utilize hand tools safely
- d. Maintain tools properly
- e. Bend and install tubing and tube fittings for safe, leak proof installations.
- f. Install and tighten connections for safe, leak proof service.
- g. Utilize metal working tools (e.g. layout instruments, hacksaw, files, drills and thread taps)
- h. Thread and install metal pipe and fittings for safe, leak tight installations.

Fundamentals of Industrial Measurement I

The first of two introductory courses that cover the concepts and principles of industrial measurement required for instrument technicians. Pre-requisites: None.

Description

A study of the concepts, principles and devices for the measurement of industrial pressure and level variables.

Minimum Learning Outcome

Apply the principles of process instruments and devices as applied to control and detection of pressure and level. Ability to perform industrial pressure and level measurements.

Competency:

1. Calculate and convert pressure measurements (English and metric units)

Objectives:

- a. Define terms associated with pressure measurement (e.g. work, power, efficiency, energy, potential and kinetic energy, static pressure, absolute and barometric pressure.
- b. Calculate pressure measurements and conversions. (e.g. percentages, cross multiplication problems, instrument scale conversions, head pressure, and force and pressure on a given area.
- c. Define the concepts of pressure
- d. Describe the necessity for pressure measurement in industry
- e. Describe Pascal's law
- f. Describe conditions that affect pressure
- g. Apply live zero concept
- h. Describe the calibration concept

Competency:

2. Describe the principles of operation of pressure sensing devices.

Objectives:

- a. Describe the use of pressure sensing devices.
- b. Explain accuracy, resolution, reproducibility, sensitivity, and responsiveness as applied to pressure measuring devices
- c. Explain the principle of operation of the bourdon tube
- d. Differentiate between c-type, spiral and helical bourdon tubes
- e. Differentiate between u-tube, well, raised well and inclined manometers
- f. Differentiate between diaphragm, capsule and bellows elements
- g. Explain the construction and operation of the strain gauge
- h. Explain the construction and operation of the Wheatstone bridge
- i. Explain the construction and operation of the capacitance cell
- j. List the advantages and disadvantages of differential pressure cells
- k. Describe installation arrangements and designs of pressure sensing devices.
- l. Describe the application of pig-tail siphons.
- m. Explain the role of pressure snubbers.
- n. Explain the use of rupture discs
- o. Describe the importance of chemical seals

Competency:

3. Perform pressure measurements.

Objectives:

- a. Identify the scales used in pressure measurements.
- b. Identify the tools and materials used to make pressure measurements.
- c. Identify pressure sources and instruments used for pressure measurements.
- d. List appropriate safety precautions.
- e. Describe calibration devices and their use
- f. Describe the force balance method of measuring differential pressure
- g. Describe the motion balance method of measuring differential pressure
- h. Describe the applications and limitations of $\ddot{A}P$, absolute, receiver and test gauges
- i. Examine the construction of an electronic $\ddot{A}P$ cell
- j. Disassemble and rebuild a pneumatic $\ddot{A}P$ cell to manufacturer's specifications
- k. Calibrate using a dead weight tester
- l. Calibrate and align a link and lever system and describe operation
- m. Calibrate a pneumatic pressure transmitter
- n. Calibrate an electronic pressure transmitter
- o. Calibrate and explain pressure switches.

Competency:

4. Identify instrument air systems.

Objectives:

- a. Identify instrument air standards, sources, distribution and components.
- b. List appropriate safety precautions.
- c. Identify pneumatics as applied in process control

Competency:

5. Service filters, regulators and dryers in an instrument air supply system.

Objectives:

- a. Identify components of an instrument air system.
- b. Identify tools and materials for servicing instrument air systems.
- c. Describe procedures for servicing instrument air systems.
- d. Describe principles of operation of filters, regulators and dryers
- e. List appropriate safety precautions.
- f. Install and set regulators

Competency:

6. Troubleshoot and repair/replace pressure gauges/indicators.

Objectives:

- a. Identify terms and types of pressure gauges.
- b. Identify equipment, tools, and materials necessary for calibration and troubleshooting.
- c. Demonstrate appropriate safety procedures.
- d. Demonstrate procedures to repair/replace pressure gauges/indicators.

Competency:

7. Troubleshoot and repair/replace pressure transmitters.

Objectives:

- a. Identify terms and types of pressure transmitters.
- b. Identify equipment, tools, and materials necessary for calibration and troubleshooting of pressure transmitters.

- c. Demonstrate appropriate safety procedures.
- d. Align and calibrate a pressure transmitter
- e. Prepare required documentation of test performance

Competency:

8. Troubleshoot and repair/replace pressure transducers.

Objectives:

- a. Identify terms and types of pressure transducers.
- b. Identify equipment, tools, and materials necessary for calibration and troubleshooting of pressure transducers.
- c. Demonstrate appropriate safety procedures.
- d. Demonstrate procedure to repair/replace pressure transducers.

