Energy Systems Instrumentation & Control Technician - Tier 6 Competencies

January 1

2009

This document has recommended job specific competencies for the Energy Systems Instrumentation & Control Technician. This document is in Draft form and should not be Copied nor Distributed.

Energy Systems Instrumentation and Control Technician

Developed by the Idaho State University Energy Systems Technology and Education Center

Tier 6
Occupation – Specific Knowledge Areas

Laboratory and Tools

- Given the program's laboratory and tool list, locate and identify the listed items.
- Given the program's Hazardous Materials List, locate and identify listed containers.
- Locate Material Date Safety Sheets (MSDS) for each.
- Locate and identify Fire, First Aid, and Emergency Equipment.
- Identify the proper equipment and materials for using through-hole soldering and de-soldering.
- Discuss the proper set-up and operation of an oscilloscope and probes.
- Discuss the different display types used in test equipment.
- Discuss oscilloscope block diagram
- Describe the functions of each control knob and push button of the oscilloscope
- Examine the basic internal circuits of an oscilloscope
- Describe triggering techniques
- Discuss scope probes and proper use and calibration of the probe
- Discuss Cathode ray tube
- Discuss Liquid crystal display
- Discuss Plasma displays

Batteries

- Identify different types of electrochemical sources
- Describe "memory" conditions of batteries
- Describe disposal of used or expired portable batteries.

DC Circuits

- Using a simple electrical circuit and the power formulas, apply Ohm's Law to solve for voltage,
- resistance, current, or power.
- Determine the value and tolerance of components from color codes and markings
- Match components to electronic symbols
- Identify components by physical appearance, shape or configuration or measurement with test equipment.
- Describe safety procedures for using test equipment.
- Define short circuit.
- Define open circuit.
- Determine shorts, opens, using resistance readings
- Determine shorts, opens, using voltage readings
- Determine shorts, opens, using current readings
- Calculate total resistance, total current, total voltage, and total power in series DC circuits.

- Calculate individual voltage drops, power consumed by each component, current flow through each component in series DC circuits.
- Calculate total resistance and total power in parallel circuits
- Calculate current flow in each branch of a parallel circuit
- Calculate voltage drop across each component in a parallel circuit
- Use voltage divider formula.
- Use current divider formula.
- Graph Ohm's law results.
- Use Kirchhoff's voltage law to analyze series DC circuits.
- Use Kirchhoff's voltage law to analyze parallel DC circuits.
- Use Kirchhoff's voltage law to analyze series-parallel DC circuits.
- Calculate total resistance in series-parallel DC circuits
- Calculate voltage drops in series-parallel DC circuits
- Calculate current through each component in series-parallel DC circuits
- Calculate power for each component in series-parallel DC circuits
- Calculate individual resistor values
- Calculate total power in series-parallel DC circuits
- Determine circuit conditions in loaded voltage divider circuits
- Analyze circuit conditions in bridge circuits
- Troubleshoot and repair series-parallel DC circuits
- Use network theorems and laws such as Thevenin, Norton, Superposition, Kirchhoff Voltage and Current to analyze a series-parallel DC circuit
- Discuss loading effects of test equipment
- Demonstrate maximum power transfer.

Electronic Components

- Identify a resistor, capacitor and an inductor and draw the schematic symbol.
- Discuss how physical dimensions and materials affect capacitance.
- Discuss the electrostatic field within a capacitor.
- Calculate total capacitance in series.
- Calculate total capacitance in parallel.
- Discuss effects of stray capacitance.
- Calculate voltage and current in capacitive circuits.
- Evaluate RC time constants.
- Analyze RC time constant graphs.
- Discuss effects of physical factors on inductance.
- Calculate inductance in terms of physical characteristics.
- Calculate inductance in terms of electrical characteristics.
- Discuss the effects of an electromagnetic field on an inductor.
- Calculate induced voltage in the coil.
- Calculate total inductance in series.
- Calculate total inductance in parallel.
- Discuss effects of stray inductance.
- Evaluate RL time constants and their effect on pulsating DC circuits.

- Calculate voltage and current in inductive circuits.
- Analyze RL time constant graphs.
- Calculate time constant of RC circuit
- Calculate voltage and current in RC circuit
- Discuss RC differentiator circuits
- Discuss RC integrator circuits
- Use appropriate network analysis methods to determine RC time constants in pulsed series-parallel circuit
- Demonstrate applicable laws for RC circuits
- Graph the predicted wave shape across components.
- Calculate time constant of RL circuits
- Calculate voltage and current in RL circuits
- Discuss RL differentiator circuits
- Discuss RL integrator circuits
- Evaluate RL time constants and their effect on pulsed DC circuits.
- Describe the principle and operation of RC circuits
- Describe the principle and operation of RL circuits.
- Describe how to troubleshoot and repair RC circuits
- Describe how to troubleshoot and repair RL circuits.
- Describe the characteristics of RLC circuits (series, parallel, and complex)
- Describe how to troubleshoot and repair RLC circuits.

AC Circuits

- Draw and label sine waveform
- Determine peak voltage of a waveform
- Determine peak-to-peak voltage of waveform
- Determine the effective voltage of waveform
- Determine average voltage of waveform
- Calculate frequency of sine wave
- Calculate phase relationship
- Calculate the period of the sine wave
- Calculate instantaneous voltages and currents
- Identify non-sinusoidal waveforms by name
- Discuss effects of stray capacitance in RC circuit
- Describe the properties of a RC circuit that affect the frequency response
- Discuss effects of stray capacitance in RL circuit
- Describe the properties of a RL circuit that affect the frequency response
- Describe the characteristics of series and parallel resonant circuits
- Describe the principle and operation of filter circuits
- Describe the procedure to troubleshoot and repair filter circuits.

Transformers

- Describe the principles of operation of various types of transformers.
- Describe the various types of transformers and their applications.

- Describe the procedure to troubleshoot and repair transformer circuits.

AC/DC Generators

- Describe the purpose of AC/DC generators
- Compare AC generators to DC generators
- Describe the purpose of poly-phase generator circuits.
- Given the appropriate reference materials and equipment, describe the theory and operation of AC/DC generation.