Competency:

9. Calculate and convert level measurements (English and metric units)

Objectives:

- a. Describe the principles of operations of level sensing devices (e.g. zero elevation and suppression, range elevation and suppression, density for liquids and gases, specific gravity, buoyancy),
- b. Calculate level measurements and conversions
- c. Describe the necessity for level measurement in industry
- d. Describe conditions that affect level

Competency:

10. Describe the principles of operations of level sensing devices.

Objectives:

- a. Describe the uses of level sensing devices
- b. Explain accuracy, resolution, reproducibility, sensitivity, and responsiveness as applied to level measuring devices
- c. Explain light refraction in reference to sight glasses.
- d. Identify density of various liquids and gases
- e. Explain specific gravity and convert between common mass-volume units
- f. Calculate problems related to pressure, density and height of liquid
- g. Calculate hydrostatic head pressure
- h. Calculate span and elevation settings
- i. Explain interface level and calculate span

Competency:

11. Perform level measurements.

Objectives:

- a. Identify the scales used in level measurements.
- b. Identify the tools and materials used to make level measurements.
- c. Identify level sources and instruments used for level measurements.
- d. List appropriate safety precautions.
- e. Differentiate between point level and continuous level detection
- f. Differentiate between direct and indirect level measurement
- g. Explain dip stick, float and gauge glass measurement in terms of primary elements.
- h. Describe installation arrangements and designs for optical, float, bubbler, displacer, differential pressure, capacitance probes, ultrasonic and nuclear radiation level instruments

- i. List advantages and disadvantages for optical, float, bubbler, displacer, differential pressure, capacitance probes, ultrasonic and nuclear radiation level instruments
- j. Compare atmospheric and pressurized vessel methods of measuring level

Competency:

12. Troubleshoot and repair/replace level gauges/indicators.

Objectives:

- a. Identify the tools and materials used to make level measurements.
- b. Identify level sources and instruments used for level measurements.
- c. List appropriate safety precautions.
- d. Compare the construction of refractive and see-through gage glasses
- e. Identify the use of gage glasses instruments.
- f. Describe the principle of operation for contacting and non-contacting optical level switches.
- g. Differentiate between a float and a displacer.
- h. Explain a stilling well installation and describe the purpose of each component.
- i. Describe a float and tape level instrument with vapor seal and preventive maintenance techniques.
- j. Describe a bubbler level system including the required supply pressure set
- k. Describe the operating principle of a torque tube.
- l. Describe the operation of a liquid-liquid interface displacer element.
- m. Explain the purpose and characteristics of seal fluids

Competency:

13. Troubleshoot and repair/replace level transmitters.

Objectives:

- a. Identify terms and types of level transmitters.
- b. Identify equipment, tools, and materials necessary for calibration and troubleshooting of level transmitters.
- c. Demonstrate appropriate safety procedures.
- d. Calibrate a level transmitter.
- e. Calibrate and test displacer devices
- f. Calibrate a differential pressure transmitter with elevation and suppression
- g. Prepare required documentation of test performance
- h. Calculate a zero elevation and a zero suppression application
- i. Describe a calibration procedure for an elevation application
- j. Describe a calibration procedure for a suppression application

Competency:

14. Troubleshoot and repair/replace level transducers.

Objectives:

- a. Identify terms and types of level transducers.
- b. Identify equipment, tools and materials necessary for calibration and troubleshooting of level transducers.
- c. Demonstrate appropriate safety procedures.

Competency:

15. Utilize various types of calibration equipment

Objectives:

- a. Identify equipment commonly used in the calibration of instruments – Volt-ohm meters, AC/DC power supplies, pneumatic process simulators, electronic process simulators, dead weight testers, vacuum pump and air supply, precision vacuum and pressure gauges, calibration units, and communicators
- b. Apply proper safety precautions when using calibration equipment.

Fundamentals of Industrial Measurement II

The second of two introductory courses that cover the concepts and principles of industrial measurement required for instrument technicians. Pre-requisites: None

Description

A study of the concepts, principles and devices for the measurement of industrial temperature and flow variables.

Minimum Learning Outcome

Apply the principles of process instruments and devices as applied to control and detection of temperature and flow. Ability to perform industrial temperature and flow measurements.

Competency:

1. Calculate and convert temperature measurements (English and metric units)

Objectives:

- a. Define terms associated with temperature measurement. (e.g. forms of energy, potential and kinetic energy, linear expansion, convection and radiation, conductors and insulators, laws related to heat, absolute zero, coefficient of linear expansion, coefficient of area expansion, coefficient of volume expansion)
- b. Define concepts of temperature. (e.g. sources of heat energy, sensible and latent heat, specific heat, heat of fusion, latent heat of evaporation, boiling point, saturation temperature, superheat, condensation, freezing, heat transfer by conduction, laws of thermodynamics, molecular theory of heat related to the change of state of a substance)
- c. Describe the uses of temperature measurement.
- d. Identify scales used in temperature measurement. (e.g. Fahrenheit, Rankin, Celsius and Kelvin)
- e. Describe conditions that affect temperature

Competency:

2. Describe operating principles of temperature sensing devices.

Objectives:

- a. List four types of temperature primary elements used in industrial applications (i.e. thermometer, thermocouple, RTD and thermistor)
- b. Describe the uses for temperature sensing devices.
- c. Explain accuracy, resolution, reproducibility, sensitivity, and responsiveness as applied to temperature measuring devices
- d. Compare direct and indirect temperature measurement

Competency:

3. Utilize tools and materials needed for temperature measurement.

Objectives:

- a. Identify tools and materials needed for temperature measurement.
- b. Connect temperature sources to temperature instruments.
- c. Apply appropriate safety precautions.