Semiconductors

- Describe the construction of semiconductor diodes, draw the schematic symbols, draw the current flows and test the device with an ohm meter.
- Analyze and explain the different configurations of diodes.
- Draw and label input and output wave forms showing voltage levels and time reference.
- Describe how to troubleshoot the different configurations of diodes.
- Describe PN Junction Diodes.
- Describe crystalline structure of diodes.
- Explain types of diodes junctions.
- Explain Biasing of diodes.
- Analyze Characteristic Curves.
- Describe Conventional Current Flow through a diode.
- Describe Electron Current Flow through a diode.
- Identify Diode Symbol(s).
- Describe Barrier Potential (Depletion Region) and Bulk Resistance of a silicon diode.
- Describe Barrier Potential (Depletion Region) and Bulk Resistance of a Germanium diode.
- Explain methods of Diode Checking using an Ohmmeter.
- Explain methods of Diode Checking using a Curve tracer.
- Explain other methods of checking diodes for proper operation.
- Discuss Special Purpose Diodes.
- Describe the operation of Zener diodes.
- Explain and analyze LED's (light emitting diode)
- Describe Photo Diodes
- Describe Varactor Diodes
- Describe Switching Diodes
- Analyze and explain the different configurations of clippers and clampers.
- Draw and label input and output wave forms showing voltage levels and time reference.
- Analyze Clippers
- Describe input and output waveforms for Series clippers.
- Describe input and output waveforms for Shunt clippers.
- Describe input and output waveforms for Biased Clippers.
- Analyze Clampers
- Describe input and output waveforms for Non-Biased Clampers
- Describe input and output waveforms for Biased Clampers
- Describe the proper procedures when troubleshooting both Clippers and Clampers

- Analyze and explain the different configurations of power supplies and filters.
- Draw and label input and output wave forms showing voltage levels and time reference.
- Memorize the formulas needed to predict AC and DC parameters for all of the power supply configurations.
- Describe the basic operation of power supplies.
- Explain Half Wave Rectification (Series Clippers).
- Analyze Average DC output and P-P output for Half Wave Rectification.
- Explain advantages of Line Isolation Transformers.
- Explain the Fuse in Line Isolation Transformers.
- Describe Full Wave Rectification.
- Analyze Average DC output and P-P output.
- Describe Bridge Circuits.
- Describe Filter Circuits.
- Describe Ripple.
- Show calculations of Time Constant Analysis.
- Demonstrate Sine Wave Analysis.
- Analyze Pi RC power supplies.
- Analyze Pi LC power supplies.
- Describe In-Rush Current.
- Analyze a power supply containing a Zener Diode.
- Explain the characteristics of a power supply containing a Zener diode.
- Reference Voltages
- Explain Voltage Regulation.
- Analyze Voltage Multipliers.
- Analyze Doublers, Tripler's, and Quadrupler's,
- Describe Troubleshooting procedures pertaining to Power Supplies.
- Explain Symptoms.
- Describe Repair Procedures and Safety Precautions
- Describe Troubleshooting procedures pertaining to various filters.
- Explain Symptoms.

Transistors

- Describe the construction of a transistor.
- Draw a schematic of a transistor. Label all parts and the current flows.
- Examine BJT Structure
- Describe elements of transistor structure
- Describe doping of emitter, base, collector region (PNP NPN)
- Describe the importance of physical size of emitter, base, and collector regions
- Describe electrical equivalent of using two diodes
- Describe ohmmeter testing.
- Analyze variable resistor model.
- Correctly identify BJT Schematic Symbols
- Draw NPN terminals and symbols
- Draw PNP terminals and symbols

- Examine Biasing of BJTs
- Describe forward and Reverse junction biasing
- Draw Current Flows (Alpha and Beta)
- Identify, calculate and draw the biasing arrangements with load lines (NPN and PNP)
- Describe and calculate Bias Stability of Base Bias
- Describe and calculate Bias Stability of Voltage Divider Bias
- Describe and calculate Bias Stability of Collector Feedback Bias
- Describe and calculate Bias Stability of Emitter Self Bias
- Analyze the effects of an emitter stabilization resistor.
- Analyze DC/AC Load Line for a Common Emitter Amplifier
- Describe Current Gain Analysis
- Describe Voltage Gain Analysis
- Describe Power Gain Analysis
- Explain Impedance characteristics for a Common Emitter Amplifier
- Calculate voltage input for a Common Emitter Amplifier
- Calculate voltage output for a Common Emitter Amplifier
- Analyze CB (common base) and CC (common collector) Configurations
- Explain Configuration Characteristics
- Analyze Voltage gain for amplifier configurations
- Analyze Current gain for amplifier configurations
- Analyze Power gain for amplifier configurations
- Calculate Input and output Impedance for amplifier configurations
- Discuss Phase relationships.
- Describe using Transistors as switches
- Describe High Side Switch (PNP)
- Describe Low Side Switch (NPN)
- Examine JFET construction, operation, and characteristics
- Examine and calculate DC and AC parameters
- Discuss precautions of handling ESD
- Discuss precautions of handling Wrist straps
- Discuss precautions of handling Static mats
- Discuss precautions of handling Packaging
- Predict device operation using characteristic curves
- Calculate and analyze DC biasing methods
- Examine the operation and characteristics of the JFET amplifier
- Calculate and analyze amplifier configurations
- Analyze impedance characteristics
- Discuss and calculate gain characteristics of each configuration
- Discuss and calculate frequency response of each configuration
- Examine MOSFET construction, operation, and characteristics
- Examine the operation and characteristics of the MOSFET amplifier
- Examine and calculate DC and AC parameters
- Analyze impedance characteristics
- Discuss applications and advantages of MOSFET amplifiers

- Describe methods of ohm-meter testing and comparison of FET devices

Amplifiers

- Calculate gains of individual stage.
- Derive overall gain calculations
- Analyze direct coupling techniques
- Analyze capacitive coupling techniques
- Calculate impedance and loading effect of combined stages
- Calculate and analyze frequency response of combined stages.
- Determine low critical response
- Determine high critical response
- Determine overall frequency response
- Discuss Rise time method
- Discuss Phase shift method
- Discuss Half power method
- Discuss design criteria
- Discuss Input impedance criteria
- Discuss Output impedance criteria
- Discuss Intermediate stage matching.
- Discuss possible problems
- Discuss Positive feedback and decoupling networks
- Discuss Distortion of signal.
- Predict, calculate, and analyze the effects of combining multiple amplifier stages together
- Discuss the Characteristics of operational amplifiers
- Explain Ideal Amplifiers
- Discuss High Open Loop Gain of operational amplifiers
- Discuss Input Impedance
- Discuss Output Impedance
- Explain Rules of Operation for operational amplifiers
- Discuss No Signal Current in to or Out of the Inputs of operational amplifiers
- Discuss With negative feedback the Output will do whatever it can to equalize the two inputs
- Explain Step by Step Analysis
- Discuss Input Offset Voltage
- Discuss Input Bias Current
- Discuss Input Offset Current
- Discuss CMRR
- Discuss Short-Circuit Output Current
- Discuss Gain Bandwidth Product
- Discuss Slew Rate of operational amplifiers
- Discuss Output Swing (Rail to Rail)
- Discuss Configurations of operational amplifiers
- Analyze Comparator
- Analyze Inverting Amplifier
- Analyze Voltage Follower

- Analyze Non-Inverting Amplifier
- Analyze Summing Amplifier
- Analyze a Scalar Amp
- Analyze a Averaging Amp
- Analyze a Subtractor
- Analyze an Integrator
- Analyze a Differentiator
- Analyze Multi-stage operational amplifiers
- Predict, calculate, and analyze operational amplifier circuits and discuss the advantages and disadvantages

Sinusoidal Oscillators and Multivibrators

- Analyze an RLC oscillator circuit
- Design one-shot, astable and bi-stable multiviorators to instructor specifications

Logic

- Measure propagation delays
- Calculate noise immunity
- Measure and, calculate loading effects
- Analyze, implement, and minimize combinational logic.
- Explore properties and dynamic operation of combinational gates.
- Write Boolean equations for combinational logic applications.
- Utilize Boolean algebra laws and rules for simplifying combinational logic circuits.
- Apply De'Morgans theorem to complex equations to arrive at simplified equivalent equations.
- Design single gate logic circuits
- Explain universal capability of NAND and NOR gates.
- Utilize the Karnaugh mapping procedure to systematically reduce complex Boolean equations to their simplest form.
- Explain analyze and use adders, use Comparator, build and use decoders and encoders, use multiplexers and demultiplexers, and use parity checkers
- Draw the logic circuit, schematic symbol, and develop the truth table for an S/R flip-flop.
- Draw the logic circuit, schematic symbol, and develop the truth table for a clocked S/R flip-flop.
- Discover through experimentation how a switch bounces.
- Use NAND gates for switch de-bouncing circuits. Build, test and prove that it works.
- Draw the logic circuit and develop the truth table for a D flip-flop.
- Draw the logic circuit and schematic symbols and truth tables for an edge triggered and master slave J-K flip-flops.
- Explain or describe and use flip-flops to count, use decade counters, analyze and design special count sequences, analyze shift register functions, construct and use Ring and Johnson counters.

The Superhetrodyne AM Receiver

- Document radio construction

- Document radio alignment.
- Document radio testing procedures

Relay Control

- Explain the function of an electro-mechanical relay
- Identify the contact operation of an electro-mechanical
- Give operational requirements and design relay logic to meet the requirements
- Convert logic to and from Boolean, using logic gates and relay

Motor Starters

- Explain the function of a magnetic motor starter.
- Identify the contact operation of a magnetic motor starter.

Analog Process Measurement

- Explain the function of a transmitter
- Identify acceptable tolerance limits in transmitter calibration
- Calculate zero, span and intermediate calibration points
- Explain the basic operation, calibration, and troubleshooting procedure of 4-20mA transmitters.

Tool Proficiency

- Explain basic use of common selected hand and power tools and be able to use those tools to fabricate components and perform common tasks associated with work as an I&C technician.

Relay Logic and Programmable Logic Controllers (PLC)

- Display knowledge of relay logic and PLC equipment functions, applications, components, operations and maintenance.
- Describe the function and operation of control relays
- Describe the functions of a PLC.
- State the functions of PLC equipment.
- Describe how control relays PLCs are operated and maintained.
- List the normal PLC operating parameters.
- Given a PLC, Identify the controller(s), input/output rack(s), input/output module(s), and battery module, batteries, and chassis power

- **Single and Poly Phase Motors**
- Describe the functions of single and poly-phase motors
- Explain the operational principles of various single and poly phase motors
- State the functions of the single and poly-phase motors
- Describe how the single and poly-phase motor is operated and maintained
- List the normal single and poly-phase motor operating parameters

- **Low Voltage Breakers**
- Describe the functions of the low voltage breaker.
- State, from memory, the functions of the low voltage breaker equipment.

- Describe how the low voltage breaker is operated and maintained.
- List the normal low voltage breaker operating parameters.
- Explain equipment functions, applications, components, operations and maintenance associated with low voltage breaker

- **Medium Voltage Breakers**
- Describe the functions of the low voltage breaker.
- State, from memory, the functions of the low voltage breaker equipment.
- Describe how the low voltage breaker is operated and maintained.
- List the normal low voltage breaker operating parameters.
- Explain equipment functions, applications, components, operations and maintenance associated with low voltage breaker

Variable Frequency Drives

- State, from memory, the functions of the Variable Frequency Drives.
- Describe how the variable frequency drives is operated and maintained.
- List the normal variable frequency drives operating parameters.
- Explain and demonstrate variable frequency drive equipment functions, applications, components, operations and maintenance.

Protective Relays

- Describe the functions of protective relays
- State, from memory, the functions of the protective relay equipment
- Describe how the protective relay is operated and maintained
- List the normal protective relay operating parameters
- Explain protective relay equipment functions, applications, components, operations and maintenance

Process Control Switches

- Describe the functions of process control switches.
- State, from memory, the functions of the process control switch equipment.
- Describe how the process control switch is operated and maintained.
- List the normal process control switch operating parameters.
- Explain how process control switch equipment functions, its applications, components, operations and maintenance.

Station Batteries

- Describe the functions of the station batteries.
- State, from memory, the functions of the station batteries equipment.
- Describe how the station batteries are operated and maintained.
- List the normal station batteries operating parameters.
- Explain how the Station Battery equipment functions, its applications, components, operations and maintenance.

Speed, Displacement and Vibration Measurements

- Explain the objectives of machine monitoring

- Define key terms used in discussing speed, displacement and vibration monitoring
- Discuss the factors in a mechanical system to be considered when selecting the parameters to monitor
- Differentiate between rotor motion and housing motion related problems
- Discuss factors to be considered when selecting transducers for vibration monitoring
- Explain the engineering units used in the measurement of speed, displacement and vibration
- Explain the advantages/disadvantages of different types of transducers
- Explain the function and theory of operation of the velocity vibration transducer
- Explain the function and theory of operation of accelerometer type vibration transducers
- Explain the function and theory of operation of non-contact pickups
- Explain the function and theory of operation of Linear Variable Displacement Transformers (LVDTs) as displacement transducers
- Describe the function and theory of operation of potentiometers as displacement transducers
- Describe speed sensor types and their applications
- Determine any special precautions or safety considerations that must be observed when performing maintenance on speed/vibration/displacement sensors and identify any applicable human performance tools and traps
- Review applicable plant and industry events
- Demonstrate understanding of common instrumentation used for measuring speed, displacement and vibration of power plant equipment and explain the theory of operation of each.

Cable and Wire Termination

- State, from memory, the functions of the cable and wire termination equipment.
- Draw a simplified arrangement of the cable and wire termination equipment.
- Describe how the cable and wire termination equipment is operated and maintained.
- List the normal cable and wire termination operating parameters.
- Demonstrate knowledge and skill in cable and wire termination kit equipment functions, components and use.

Fasteners

- Define the following:

1. Fastener
2. Bolt
3. Screw
4. Stud
5. Washer
6. Nut

- Define the two purposes that a bolt serves
- Define the following:

1. Preload
2. Tensile Stress
3. Tensional Stress
4. Bending Stress
5. Embedment Relaxation

6. Elastic Body
7. Plastic Body
8. Proof Strength

- Given definitions of failures and failure terms, match the problem created by incorrect preload with the appropriate definitions
- Explain vibration loosening
- Describe the sequence of fatigue failure
- Explain why casketed joints leak
- Define gasket stress
- Explain the factors that affect preload accuracy
- Describe the unique characteristics (advantages vs. disadvantages) of the following tools:

1. Manual Torque Wrenches
2. Torque Multipliers
3. Geared Torque
4. Hydraulic Wrenches
5. Impact Wrenches
6. Nut Runners
7. Air Powered Torque Wrenches

- Using the Torturing table demonstrate purpose of a torque wrench
- Given necessary data demonstrate the proper method of using the torque wrench
- Given the appropriate formula perform a torque conversion calculation
- Given necessary data demonstrate proper torque wrench setting to achieve desired final applied torque to a fastener, using adapters and extensions
- Given necessary data demonstrate the proper use of multipliers
- Discuss inspection of fastener mating surfaces for conditions that could adversely affect proper fastener tightening
- List fastener installation criteria
- Determine fastener reuse criteria
- Determine proper thread engagement
- Explain thread specifications
- Summarize applicable Operating Events, Plant Procedures, Condition Reports, etc associated with Fasteners
- Describe and demonstrate how to torque various fasteners and equipment.