Competency:

4. Troubleshoot and repair/replace temperature indicators, temperature transmitters, and transducers.

Objectives:

- a. Identify terms and types of temperature indicators, transmitters, and transducers.
- b. Identify equipment, tools, and materials necessary for calibration and troubleshooting temperature indicators, transmitters, and transducers (e.g. Volt-ohm meters, AC/DC power supplies, fluidized sand bath, temperature baths, dry block calibrators, air supply, thermocouple calibration devices, decade boxes, precision thermometers and communications equipment)
- c. Demonstrate appropriate safety procedures.
- d. State the calibration standards used for temperature measuring devices
- e. Describe the operation of fluid filled temperature measuring device
- f. Describe head elevation effects, thermowells and transmission lag
- g. Describe the operating principle of a bimetallic thermometer
- h. Explain the principle of operation of an RTD
- i. Compare the characteristics of the metals commonly used in RTDs
- j. Calculate the temperature given the resistance of an RTD
- k. Describe how the Wheatstone bridge is used as a measurement circuit of the RTD
- l. Describe the typical applications for RTDs
- m. List the advantages and limitations of RTDs
- n. Describe the principle of operation of thermistors
- o. Describe the industrial applications of thermistors
- p. Explain the principle of operation of a thermocouple with reference to Seebeck effect, measuring junction, reference junction and emf output
- q. Describe the operation of a thermocouple circuit with reference junction compensation, using the battery equivalent for each point of emf generation
- r. List the types of thermocouples, the materials used for each type and the color codes used for identification
- s. State the characteristics of each type of thermocouple including their advantages, limitations and temperature range
- t. Describe the most common methods of thermocouple installation with reference to terminal blocks, connection heads, protection tubes, extension wires, junction boxes and thermowells
- u. Connect series thermocouples, calculate temperature using the formula and describe the operation
- v. Connect parallel thermocouples with swamping resistors, calculate temperature using the formula and describe the operation
- w. Explain the principle of radiant heat used in optical and infrared pyrometers
- x. List the advantages and limitations of non-contact pyrometers
- y. Explain the difference between a 2-wire, 3-wire, and 4-wire transmitter
- z. Calibrate a voltage to current converter (E/I transducer).
- aa. Calibrate an RTD transmitter.
- bb. Calibrate a thermocouple transmitter.

Competency:

5. Calculate and convert flow measurements. (English and metric units)

Objectives:

- a. Define terms associated with flow (e.g. laws of energy conservation, liquid cohesion, adhesion, capillary action, compressibility and expansion, density, specific volume of fluids and solids, Boyle's and Charles' gas laws, head, differential pressure, range, span, accuracy, rangeability, primary and secondary elements, laminar and turbulent flow, velocity head, pressure head, elevation head, orifice plate, venturi, flow nozzle, pitot tube, annubar, integral orifice)

- b. Identify uses and methods for flow measurements.
- c. Describe conditions that affect flow – viscosity, Reynolds number, beta ratio.
- d. Use a hand calculator to square numbers and find the square root of numbers
- e. Explain why flow measurement is required in industry
- f. List the common units of flow measurement

Competency:

- 6. Describe the principles of operation of flow sensing devices.

Objectives:

- a. Identify types of flow sensing devices (e.g. differential pressure, magnetic, vortex, target, positive displacement, mass, sonic, weirs, flumes, turbine)
- b. Describe the uses of flow sensing devices.
- c. Explain accuracy, resolution, reproducibility, sensitivity, and responsiveness as applied to flow measuring devices

Competency:

- 7. Perform flow measurements.

Objectives:

- a. Identify equipment needed to make flow measurements and differentiate direct and inferential flow devices.
- b. Identify flow measurement scales.
- c. Connect flowing fluids to flow instruments.
- d. Interpret flow results.
- e. List appropriate safety precautions.
- f. Describe pipe taps, flange taps, vena contracta taps, corner taps, D and D/2 taps and layouts for liquid, steam and gas flow measurement
- g. State the upstream and downstream piping requirements
- h. Explain the purpose of straightening vanes
- i. Describe the requirements for seal and condensate pots
- j. List common seal fluids and describe the desirable characteristics of seal fluid
- k. Compare mass flow and volumetric flow
- l. Explain the effect of viscosity on flow measurement

Competency:

- 8. Troubleshoot and repair/replace flow indicators, transmitters and transducers

Objectives:

- a. Identify terms and types of flow indicators.
- b. Identify equipment, tools, and materials necessary for troubleshooting.
- c. Demonstrate appropriate safety procedures.
- d. Compare the advantages and disadvantages of elbow type flow meters
- e. Describe the application of segmental, concentric and eccentric orifice plates
- f. Explain the purpose of the orifice plate weep hole, vent hole and tab or tang
- g. Describe how an annubar is removed from a pressurized line
- h. List the different types and typical applications of rotameters
- i. Explain the principle of operation of the rotameter
- j. Compare the advantages and disadvantages of rotameter devices
- k. State Faraday's Law and use it to explain the operation of a magnetic flow meter
- l. Explain the function of a magnetic flow meter with the aid of a diagram
- m. List methods employed to keep magmeter electrodes free of deposits
- n. Describe the typical applications for magnetic flow meters
- o. Explain the advantages and limitations of magnetic flow meters
- p. Describe the Vortex meters principles of operation

- q. Explain the construction of a vortex shedding flow meter with the aid of a diagram showing the bluff body, the vortices and the sensors
- r. Compare the advantages and disadvantages of vortex meter devices
- s. List the different types and typical applications of vortex meters
- t. Explain the advantages and disadvantages of the target flow meter
- u. Explain the advantages and disadvantages of positive displacement meters
- v. List industrial applications for positive displacement meters
- w. Explain the purpose of a meter prover and why it is used in conjunction with positive displacement meters
- x. Explain the operation of a coriolis mass flow meter
- y. Describe the method of pick-off used in the mass flow meter
- z. List the industrial applications and limitations of the mass flow meter
- aa. Describe the operation of twin turbine, impeller/turbine and thermal mass flow meters
- bb. Describe the operation of a Doppler flow meter
- cc. Explain the advantages and limitations of an ultrasonic flow meter
- dd. Describe the operation of a turbine flow meter and the pick-ups used to detect turbine rotation
- ee. Explain the terms "K" factor, linearity, accuracy and range ability
- ff. Explain the advantages and limitations of a turbine flow meter
- gg. Calibrate a frequency to current converter.
- hh. Calibrate a DP transmitter (pneumatic and electronic)
- ii. Explain the use and operation of square root extractors.
- jj. Explain the use and operation of integrators.
- kk. Explain the use and operation of the totalizer/integrator.