Thermodynamics and Heat Exchangers

- Use steam tables to determine the heat input in and output of steam and water systems
- Describe the functions of various heat exchangers
- Calculate heat exchangers efficiencies, determine heat exchanger performance and verify performance to vender specifications
- Evaluate heat balances for possible problems and identify areas of unexpected thermal performance.
- Demonstrate knowledgeable of the fundamentals of thermodynamics and the function of heat exchangers.

Temperature Transmitters

- Describe the functions of the temperature transmitter
- State, from memory, the functions of the temperature transmitter equipment
- Describe how the temperature transmitter is operated and maintained
- List the normal temperature transmitter operating parameters
- Demonstrate knowledge of temperature transmitter equipment functions, applications, components, operations and maintenance.

Pressure Transmitter

- Describe the functions of the pressure transmitters
- State, from memory, the functions of pressure transmitter equipment
- Describe how the pressure transmitter is operated and maintained
- List the normal pressure transmitter operating parameters.
- Demonstrate knowledge of pressure transmitter equipment functions, applications, components, operations and maintenance.

Level Transmitter

- Describe the functions of level transmitters
- State, from memory, the functions of the level transmitter equipment
- Describe how the level transmitter is operated and maintained
- List the normal level transmitter operating parameters
- Demonstrate knowledge of level transmitter equipment functions, applications, components, operations and maintenance.

Flow Transmitter

- Describe the functions of the flow transmitters
- State, from memory, the functions of the flow transmitter equipment
- Describe how the flow transmitter is operated and maintained
- List the normal flow transmitter operating parameters
- Demonstrate knowledge of flow transmitter equipment functions, applications, components, operations and maintenance.

Tubing, Fittings, and Tube-Line Fabrication

- Describe the fittings, tubing and valves typically used in instrumentation work. The student is to properly describe the installation of tubing and fittings to manufacturer's specifications.
- Describe the tube bending process typically used in instrumentation work. The student is to properly describe the tube bending process to include layout, support, fabrication / bending, and cutting.
- Discuss the various Operating Experiences associated with tubing.
- Recognize advantages of tubing over pipe
- Identify the 2 most common tubing materials used in permanent installations
- Identify the most common tubing material used for instrument testing and state its nominal burst strength
- Define the dimension by which tubing is measured

- From a list, select an appropriate method of straightening tubing
- Recognize good tubing handling practices
- Recognize the considerations for selecting proper tubing materials
- Describe a Swagelok fitting
- Identify the sizes of tubing common to instrumentation
- Identify the function of common tubing fittings:
    a. Union
    b. Tee
    c. Elbow
    d. Pipe to tubing
- Identify common tubing valve types and give examples of their applications. (12)
- Identify the most important part of any clamping system used to support tubing
- State the most critical point for a tubing support
- Describe the 2 most common tools used to cut tubing
- Describe FME practices for tubing and tubing fittings
- When bending tubing, identify the basis for measurement for all bends after the initial bend
- Describe the characteristics of a well-made tubing circuit
- Define spring back
- Describe the assembly process for tubing fittings
- Describe the proper usage of Parker and Swagelok inspection gauges
- State the hazards of over-tightening a compression fitting
- Describe the fitting remake process
- Describe good radiation work practices for removal of existing tubing
- Demonstrate an understanding of the process of selection, use and fabrication of tubing and fittings for the installation of instrument lines.

Controllers

- Given a process loop, identify the components, purposes and functions of each
- Given a process loop, describe its overall operation while demonstrating knowledge of process loop definitions and proper terminology
- Provided with a symbol, recognize the implied control mode
- Explain individual component gains and how they affect loop gain
- Distinguish between proportional only action curves and proportional plus reset action curves (time versus input/output relationships)
- Distinguish between the proportional plus integral curves compared to the proportional plus integral plus derivative response for a changing process signal
- Given a process loop, calculate the gain of a controller in terms of percent proportional band or gain
- Predict the effects of integral action of a controller for a given step change of the process variable
- Demonstrate an understanding of the various principles associated with control parameters.

Valves, Actuators and Positioners.

- Identify three major types of plug and seat designs and describe the inherent flow characteristics curves of each

- Explain why valve process application can require different types of actuators
- Identify conditions that affect "bench set"
- Explain the advantages and disadvantages of using positioners compared to actuators only with addition of booster relays
- Explain the principle of operation of the Fisher 3582
- Explain the principle of operation of the Fisher 546
- Explain the principle of operation of the Fisher 3570
- Explain the principle of operation of the Bailey Positioners
- Identify problems which affect the operation of a final control device such as component failure, dirty instrument air and water in the air system
- Demonstrate a knowledgeable of valve positioning system applications, including different types of valve construction and flow characteristics.

Pneumatic Valve Positioners

- Describe the functions of pneumatic valve positioner.
- State, from memory, the functions of the pneumatic valve positioner equipment.
- Describe how the pneumatic valve positioner is operated and maintained.
- List the normal pneumatic valve positioner operating parameters.
- Demonstrate a knowledge of pneumatic valve positioner equipment functions, applications, components, operations and maintenance

Electric Valve Positioners

- Describe the functions of electric valve positioner
- State, from memory, the functions of the electric valve positioner equipment
- Describe how the electric valve positioners is operated and maintained
- List the normal electric valve positioner operating parameters
- Demonstrate a knowledge of electric valve positioner equipment functions, applications, components, operations and maintenance.

Analytical Transmitters

- Describe the functions of the analytical transmitters
- State, from memory, the functions of the analytical transmitter equipment
- Describe how the analytical transmitter is operated and maintained
- List the normal analytical transmitter operating parameters.
- Demonstrate a knowledge of analytical transmitter equipment functions, applications, components, operations and maintenance.

Boiler, Reactor and Turbine Fundamentals

- Describe the basic components of a boiler fuel, air, steam and water systems
- Identify excess air requirements for various operational conditions
- Explain the fuel/air control system, the feed water system; drum level control and burner control systems
- Explain the quantum mechanics of energy production through fast, intermediate and thermal fission
- Explain the fundamental operation principles of PWR and BWR reactor plants

- Explain the major principles of the nuclear chain reaction control
- Identify radiation types
- Explain the basic radiological fundamentals and radiation protection concepts.
- Explain the difference(s) between Radiation and Contamination.
- Explain the Administrative Control (ACL) for whole body?
- Identify relative risks of exposure to radiation and radioactive materials, including prenatal radiation exposure.
- State the methods used to control radiological material.
- Describe the basic safety systems of a nuclear reactor
- Describe the fundamentals of steam and gas turbine operation
- Explain the Carnot, Rankin and Brayton cycles
- Draw and explain a pressure/velocity diagram for a variety of turbine types
- Explain the fundamentals of steam and gas turbine control and supervisory systems

Tier 7
Occupation – Specific Technical Competencies

Laboratory and Tool Usage and Safety

- Demonstrate proper usage of laboratory components.
- Identify hand tools.
- Demonstrate proper use of the hand tools.
- Demonstrate safety with power tools.
- Demonstrate safety with hazardous materials.
- Demonstrate safe procedures when troubleshooting.
- Demonstrate knowledge of accessibility of first aid equipment.
- Demonstrate knowledge of energy isolation procedures.
- Demonstrate the proper care of soldering and de-soldering equipment.
- Identify the proper equipment and materials for using through-hole soldering and de-soldering.
- Use the proper techniques for soldering and de-soldering on printed circuit boards with
- through-hole components.
- Identify the proper equipment and materials for using surface mount device soldering and
- de-soldering techniques.
- Use the proper techniques for soldering and de-soldering on printed circuit boards with surface
- mount devices.
- Demonstrate proper usage and operation of an oscilloscope.
- Demonstrate proper usage and operation Cathode ray tube
- Demonstrate proper usage and operation Liquid crystal display
- Demonstrate proper usage and operation Plasma displays

Batteries

- Using appropriate test equipment, determine the operating condition of the electrochemical sources (batteries).

DC Circuits

- Demonstrate proper use of electronic test equipment to determine correct circuit parameters such as voltage, current, and resistance
- Set up and operate DC power supplies.
- Demonstrate the procedure to troubleshoot and repair series DC circuits.
- Demonstrate the procedure to troubleshoot and repair parallel DC circuits.
- Demonstrate the procedure to troubleshoot and repair series-parallel DC circuits.

Electronic Components

- Given the appropriate reference materials, determine the physical and electrical characteristics of capacitors in DC circuits.
- Given the appropriate reference materials, determine the physical and electrical characteristics of inductors in DC circuits.
- Given the appropriate reference materials and circuits, demonstrate applicable laws for RC network analysis.
- Given the appropriate reference materials and circuit, demonstrate applicable laws for RL network analysis.
- Demonstrate the operation of RC circuits
- Demonstrate the operation of RL circuits
- Demonstrate the operation of RLC circuits (series, parallel and complex)

AC Circuits

- Given the appropriate reference materials and equipment, analyze the characteristics of waveforms.
- Demonstrate the operation of series and parallel resonant circuits
- Demonstrate the operation of filter circuits

Transformers

- Demonstrate the operation of transformer circuits.

AC/DC Generators

- Demonstrate an understanding of the operation of generators
- Using proper test equipment, test and identify generator electrical faults
- Using proper test equipment, test and identify exciter electrical faults
- Adjust generator exciter to obtain specified VAR production

Semiconductors

- Practice proper Troubleshooting techniques of diodes.
- Practice proper Troubleshooting techniques of clippers and clampers.
- Practice proper Troubleshooting techniques of power supplies.
- Practice proper Troubleshooting techniques of various filters

Transistors

- Build a transistor circuit and test for proper operation using approved test equipment.

- Using a BJT circuit, practice proper troubleshooting techniques of all of the bias circuits.
- Using available components, build an FET circuit
- Practice proper troubleshooting techniques for various FET circuits.

Amplifiers

- Using available components, build a multistage amplifier circuit.
- Practice proper troubleshooting techniques on multiple stage amplifier circuits
- Using available components, build an operational amplifier circuit.
- Practice proper troubleshooting techniques on operational stage amplifier circuits

Sinusoidal Oscillators and Multivibrators

- Build an RLC oscillator circuit
- Demonstrate an understanding of fundamental oscillator circuitry including; RLC circuits, sinusoidal and non-sinusoidal oscillators.

Logic

- Demonstrate operational knowledge of logic gates such as the Inverter, AND, OR, NOR, NAND.
- Using available components, build single and multiple gate logic circuits and test their operation
- Describe the operation, pin out, and function of each pin for a comparator chip (7485).
- Build and test the comparator chip to compare two 4-bit numbers and light an LED for each of the three output conditions.
- Build and test a circuit using comparators and any other basic gates that are needed to turn on a single LED when a four bit number is less than 8 or greater than 12.
- Describe the operation, pin out, and truth table for an Exclusive OR and Exclusive NOR gate.
- Show, build, and test how an exclusive OR gate can be used as a switchable buffer/inverter gate with a square wave signal on the input.
- Describe the purpose and operation of an odd and even Parity Generator and Checker.
- Show in your lab book how to build a 4-bit Odd parity generator and checker using exclusive OR and NOR gates.
- Describe the function of a decoder and encoder.
- Describe the operation, build and test a circuit using decoder and encoder chips (74138 and 74147) and prove their function tables.
- Describe the operation, pin out, and function of the 7447 decoder and the 7-Segment display.
- Design, build and test a circuit that takes a decimal number input and displays it on a 7-Seg display. (Use a 74147, 7447, and the 7-Seg display for this project)
- Describe the function and uses of multiplexers and demultiplexers.
- Connect and test a 74151 multiplexer and a 74138 demultiplexers to show how they work.
- Show how a 74151 multiplexer can be connected to the 74138 demultiplexers to transmit and receive data.
- Describe the function and uses of code converters.
- Design, build, and test a circuit that converts gray code data that is coming off a decoder wheel on a robot arm, to binary to go to a computer processor.
- Explain, construct and use a S-R flip-flop, construct master slave flip-flops, use “D” flip-

flops, and use one-shot multi vibrator.
- Design and construct an asynchronous counter using flip-flops to count 0-15.
- Display the output count in binary using LEDs.
- Modify the counter above to a MOD 11 counter.
- Design and construct a synchronous counter (MOD 16) and (MOD 12).
- Display the output count in binary using LEDs.
- Design and construct a decade counter and display the output on a 7-segment display.
- Describe the pin out and operation of an up/down counter chip. Connect the chip and display the count on a seven segment display.

The Superhetrodyne AM Receiver

- Demonstrate an understanding of the principles of amplitude modulation with respect to transmission, reception, modulation and detection and receiver circuitry utilizing a block diagram.

Relay Control

- Construct operational relay control circuits based on given circuit requirements.

Motor Starters

- Given operational requirements, design relay logic interface with a magnetic motor starter.