Electrical Fundamentals

An introductory course covering basic AC/DC circuits. Pre-requisites: None

Description

Fundamentals of DC and AC circuits operation including Ohm's law, Kirchoff's laws, networks, transformers, resonance, phasors, capacitive and inductive circuit analysis techniques. Construction and troubleshooting are also included.

Minimum Learning Outcome

The student will analyze DC and AC circuits from simple to complex; construct and make measurements for DC and AC circuits from simple to complex; utilize a multi-meter and oscilloscopes; describe the poly-phase relationships of AC circuits; describe an AC signal with respect to voltage, current and power as seen across a parallel resistive circuit.

Competency:

1. Define symbols, components and schematics associated with DC circuits.

Objectives:

- a. Identify symbols and components of DC circuits.
- b. Recognize direct current schematics.

Competency:

2. Apply the principles of DC voltage.

Objectives:

- a. Explain the sources of DC voltage.
- b. Explain the principles and the operation of batteries.
- c. Measure DC voltage.
- d. Explain shorts and opens.

Competency:

3. Apply the principles of DC current.

Objectives:

- a. Explain the principles of DC current.
- b. State the two requirements for current flow in a circuit
- c. Measure DC current.

Competency:

4. Analyze the principles of DC resistance and conductance.

Objectives:

- a. Explain the principles of DC resistance and conductance.
- b. Compute conductance.
- c. Identify color codes and other descriptors.
- d. Measure resistance.

Competency:

5. Apply the fundamentals of Ohm's Law and associated formulas.

Objectives:

- a. Identify the relationship between voltage, current, and resistance in electrical circuits.
- b. Utilize Ohm's Law formulas.

Competency:

6. Calculate DC power formulas

Objectives:

- a. Define DC power.
- b. Identify the principles of DC power.
- c. Solve DC power formulas.

Competency:

7. Troubleshoot DC series circuits.

Objectives:

- a. Describe concepts of DC series circuits.
- b. Construct DC series circuits.
- c. Calculate values of series circuits.

Competency:

8. Troubleshoot DC parallel circuits.

Objectives:

- a. Describe the principles of DC parallel circuits.
- b. Construct DC parallel circuits.
- c. Calculate values of parallel circuits.

Competency:

9. Troubleshoot DC series-parallel circuits.

Objectives:

- a. Describe the principles of DC series-parallel circuits.
- b. Construct DC series-parallel circuits.
- c. Calculate DC series-parallel circuits.

Competency:

10. Troubleshoot DC bridge circuits.

Objectives:

- a. Define the terms associated with DC bridge circuits.
- b. Describe the use of bridge circuits.
- c. Identify the principles and operations of a Wheatstone bridge.
- d. Draw and construct DC bridge circuits.

Competency:

11. Troubleshoot the operation of DC voltage divider circuits.

Objectives:

- a. Define the terms associated with DC voltage divider circuits.
- b. Describe the uses of DC voltage divider circuits.
- c. Construct DC voltage divider circuits.
- d. Apply the concepts of utilizing DC voltage divider circuits.

Competency:

12. Describe the principles of magnetism.

Objectives:

- a. Define terms correlated with magnetism.
- b. Describe magnetic properties of circuits and devices.
- c. Describe laws and theories associated with magnetism.
- d. Identify the principles and operation of relays and solenoids.

Competency:

13. Define symbols, components and schematics associated with alternating current circuitry.

Objectives:

- a. Identify symbols and components of alternating current.
- b. Recognize alternating current schematics.

Competency:

14. Apply the principles of AC voltage.

Objectives:

- a. Explain the sources of AC voltage.
- b. Explain the principles and operations of AC voltage.
- c. Measure AC voltage.
- d. Explain shorts and opens.
- e. Explain safety considerations when working with AC power

Competency:

15. Measure waveform characteristics of AC current.

Objectives:

- a. Describe the principles and characteristics of AC current.
- b. Demonstrate proper use of AC test instruments.
- c. Display waveform characteristics utilizing oscilloscopes.
- d. Measure waveform characteristics utilizing oscilloscopes.
- e. Define voltage and current regulators

Competency:

16. Analyze the fundamentals of inductance.

Objectives:

- a. Describe the construction of inductors.
- b. Identify inductor symbols.
- c. Describe the physical and electrical characteristics of inductors.
- d. Identify types of inductance.
- e. Calculate appropriate formulas.

Competency:

17. Troubleshoot AC inductive circuits (X_L).

Objectives:

- a. Define terms associated with AC inductive circuits.
- b. Describe the basic concepts of AC inductive circuits
- c. Construct and analyze the effects of AC inductive circuits.
- d. Calculate appropriate formulas.

Competency:

18. Troubleshoot circuits using transformers.

Objectives:

- a. Define terms associated with transformers.
- b. Describe the uses of transformer.
- c. Solve appropriate formulas.
- d. Describe operations of AC circuits using transformers.
- e. Explain the impedance matching theory
- f. Construct AC circuits using transformers.