Analog Process Measurement

- Calibrate a temperature transmitter
- Calibrate a pressure transmitter
- Calibrate a flow transmitter
- Calibrate a level transmitter

Tool Proficiency

- Cut metal stock to specified dimensions and angles
- Use a tap and die to install fasteners
- Demonstrate proper use of a torque wrench
- Cut and tread carbon steel pipe
- Remove stripped/broken screws and bolts
- Bend tubing to specification using standard benders
- Properly install compression fittings
- perform leak tests and pressure tests
- Make penetrations in metal plates for installation of electrical devices
- Demonstrate proper use of wrenches, screw drivers, drills, drill presses, threaders, pipe and tube cutters, hammers, saws and punches

Relay Logic and Programmable Logic Controllers (PLC)

Given a PLC:

- Demonstrate preparation of PLC circuit per maintenance procedure (e.g., power to the PLC is off, correct replacement batteries are available, estimates of battery life are conducted)

- Demonstrate operational checks for operation of the PLC per maintenance procedure (e.g., ladder programming; battery leakage, life and module life checks)
- Demonstrate proper of use diagnostic and test equipment
- Given a process specification, design I/O and write relay logic to comply with the performance specification
- Install relays and wire as prescribed to meet performance specifications
- Given a process specification, design I/O and write ladder logic to comply with the performance specification
- Document, I/O wiring, ladder logic and project information
- Construct HMI interface commands using vender software to interface a PLC to a HMI

Single and Poly Phase Motors

Given a single and poly-phase or motor and associated circuits:

1. Isolate power to motor and identify: yoke or frame assembly, stator winding, end bells or bearing brackets, bearings, brush assembly (synchronous motor only), and rotor
2. Demonstrate ability to prepare work area, verify power is isolated and ensure correct replacement parts are available.
3. Demonstrate proper use of appropriate maintenance procedure to perform assigned maintenance (e.g., preventive maintenance or corrective maintenance)
4. Demonstrate proper of use diagnostic and test equipment
5. Utilize all required safety precautions

Low Voltage Breakers

Given a low voltage distribution box breaker circuit, associated single phase circuit, and a breaker bench test setup:

1. Identify breaker operating mechanism, pole units, main contacts, arcing contacts, arc chutes, automatic tripping system
2. Demonstrate proper isolation and removal of the low voltage breaker
3. Using applicable maintenance procedure, demonstrate bench testing of the breaker
4. Demonstrate proper disassembly, inspection, cleaning and lubricating of the breaker
5. Demonstrate proper of use diagnostic and test equipment
6. Utilize all required safety precautions

Medium Voltage Breakers

Given a medium voltage breaker in a distribution panel, and associated single and poly-phase circuit:

1. Identify breaker stored energy mechanism, pole units, contacts, arc chutes, interphase barriers, levering-in device, puffer, shutter roller, secondary contacts, interlocks
2. Using applicable maintenance procedure with breaker racked to test position, demonstrate functional checks of breaker closing and opening features, verifying appropriate component responses (e.g., breaker in test position, shutters closed, UV trip, springs, associated controls and trip device testing, etc.)
3. Demonstrate proper isolation of the medium voltage breaker prior to its removal from the switchgear cabinet
4. Demonstrate proper removal, disassembly, inspection, cleaning and lubricating of the breaker
5. Demonstrate proper of use diagnostic and test equipment
6. Utilize all required safety precautions

Variable Frequency Drives

Given a variable frequency drive circuit and associated circuit:

1. Identify the AC motor, controller, operator interface and VFD circuit breaker
2. Demonstrate safe preparation for maintenance activities, (e.g., VFD is isolated from power source ≥ specified time before servicing drive as capacitors retain charge after power is removed, and work area prepared and spare parts available)
3. Using applicable maintenance procedure, demonstrate inspection and functional checks of VFD.
4. Demonstrate proper cleaning, voltage and frequency checks and system adjustments
5. Demonstrate proper of use diagnostic and test equipment
6. Utilize all required safety precautions

Protective Relays

Given a protective relay and associated circuit:

1. Isolate power to protective relay and identify: cradle/case, induction unit and instantaneous unit
2. Demonstrate ability to prepare work area, verify power is isolated and ensure correct replacement parts are available
3. Demonstrate proper use of appropriate maintenance procedure to perform assigned maintenance (e.g., preventive maintenance or corrective maintenance)
4. Demonstrate proper of use diagnostic and test equipment
5. Utilize all required safety precautions

Process Control Switches

Given a process control switch, instrument circuit, and maintenance procedure,

1. Identify the sensor housing, pressure sensing element and switching element, circuit power supply, process fluid isolation device
2. Demonstrate isolation of process control switch (electrical and process circuits)
3. Demonstrate performance of the following maintenance actions:
    a. Static "O" ring process control switch calibration
    b. Adjustable dead band process control switch calibration
    c. Disassembly and inspection, then reassembly
    d. Static "O" ring process control switch recalibration
    e. Adjustable dead band process control switch recalibration
4. Demonstrate proper of use diagnostic and test equipment
5. Utilize all required safety precautions

Station Batteries

Given access to a simulated station battery bank system,

1. Identify station battery, battery cells, battery charger(s), AC power breaker, DC power breaker, equalizing charge timer
2. Explain special safety precautions necessary when working on battery systems (e.g., PPE, safety station availability, use of non-sparking tools, high short circuit current potential, flammable off gas, chemical hazards, etc)
3. Using the system operating procedure, walkthrough the following battery systems operations:
    a. Charger startup

    b. Charger normal operations
    c. Charger shutdown
4. Perform the following battery preventative maintenance checks/actions
    a. Battery electrolyte level
    b. Battery electrolyte specific gravity
    c. Clean battery terminals/connections
    d. Charger inspection
5. Explain when battery cell replacement should be done and accomplished
6. Demonstrate proper of use diagnostic and test equipment
7. Utilize all required safety precautions

Speed, Displacement and Vibration Measurements

Using selected speed, displacement and vibration equipment vendor manuals:

1. Demonstrate selected speed, displacement and vibration equipment preventive maintenance, consisting of routine and troubleshooting techniques
2. Demonstrate isolation of an assigned speed, displacement or vibration system (electrical and process circuits)
3. Demonstrate performance of corrective maintenance consisting of component disassembly, inspection, cleaning, component replacement, reassembly and lubrication
4. Demonstrate proper of use diagnostic and test equipment
5. Utilize all required safety precautions

Cable and Wire Termination

Given a access to cables used in power distribution, a wire termination kit and equipment used for cable termination:

1. Identify/explain the following
    a. Types of cables used in distribution
    b. Use of contents in a termination kit
    c. Equipment used for cable termination
    d. Type(s) of torches that may be used
2. Perform the following cable and wire terminations:
    a. Low voltage unshielded cable and wire
    b. Cable shielded with copper tape
    c. Cable shielded with wire
    d. UniShield cable
    e. Cable shielded with lead
    f. Outdoor cable
3. Demonstrate application of the following:
    a. Stress relief material (SRM) to a cable
    b. Grounding of cable shielding
    c. Placing a HV tube on a cable
4. Demonstrate proper use of appropriate maintenance procedure to perform assigned maintenance
5. Demonstrate proper of use diagnostic and test equipment
6. Utilize all required safety precautions

Fasteners

Using selected torquing equipment manuals and a typical component/system maintenance procedure that requires torquing:

1. Demonstrate understanding of component preparation, tool selection, procedure, documentation of a given valve typically used in power plant applications
2. Demonstrate performance of corrective maintenance on a component damaged by improper torquing applications
3. Demonstrate proper of use torque multipliers and other special equipment
4. Utilize all required safety precautions

Thermodynamics and Heat Exchangers

- Take data in the lab used in thermodynamic calculations and perform those calculations.
- Demonstrate techniques for venting heat exchangers

Temperature Transmitters

Using a Temperature Transmitter and associated system components:

1. Identify the sensor housing, TT-Sensor, electronics module, terminal board, display and power supply.
2. Demonstrate preventive maintenance, consisting of the maintenance activities listed below. Refer to maintenance procedure for complete description.
    a. Troubleshoot malfunction
    b. Online testing
    c. Temperature transmitter setup
    d. Trimming analog output
3. Demonstrate isolation of temperature transmitter (electrical and process circuits)
4. Demonstrate performance of corrective maintenance consisting of component disassembly, inspection, cleaning, component replacement and reassembly. Refer to maintenance procedure.
5. Demonstrate proper of use diagnostic and test equipment
6. Utilize all required safety precautions

Pressure Transmitter

Given a pressure transmitter, instrument circuit, and maintenance procedure:

1. Identify the sensor housing, PT-Sensor, electronics module, terminal board, display and power supply
2. Demonstrate preventive maintenance, consisting of extensive troubleshooting diagnostic checks. (e.g., transmitter does not communicate, loop wiring, I.S. barrier, impulse piping, power supply, transmitter electronics, sensing element, process pulsation, etc). Refer to maintenance procedure for complete troubleshooting list.
3. Demonstrate isolation of pressure transmitter (electrical and process circuits)
4. Demonstrate performance of corrective maintenance consisting of component disassembly, inspection, cleaning, component replacement and reassembly. Refer to maintenance procedure
5. Demonstrate proper of use diagnostic and test equipment
6. Utilize all required safety precautions

Level Transmitter

Given a level transmitter, instrument circuit, and maintenance procedure:

1. Identify the level sensor housing, probes, electronics module, terminal board, display and power supply.
2. Demonstrate preventive maintenance, consisting of extensive troubleshooting vary with instrument manufacturer. Refer to maintenance procedure for complete troubleshooting list.
    a. LEVEL, percent output, and loop values are all inaccurate
    b. LEVEL readings are repeatable but consistently high or low from actual by a fixed amount
    c. LEVEL, percent output, and loop values fluctuate
    d. LEVEL, % output, and loop values all reading low vs. actual
    e. LEVEL reading on display is correct but loop is stuck on 4 ma
    f. LEVEL reading on display is stuck at full scale; loop is stuck at 20.
3. Demonstrate performance of corrective maintenance consisting of component disassembly, inspection, cleaning, component replacement and reassembly. Refer to maintenance procedure.
4. Demonstrate proper of use diagnostic and test equipment
5. Utilize all required safety precautions

Flow Transmitter

Given a flow transmitter, instrument circuit, and maintenance procedure:

1. Identify the sensor housing, FT-Sensor, electronics module, terminal board and display and power supply.
2. Demonstrate preventive maintenance, consisting of extensive troubleshooting diagnostic checks. (e.g., Transmitter does not communicate, loop wiring, I.S. Barrier, impulse piping, power supply, transmitter electronics, sensing element, process pulsation, etc). Refer to maintenance procedure for complete troubleshooting list.
3. Demonstrate isolation of flow transmitter (electrical and process circuits)
4. Demonstrate performance of corrective maintenance consisting of component disassembly, inspection, cleaning, component replacement and reassembly. Refer to maintenance procedure.
5. Demonstrate proper of use diagnostic and test equipment
6. Utilize all required safety precautions

Tubing, Fittings, and Tube-Line Fabrication

- Given a new fitting, state the proper number of turns to tighten the fitting
- Given an engineering drawing (P&ID), fabricate an instrument tubing system from a given system tap point to the instrument sensor.
- Test and place the instrument in service.
- Explain the process steps typically observed in power plant setting for the replacement of an existing faulty instrument line.

Controllers

Using selected controller vendor manuals:

1. Demonstrate controller and associated loop preventive maintenance, consisting of routine and troubleshooting techniques

2. Demonstrate isolation of an assigned control loop (electrical and process circuits)
3. Demonstrate performance of corrective maintenance consisting of component disassembly, inspection, cleaning, component replacement, reassembly and lubrication
4. Demonstrate proper of use diagnostic and test equipment
5. Utilize all required safety precautions

Valves, Actuators and Positioners.

- Identify pneumatic and electric valve components
- Operate a pneumatic and electric valve from remote and local locations
- Given a maintenance procedure, disassemble and reassemble a pneumatic or electric valve

Pneumatic Valve Positioners

Given a pneumatic valve positioner, associated equipment, and maintenance procedure:

1. Identify the pneumatic valve positioner bellows assembly, beam, positioner relays, bias spring and adjusting screw, and range spring
2. Demonstrate preventive maintenance, consisting of the maintenance activities listed below. Refer to maintenance procedure for complete description.
    a. Troubleshoot malfunction
    b. Online testing
    c. Temperature transmitter setup
    d. Trimming analog output
    e. Cylinder connection
    f. Vent connection
    g. Supply pressure connection
    h. Instrument/controller connection
3. Demonstrate isolation of pneumatic valve positioner (electrical and process circuits)
4. Demonstrate performance of corrective maintenance consisting of component disassembly, inspection, cleaning, component replacement and reassembly. Refer to maintenance procedure
5. Demonstrate proper of use diagnostic and test equipment
6. Utilize all required safety precautions

Electric Valve Positioners

Given an electric valve positioner, associated equipment, and maintenance procedure:

1. Identify electric valve positioner housing, control motor, gear train, self locking mechanism, handwheel, hand switch, micro switches, contactless position sensor (CPS-2) and digital control module (DCM)
2. Demonstrate preventive maintenance, consisting of the maintenance activities listed below. Refer to maintenance procedure for complete description.
    a. Setting overtravel limit switches
    b. Setting auxiliary switches
    c. DCM board calibration procedure
    d. Lubrication
3. Demonstrate isolation of electric valve positioner (electrical and process circuits)

4. Demonstrate performance of corrective maintenance consisting of component disassembly, inspection, cleaning, component replacement, reassembly and lubrication. Refer to maintenance procedure.
5. Demonstrate proper of use diagnostic and test equipment
6. Utilize all required safety precautions

Analytical Transmitters

(For Oxygen, Conductivity, pH, Combustible gasses, CO, NOX, SOX transmitters)
Given a analytical transmitter, instrument circuit, and maintenance procedure:

1. Identify the sensor housing, analytical Sensor, electronics module, terminal board and display and power supply.
2. Demonstrate preventive maintenance, consisting of extensive troubleshooting diagnostic checks. (e.g., Transmitter does not communicate, loop wiring, I.S. Barrier, impulse piping, power supply, transmitter electronics, sensing element, process pulsation, etc). Refer to maintenance procedure for complete troubleshooting list.
3. Demonstrate isolation of analytical transmitter (electrical and process circuits)
4. Demonstrate performance of corrective maintenance consisting of component disassembly, inspection, cleaning, component replacement and reassembly. Refer to maintenance procedure.
- Demonstrate proper of use diagnostic and test equipment
5. Utilize all required safety precautions

Boiler, Reactor and Turbine Fundamentals

Give thermal performance data:
Calculate Boiler, turbine and reactor thermal outputs and efficiencies

Tier 8
Occupation – Specific Requirements

Laboratory Safety

- Given a set of safety standards, the student will demonstrate compliance by practical demonstration in laboratory setting.

Soldering

- Given a circuit board with through-hole and surface mount devices, demonstrate the proper techniques of soldering and de-soldering.