Competency:

19. Analyze the fundamentals of capacitance.

Objectives:

- a. Review formulas and describe the construction of capacitors.
- b. Identify capacitor symbols.
- c. Describe the physical and electrical characteristics of capacitors.
- d. Identify types of capacitors.
- e. Calculate appropriate formulas.

Competency:

20. Troubleshoot AC capacitive circuits (X_C).

Objectives:

- a. Define terms associated with AC capacitive circuits.
- b. Describe the basic concepts of AC capacitive circuits.
- c. Construct and analyze AC capacitive circuits.
- d. Calculate appropriate formulas.

Competency:

21. Troubleshoot RC and RL series and parallel circuits.

Objectives:

- a. Define terms associated with RC and RL series and parallel circuits.
- b. Solve appropriate formulas.
- c. Construct RC and RL circuits.
- d. Describe the principles and operations of AC differentiator and integrator circuits.
- e. Determine RC and RL time constants.

Competency:

22. Troubleshoot RLC time constants.

Objectives:

- a. Define related terms.
- b. Describe the operation of RLC circuits.
- c. Explain the principles and operations of AC series and parallel resonant circuits.
- d. Specify the concepts of AC frequency selective filter circuits.
- e. Construct RLC series and parallel circuits and AC frequency selective filter circuits.

Competency:

23. Measure AC power.

Objectives:

- a. Define apparent, true, and reactive power.
- b. Demonstrate the use of the power triangle.
- c. Apply appropriate formulas.
- d. Identify the interaction of components in a power source

Competency:

24. Describe the principles associated with motors and generators.

Objectives:

- a. Define the laws and terms associated with motors and generators.
- b. Describe the operations of AC, DC, and universal motors.
- c. Explain the various laws pertaining to motors and generators.
- d. Describe the operations of single and poly-phase AC circuits.
- e. Identify the use and operation of motor phase control circuits.

Industrial Controls I

An intermediate level course that applies all elements of pneumatic and electronic process control loops. Pre-requisite: Introduction to Instrumentation Technology, Fundamentals of Industrial Measurement I and II, Electrical Fundamentals.

Description

A review of measurement theory and includes the principles of operation, connection, maintenance, testing, calibration, troubleshooting and repairing/replacing of pneumatic and electronic analog process controllers, signal transmitters, recorders, alarms and associated test equipment along with annunciator/shutdown systems and introduce the concepts of proportional, integral, and derivative control modes, loop tuning, and documentation.

Minimum Learning Outcome

Explain basic concepts of measurement and process control loops; connect and troubleshoot control loops; interpret P&IDs, wiring and block diagrams.

Competency:

1. Troubleshoot and repair/replace instrument indicators and recorders.

Objectives:

- a. Identify terms and types of pressure, level, temperature and flow indicators
- b. Identify terms and types of pressure, level, temperature and flow recorders
- c. Identify equipment, tools, and materials necessary for calibration and troubleshooting indicators and recorders
- d. Demonstrate appropriate safety procedures.
- e. Describe the operation of various types of indicators and recorders
- f. Replace and calibrate process indicators and recorders
- g. Fill out appropriate documentation per project specifications

Competency:

2. Troubleshoot and repair/replace pneumatic analog controllers.

Objectives:

- a. Define the function of a loop controller
- b. Identify terms associated with pneumatic analog controllers.
- c. Identify types of pneumatic analog controllers.
- d. Describe the operation of pneumatic analog controllers.
- e. Identify the test equipment, tools, and materials needed for troubleshooting.
- f. Describe the calibration procedure for pneumatic analog controllers.
- g. Calibrate a pneumatic controller
- h. Demonstrate appropriate safety procedures.

Competency:

3. Troubleshoot and repair/replace electronic analog controllers.

Objectives:

- a. Identify terms associated with electronic analog controllers.
- b. Identify types of electronic analog controllers.
- c. Describe the operation of electronic analog controllers.
- d. Identify the test equipment, tools, and materials needed for troubleshooting.
- e. Describe the calibration procedure for electronic analog controllers.
- f. Demonstrate appropriate safety procedures.
- g. Calibrate an electronic analog controller

Competency:

4. Troubleshoot, configure and repair digital controllers.

Objectives:

- a. Describe operating principles and circuitry of digital controllers.
- b. Identify test equipment, tools, and materials needed for troubleshooting.
- c. Describe troubleshooting techniques.
- d. Describe configuration of digital controllers.
- e. Configure digital controllers.
- f. Apply appropriate safety procedures.

Competency:

5. Study the concepts of manual and on/off control modes, annunciators and shutdown systems.

Objectives:

- a. Describe the application of auto/manual stations
- b. Describe an on/off controller
- c. List types and purposes of pressure switches
- d. List types and purposes of level switches
- e. List types and purposes of flow switches
- f. List types and purposes of temperature switches
- g. List the types and purpose of annunciators and shutdown systems
- h. Explain high, high-high, low, low-low alarms.

Competency

6. Study the concepts of proportional, integral and derivative control modes

Objectives:

- a. Describe the proportional, integral, and derivative functions
- b. Describe the operation of timing charts
- c. Define feedback, automatic control, measured variable, process variable, controlled variable, manipulated variable, direct acting, reverse acting, open loop, closed loop, manual control, bias and manual reset.
- d. Describe how typical instrumentation is used in control loops.
- e. Sketch typical loop drawings to ISA standards.
- f. Describe loop operation using loop drawings.