DC Circuits

- Follow proper procedure to troubleshoot, replace or repair equipment using properly identified electronic replacement components.
- Using applicable analog and digital test equipment, measure properties of a circuit to determine if a fault exists within the circuit.
- Using applicable test equipment taking readings on a series DC circuit, apply the appropriate laws to determine if the circuit is operating properly.
- Using applicable test equipment taking readings on a parallel DC circuit, apply the

appropriate laws to determine if the circuit is operating properly.
- Using applicable test equipment taking readings on a series-parallel DC circuit, apply the appropriate laws to determine if the circuit is operating properly.

Components
- Using applicable test equipment, determine if a capacitor in a circuit is functioning correctly.
- Using applicable test equipment, determine if an inductor in a circuit is functioning correctly.
- Using applicable test equipment, determine if an RC Network in a circuit is functioning correctly.
- Using applicable test equipment, determine if an RL Network in a circuit is functioning correctly.
- Given the RC circuit and test equipment, troubleshoot and repair circuit.
- Given the RL circuit and test equipment, troubleshoot and repair circuit.
- Given an RLC circuit and test equipment, troubleshoot and repair RLC circuit.

AC Circuits
- Using applicable test equipment, including an Oscilloscope, verify calculations and predictions of wave shape and size for specified AC voltage supply.
- Given appropriate reference materials, tools and equipment, troubleshoot and repair a specified AC circuit.

Transformers
- Given the appropriate reference information and test equipment, troubleshoot and repair faulty transformer circuits.

AC/DC Generators

- Following a technical manual, conduct inspection and maintenance on specified generators

Semiconductors
- Given a circuit consisting of various diode configurations and applicable test instruments, the student will troubleshoot and recommend a repair plan for the circuit.
- Given a circuit consisting of various Clipper and Clamper configurations and applicable test instruments, the student will troubleshoot and recommend a repair plan for the circuit.
- Given a circuit consisting of various power supply configurations and applicable test instruments, the student will troubleshoot and recommend a repair plan for the circuit.
- Given a circuit consisting of various filter configurations and applicable test instruments, the student will troubleshoot and recommend a repair plan for the circuit.

Transistors
- Given a BJT circuit, calculate and analyze the four types of biasing configurations and describe the characteristics of each.
- Given a faulty BJT circuit, troubleshoot and repair circuit using applicable test equipment.
- Given a BJT circuit, calculate and analyze the different transistor amplifier configurations and describe the characteristics of each.

- Given a field effect transistor circuit, calculate and analyze the transistor configurations and describe the characteristics of each.

Amplifiers

- Given a multistage amplifier circuit, troubleshoot and repair the circuit using applicable test equipment.
- Given an operational amplifier circuit, troubleshoot and repair the circuit using applicable test equipment.

Sinusoidal Oscillators and Multivibrators

- Given applicable test equipment, demonstrate troubleshooting procedures for Hartley and RC oscillators.

Logic

- Given a basic logic circuit, troubleshoot and recommend repair procedures using proper test equipment.
- Given a faulty logic circuit and applicable test equipment, troubleshoot and repair circuit.
- Given a faulty comparator circuit and applicable test equipment, troubleshoot and repair circuit.
- Given a faulty decoder or encoder circuit and applicable test equipment, troubleshoot and repair circuit.
- Given a faulty multiplexer or demultiplexers circuit and applicable test equipment, troubleshoot and repair circuit.

The Superhetrodyne AM Receiver

- Describe and perform troubleshooting procedures for a Superhetrodyne receiver.

Relay Control

- Given a faulty relay circuit, use test equipment to troubleshoot and repair relay circuit.

Motor Starters

- Demonstrate knowledge of the operation and maintenance of a magnetic motor starter.
- Given a faulty motor starter, use test equipment to troubleshoot and repair motor starter.

Analog Process Measurement

- Identify, troubleshoot and describe needed repairs for faulty 4-20mA transmitter.

Tool Proficiency

- Given a tool proficiency task with failed pressure test, determine location of leak and develop a repair plan to correct leak.

Relay Logic and Programmable Logic Controllers (PLC)

- Given a relay logic controller, detect and repair fault in controller.
- Given a programmable logic controller (PLC), detect and repair fault in controller.

Single and Poly Phase Motors

- Using all safety precautions, correctly connect motor to corresponding controller and demonstrate proper operation
- Detect and repair faulty wiring connections in accordance with all associated safety precautions.

Low Voltage Breakers

- Given a low voltage distribution box breaker circuit, associated single phase circuit, and a breaker bench test setup, troubleshoot and repair faulty circuit or component.

Medium Voltage Breakers

- Given a medium voltage breaker circuit in a distribution panel, associated single and poly phase circuit, and associated test equipment , troubleshoot and repair faulty circuit or component.

Variable Frequency Drives

- Given a variable frequency drive circuit, associated circuit and test equipment, verify proper operation, detect and repair any faults associated with equipment.

Protective Relays

- Given a protective relay assembly, associated circuit and test equipment, verify proper operation, detect and repair any faults associated with relay assembly.

Process Control Switches

- Given a process control switch, instrument circuit, and maintenance procedure, verify proper operation of control switch, detect and repair any faults with equipment.

Station Batteries

- Given access to a simulated station battery bank system, demonstrate corrective actions and notifications for out of specification readings of normal parameters.

Speed, Displacement and Vibration Measurements

- Identify components in lab that require measurements as part of maintenance procedure
- Conduct measurements on required equipment
- Analyze results and make required adjustments to maintain acceptable vibration levels

Cable and Wire Termination

- Identify locations in the lab where wire termination requirements apply and verify they are properly terminated.
-

Fasteners

- Identify locations in the lab where fasteners are required to be torque and visually verify or through documentation they were completed.

Thermodynamics and Heat Exchangers

- Take data in the lab used in thermodynamic calculations and perform those calculations.

Temperature Transmitters

- Given a temperature transmitter, instrument circuit, and maintenance procedure, detect and identify any faults with equipment and identify repair or replacement plan.

Pressure Transmitter

- Given a pressure transmitter, instrument circuit, and maintenance procedure, detect and identify any faults with equipment and identify repair or replacement plan.

Level Transmitter

- Given a level transmitter, instrument circuit, and maintenance procedure, detect and identify any faults with equipment and identify repair or replacement plan.

Flow Transmitter

- Given a flow transmitter, instrument circuit, and maintenance procedure, detect and identify any faults with equipment and identify repair or replacement plan.

Tubing, Fittings, and Tube-Line Fabrication

- Identify locations in the lab where tube-line fabrication requirements apply and verify the line and fittings were properly installed.

Controllers

- Given a controller and associated equipment, detect and repair any faults associated with the equipment.

Valves, Actuators and Positioners.

- Given a faulty or defective component, identify problem and recommend corrective action.

Pneumatic Valve Positioners

- Given a faulty or defective component, identify problem and recommend corrective action.

Electric Valve Positioners

- Given a faulty or defective component, identify problem and recommend corrective action.

Analytical Transmitters

- Given a faulty or defective component, identify problem and recommend corrective action.

Boiler, Reactor and Turbine Fundamentals

- Using installed instrumentation conduct a heat balance of a coal of gas fired boiler
- Determine optimal combustion air for a coal of gas fired boiler