Competency:

7. Troubleshoot and repair control loop accessories

Objectives:

- a. Explain the relationship between instrumentation and associated electrical hardware
- b. Identify and test batteries
- c. Verify wiring in a distribution panel
- d. Describe and identify the use of counters
- e. Replace and troubleshoot electric heat tracing system
- f. Certify loop wiring
- g. Apply and identify the use of low voltage breakers and fuses
- h. Replace and describe the operation of relays

Competency:

8. Troubleshoot, calibrate and repair simple proportional control loops

Objectives:

- a. Describe the operation of a proportional controller
- b. Differentiate between gain and proportional band
- c. Convert to/from proportional band and gain
- d. Describe bias and offset as applied to proportional control
- e. Explain the effect of gain on offset
- f. State the limitations of a proportional controller

Competency:

9. Troubleshoot, calibrate and repair proportional plus reset control loops

Objectives:

- a. Describe the operation of a proportional plus reset controller
- b. Describe the reset units of repeats/minute and minutes per repeat
- c. Describe the effect of reset on the gain of the controller
- d. Describe the effect of changing the gain on the reset of the controller
- e. Explain reset wind-up
- f. Explain anti-reset windup and where it must be incorporated

Competency:

10. Troubleshoot, calibrate and repair proportional plus derivative control loops

Objectives:

- a. State the purpose of rate in a controller
- b. Describe other terms used – derivative and pre-act
- c. Describe the effect of changing the gain on the derivative action of the controller
- d. Describe the process applications where rate action is advantageous

Competency

11. Select the appropriate type of controller for various process applications

Objectives:

- a. Identify the type of controller required for flow loops
- b. Identify the type of controller required for pressure loops with approximate settings
- c. Identify the type of controller required for level loops with approximate settings
- d. Identify the type of controller required for temperature loops with approximate settings

Final Controls Elements

An intermediate level course that provides a survey of valve configurations, principles of operation and hands-on work with control valves and variable speed drives (VSD). Pre-requisites: Industrial Controls I.

Description

A study of the various designs of control valves including principles of operation, sizing, selection, servicing pneumatic and electric actuators, positioners, solenoid operated valves, self contained regulators, louvers, dampers, metering pumps and required documentation. Includes instruction in basic techniques and calculations for proper liquid and gas valve sizing and introduces concepts of variable speed drives and frequency speed circuitry.

Minimum Learning Outcome

Describe the operation of various types of final control elements; choose proper valve sizing given the process conditions; service various final control devices.

Competency:

1. Describe the principles of variable speed and frequency drives.

Objectives:

- a. Identify terms associated with variable speed and frequency drives.
- b. Identify types of variable speed and frequency drives.
- c. Describe the applications of variable speed and frequency drives.
- d. Document variable speed and frequency drive connections
- e. Apply appropriate safety precautions

Competency:

2. Troubleshoot and repair control valves.

Objectives:

- a. Identify terms and types of control valves.(e.g. sliding stem and rotary valves)
- b. Define fail-safe mode and operation
- c. Define three flow characteristics (e.g. linier, equal percent, proportional)
- d. Describe valve packing materials and procedures for packing various valves.
- e. Define and discuss principles of operation and construction of various control valves.
- f. Identify equipment, tools, and materials necessary for troubleshooting.
- g. Demonstrate appropriate safety procedures.
- h. Identify various control valves, actuators and positioners using specification sheets, pictures or samples
- i. Recognize procedures to isolate and remove a control valve from service
- j. Dismantle, inspect and replace O-rings, gaskets, diaphragms and packing on conventional control valves
- k. Install gaskets for flange end connections
- l. Bench set, align and stroke control valves with positioners
- m. Define travel and valve stroking

Competency:

3. Troubleshoot and repair control valve bodies.

Objectives:

- a. Describe types of valve bodies
- b. Explain factors for utilizing one type of valve body over another
- c. Explain service procedures
- d. Define valve characteristics and CV (valve coefficient)
- e. Define corrosion, cavitation, flashing and its effect on valve trim.
- f. Disassemble and reassemble a valve body

Competency:

4. Troubleshoot and repair control valve actuators.

Objectives:

- a. Define and discuss principles of operation and construction of various actuators
- b. Describe various types of actuators
- c. Describe service procedures
- d. Disassemble and reassemble a valve actuator

Competency:

5. Troubleshoot and repair control valve positioners.

Objectives:

- a. Identify terms and types of control valve positioners.
- b. Define and discuss principles of operation and construction of various positioners
- c. Define inputs to various types of positioners.
- d. Identify equipment, tools, and materials necessary for troubleshooting.
- e. Demonstrate appropriate safety procedures.
- f. Identify control valve accessories (e.g. solenoids, positioners and metering valves)
- g. Install a valve positioner and associated hardware on a control valve
- h. Describe the operation of common I/P transducers
- i. Demonstrate principle of operation of various positioners
- j. Explain applications of positioners
- k. Configure a valve and positioner for split range
- l. Characterize a control valve and positioner
- m. Describe the principles of operations of self-contained regulators, louvers, dampers and metering pumps

Introduction to Electronics

An introductory course covering digital electronics. Pre-requisites: Electrical Fundamentals.

Description

An introduction to numbering systems, logic gates, digital integrated circuits, Boolean logic operations, flip-flops, counters, registers, combinational/sequential logic, encoders, decoders, display devices, digital to analog conversion, analog to digital conversion, multiplexers, and demultiplexers as they apply to programmable logic controllers, DCS and smart electronic instrument devices.

Minimum Learning Outcome

The student will demonstrate a working knowledge of digital logic gates and functions; use of Boolean algebra; timing logic; and create and analyze truth tables for standard digital functions.

Competency:

1. Perform conversions of various numbering systems.

Objectives:

- a. Define terms associated with the various numbering systems.
- b. Convert numbers in decimal, binary, octal and hexadecimal.

Competency:

2. Analyze various types of digital integrated circuits.

Objectives:

- a. Define terms associated with digital integrated circuits.
- b. Describe the characteristics of digital integrated circuits.
- c. Identify the different families of logic

Competency:

3. Analyze NOT, OR, AND, NAND, NOR, Exclusive OR and Exclusive NOR logic gates.

Objectives:

- a. Describe the operation of each logic gate
- b. Draw and interpret truth tables for each gate type

Competency:

4. Describe Boolean operations and logic.

Objectives:

- a. Define terms associated with Boolean operations and logic.
- b. Describe how to simplify combination/sequential logic circuits using Boolean operations.
- a. Design and draw logic diagrams for Boolean expressions

Competency:

5. Describe the use of Reset-Set (RS), Data (D) and JK flip-flops.

Objectives:

- a. Define associated terms.
- b. Describe the operation of flip-flop circuits.
- c. Interpret truth tables for flip-flops.
- d. Recognize the mode of operation and outputs for flip-flops.
- e. Identify the design and operation of IC latches.

Competency:

6. Describe the principles of shift registers.

Objectives:

- a. Describe the operational characteristics and uses of shift registers.
- b. Identify the characteristics of serial and parallel shift registers.

Competency:

7. Describe the operations of clock and timing circuits.

Objectives:

- a. Describe the principles and characteristics of clock and timing circuits.
- b. Explain the uses of clock and timing circuits.
- c. Analyze timing circuits.

Competency:

8. Troubleshoot and describe the conversions of digital to analog (D-A) and analog to digital (A-D) circuits.

Objectives:

- a. Identify the design and construction of D-A and A-D circuits.
- b. Explain the principles and operation of D-A and A-D circuits.
- c. Analyze D-A and A-D conversions.

Competency:

9. Describe the principles and types of multiplexer and de-multiplexer circuits.

Objectives:

- a. Define terms in conjunction with multiplexer and de-multiplexer circuits.
- b. Describe the operations of multiplexer and de-multiplexer circuits.

Competency:

10. Identify construction and characteristics of semiconductors.

Objectives:

- a. Identify the elements of semiconductor materials.
- b. Describe the characteristics of the semiconductor materials
- c. Describe PN junction diodes.

Competency:

11. Describe the bipolar transistor theory.

Objectives:

- a. Specify types of bipolar transistors.
- b. Identify components of bipolar transistors.
- c. Explain bipolar transistor biasing.
- d. Distinguish between PNP and NPN transistors.
- e. Test PNP and NPN transistors.
- f. Apply technical information from reference manuals.

Competency:

12. Identify and describe special purpose devices.

Objectives:

- a. Identify special diodes and transistors.
- b. Identify symbols for special purpose devices.

Competency:

13. Describe and Identify characteristics of thyristors and explain their functions. e.g. (SCR, Triac, Diac and Unijunction Transistor)

Objectives:

- a. Identify various thyristors and their symbols
- b. Analyze thyristor circuitry.

Competency:

14. Describe and demonstrate the use of operational amplifier.

Objectives:

- a. Identify the various types of op-amps and their uses
- b. Analyze a circuit utilizing op-amp components.

Industrial Controls II

An advanced level course that integrates material from previous courses for constructing, troubleshooting, calibration and repair of control systems. This course may be used as a capstone course. Pre-requisite: Final Control Elements.

Description

A study of process controllers, implementing PID (Proportional, Integral, Derivative) feedback, cascade, ratio, feed forward and auto select/override and introduce other advanced control strategies; study techniques for loop tuning and calibrating process loop components including smart transmitters and field communicators. Loop documentation and drawings will also be used.

Minimum Learning Outcome

Describe the function of process controllers; calibrate and troubleshoot transmitters, recorders, valves and various process controllers.

Competency:

- 1 Troubleshoot and repair PID feedback process control systems

Objectives:

- a. Identify terms associated with process control systems.
- b. Describe the function of proportional, integral, derivative, gain, reset, rate, set point, engineering units, bias, ramping, output limiting, offset, feedback, transient response, and steady state conditions in a control loop.
- c. Document the operation of a feedback control system.
- d. Explain the purpose of bumpless transfer
- e. Explain the difference between set point and load change to system response
- f. Describe the open-loop and closed-loop methods of determining optimum controller settings
- g. Define the circumstances when open-loop or closed-loop methods should be used
- h. Calculate the optimum controller gain, reset and derivative settings
- i. List the criteria for evaluating the performance of a closed-loop control
- j. Describe controller types (P, PI, PD, PID) used on typical processes
- k. Explain the ways in which dead time affects the performance of a feedback controller
- l. List classifications of errors associated with instrument loops
- m. State the significance of a calibration sticker on a device

Competency:

- 2 Troubleshoot and repair a cascade loop

Objectives:

- a. Identify the operation of a cascade control scheme.
- b. Design and configure a cascade loop control system.
- c. Describe the effect of cascading in a system (primary and secondary)
- d. Explain the difference between linear and non-linear system gains
- e. Explain how the effective time constant of the secondary loop is reduced with cascade control
- f. Sketch a block diagram of a cascade control loop.
- g. List advantages or uses for cascade control
- h. Describe the most common forms of secondary control loops
- i. Describe the correct method for tuning cascade control loop.
- j. Commission and tune a cascade loop.

Competency:

3. Troubleshoot and configure a ratio control system

Objectives:

- a. Identify the operation of a ratio control loop.
- b. Design and configure a ratio control parameter for operation in a process control environment.
- c. Document the process of developing ratio control loops.
- d. Describe the operation of a differential gap controller
- e. Calculate loop values for a common flow ratio loop.
- f. Explain the difference between linear and square root stations
- g. Explain the range of ratio station settings.

Competency:

4. Troubleshoot and repair/configure feed forward control schemes

Objectives:

- a. Identify the operation of a feed forward control system.
- b. Configure a feed forward control parameter for a process environment.
- c. Document the process of configuring a feed forward control system.
- d. Relate feedback trim requirements to feed forward control applications

Competency:

5. Troubleshoot and repair/configure an auto select/override control scheme.

Objectives:

- a. Identify the operation of an auto select/override control scheme.
- b. Calculate the proper settings for optimum override control.
- c. Demonstrate the methods used in selecting auto select/override parameters.
- d. Explain the principle of split range and selective control

Competency:

6. Troubleshoot and perform loop tuning techniques to stabilize a process operation.

Objectives:

- a. Identify the signs of tuning problems.
- b. Demonstrate the steps of tuning a loop.
- c. Solve process instabilities related to an imbalance in the control scheme.
- d. Explain the term quarter amplitude decay
- e. Describe the reaction curve method used for controller tuning
- f. Describe the Ziegler-Nichols method for controller tuning
- g. Determine suitable control settings to stabilize a process.
- h. Describe dynamic and steady state compensation
- i. Explain the principle of decoupling control procedures
- j. Define the operating principles and applications of self-tuning and adaptive gain

Competency:

7. Calibrate process loop components

Objectives:

- a. Identify the components of a control loop.
- b. Demonstrate the use of proper test equipment, tools and material.
- c. Document calibration process per manufacture and industry procedures.
- d. Recognize the importance of using certified test equipment on specific components.

Competency:

8. Troubleshoot and repair smart transmitters and smart valve positioners.

Objectives:

- a. Demonstrate the use of proper test equipment.
- b. Configure and calibrate smart transmitters and smart positioners
- c. Document results
- d. Analyze resistance values for control loops.

Competency:

9. Differentiate the use of field communication devices.

Objectives:

- a. Identify the different types of field communication devices.
- b. Select proper communication device for the specific task.
- c. Recognize the function of specific devices.
- d. Recognize the different protocols. (Hart/Honeywell DE)

Competency:

10. Demonstrate the process of loop documentation.

Objectives:

- a. Interpret a loop diagram
- b. Draw a loop diagram based on installed equipment (as built)
- c. Certify a control loop as operational

Competency:

11. Demonstrate knowledge in the use of instrument drawings.

Objectives:

- a. Draw/sketch/redline instrument drawings based on installed equipment.
- b. Interpret ladder diagrams and wiring diagrams.
- c. Recognize P&ID significance in instrumentation.
- d. Recognize the significance of loop sheets in instrumentation.

Competency:

12. Demonstrate knowledge in the use of instrument specification sheets

Objectives:

- a. Define information required to develop a valid instrument specification sheet
- b. Interpret an instrument specification sheet
- c. Prepare an instrument specification sheets for flow, pressure, level and temperature measurement
- d. Prepare an instrument specification sheets for valves and valve accessories to include smart positioners
- e. Specify instruments to control various processes
- f. Identify calculations necessary for instrument specification (e.g. scaling, spanning, valve selection and sizing)

Competency:

13. Demonstrate knowledge in the use of an engineering package

Objectives:

- a. Define information required to develop a valid engineering package
- b. Define all documentation used to create an engineering package
- c. Interpret an engineering package
- d. Prepare an engineering package
- e. Plan a conceptual project developed from the instructor model.
- f. Develop a Bill of Material.
- g. Sketch loop, isometric, wiring and other diagrams as required.
- h. Develop specific action sheets.
- i. Develop installation instructions.

Competency:

14. Analyze engineering packages using instrumentation drawings and documentation

Objectives:

- a. Explain the purpose of electrical prints
- b. Describe how electrical prints are organized
- c. Identify all parts of a print title block
- d. Identify the print revision number and currency
- e. Explain the purpose of drawing footnotes
- f. State the purpose of legend diagrams
- g. Identify the information available on a one-line diagram
- h. Identify the information available on a wiring diagram
- i. Identify the information available on an electrical raceway drawing
- j. Identify the information available on a P&ID
- k. Identify the information available on a location drawing
- l. Identify the information available on loop sheets
- m. Identify the information available on instrument data sheets
- n. Identify the information available on a ladder diagram
- o. Identify the information available on flow diagrams
- p. Identify the information available on isometrics
- q. Select instruments from vendor's catalogs to comply with specifications

Competency:

15. Explain the basics of PLC and distributed control

Objectives:

- a. Describe the history of the PLC
- b. Explain the sequencer concept
- c. Define ladder logic
- d. Describe batch processes and batch manufacturing
- e. Describe a process suited for PLC control
- f. Explain the function of and applications of distributed control
- g. Discuss the concepts of distributed control
- h. List the operating features of a distributed control system

Competency:

16. Review advanced topics in process control theory

Objectives:

- a. Contrast the terms direct and inferred measurement
- b. Differentiate between the terms range and span
- c. Differentiate between the terms elevated zero and suppressed zero
- d. Analyze the following characteristics of process measurements – accuracy, resolution, sensitivity, dead band, dead time, time constant, hysteresis, conformity, linearity
- e. Contrast the terms regulatory, advanced/supervisory controls.