



NCCER

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INDUSTRIAL MAINTENANCE E&I TECHNICIAN

Competencies / Objectives

Level One

MODULE 40101-07 – ORIENTATION TO THE TRADE

1. Describe the types of work performed by industrial maintenance craftworkers.
2. Identify career opportunities available to industrial maintenance craftworkers.
3. Explain the purpose and objectives of an apprentice training program.
4. Explain the responsibilities and characteristics of a good industrial maintenance craftworker.
5. Explain the importance of safety in relation to industrial maintenance craftworkers.
6. Explain the role of NCCER in the training process.

MODULE 40102-07 – TOOLS OF THE TRADE

1. Explain the purpose of each of the tools commonly used by industrial maintenance craftworkers.
2. Describe how to maintain each of the tools used by industrial maintenance craftworkers.
3. Demonstrate the proper use and basic maintenance of selected industrial maintenance tools.

MODULE 40103-07 – FASTENERS AND ANCHORS

1. Identify and explain the use of threaded fasteners.
2. Identify and explain the use of non-threaded fasteners.
3. Identify and explain the use of anchors.
4. Select the correct fasteners and anchors for given applications.
5. Install fasteners and anchors.

MODULE 40104-07 – OXYFUEL CUTTING

1. Identify and explain the use of oxyfuel cutting equipment.
2. State the safety precautions for using oxyfuel equipment.
3. Set up oxyfuel cutting equipment.
4. Light and adjust an oxyfuel torch.
5. Shut down oxyfuel cutting equipment.
6. Disassemble oxyfuel cutting equipment.
7. Change empty cylinders.
8. Perform oxyfuel cutting:
 - Straight line and square shapes
 - Piercing and slot cutting
 - Bevels
 - Washing
9. Apply a rosebud flame to remove frozen components (also for preheat and expanding larger fittings).
10. Operate a motorized, portable oxyfuel gas cutting machine.

MODULE 40105-07 – GASKETS AND PACKING

1. Identify the various types of gaskets and explain their uses.
2. Identify the various types of gasket materials and explain their applications.
3. Lay out, cut, and install a flange gasket.
4. Describe the use of O-rings.
5. Explain the importance of selecting the correct O-ring for an application.
6. Select an O-ring for a given application and install it.
7. Describe the uses and methods of packing.

MODULE 40106-07 – CRAFT-RELATED MATHEMATICS

1. Identify and explain the use of special measuring devices.
2. Use tables of weights and measurements.
3. Use formulas to solve basic problems.
4. Solve area problems.
5. Solve volume problems.
6. Solve circumference problems.
7. Solve right triangles using the Pythagorean theorem.

MODULE 40107-07 – CONSTRUCTION DRAWINGS

1. Explain the basic layout of a blueprint.
2. Describe the information included in the title block of a blueprint.
3. Identify the types of lines used on blueprints.
4. Identify common symbols used on blueprints.
5. Understand the use of architect's and engineer's scales.
6. Demonstrate the use of an architect's scale.

MODULE 40108-07 – PUMPS AND DRIVERS

1. Identify and explain centrifugal pumps.
2. Identify and explain rotary pumps.
3. Identify and explain reciprocating pumps.
4. Identify and explain metering pumps.
5. Identify and explain vacuum pumps.
6. Explain net positive suction head and cavitation.
7. Identify types of drivers.

MODULE 40109-07 – INTRODUCTION TO VALVES

1. Identify types of valves that start and stop flow.
2. Identify types of valves that regulate flow.
3. Identify valves that relieve pressure.
4. Identify valves that regulate the direction of flow.
5. Explain how to properly store and handle valves.
6. Explain valve locations and positions.

MODULE 40110-07 – INTRODUCTION TO TEST EQUIPMENT

1. Explain the operation of and describe the following pieces of test equipment:
 - Tachometer
 - Pyrometers
 - Multimeters
 - Automated diagnostics tools
 - Wiggy® voltage tester
 - Stroboscope
2. Explain how to read and convert from one scale to another using the above test equipment.
3. Define frequency and explain the use of a frequency meter.

MODULE 40111-07 – MATERIAL HANDLING AND HAND RIGGING

1. Identify and describe the uses of common rigging hardware and equipment.
2. Inspect common rigging equipment.
3. Select, use, and maintain special rigging equipment, including:
 - Jacks
 - Block and tackle
 - Chain hoists
 - Come-alongs
4. Tie knots used in rigging.
5. Use and understand the correct hand signals to guide a crane operator.
6. Identify basic rigging and crane safety procedures.

MODULE 40112-07 – MOBILE AND SUPPORT EQUIPMENT

1. State the safety precautions associated with the use of motor-driven equipment in industrial plants.
2. Explain the operation and applications of the following motor-driven equipment commonly used in industrial plants:
 - Portable generators
 - Air compressors
 - Aerial lifts
 - Forklifts
 - Mobile cranes
3. Operate and perform preventive maintenance on the following equipment:
 - Portable generators
 - Air compressors
 - Aerial lifts

MODULE 40113-07 – LUBRICATION

1. Explain OSHA hazard communication as pertaining to lubrication.
2. Read and interpret a material data safety sheet (MSDS).
3. Explain the EPA hazardous waste control program.
4. Explain lubricant storage.
5. Explain lubricant classification.
6. Explain lubricant film protection.
7. Explain properties of lubricants.
8. Explain properties of greases.
9. Explain how to select lubricants.
10. Identify and explain types of additives.
11. Identify and explain types of lubricating oils.
12. Identify and use lubrication equipment to apply lubricants.
13. Read and interpret a lubrication chart.

Level Two

MODULE 40201-08 – INDUSTRIAL SAFETY FOR E & I TECHNICIANS

1. Demonstrate safe working procedures in an industrial environment.
2. Explain the purposes of OSHA and *NFPA 70E* and how they promote safety on the job.
3. Recognize electrical/energy hazards and describe how to avoid or minimize them in the workplace.
4. Explain safety issues concerning lockout/tagout procedures, personal protection using assured grounding and isolation programs, confined space entry, respiratory protection, and fall protection systems.
5. Recognize and apply safe working practices.

MODULE 40202-08 – INTRODUCTION TO THE *NATIONAL ELECTRICAL CODE*®

1. Explain the purpose and history of the *National Electrical Code*® (*NEC*®).
2. Describe the layout of the *NEC*®.
3. Explain how to navigate the *NEC*®.
4. Describe the purpose of the National Electrical Manufacturers Association (NEMA) and the National Fire Protection Association (NFPA).
5. Explain the role of nationally recognized testing laboratories.

MODULE 40203-08 – ELECTRICAL THEORY

1. Define voltage and identify the ways in which it can be produced.
2. Explain the difference between conductors and insulators.
3. Define the units of measurement that are used to measure the properties of electricity.
4. Identify the meters used to measure voltage, current, and resistance.
5. Explain the basic characteristics of series and parallel circuits.
6. Use Kirchhoff's current law to calculate the total and unknown currents in parallel and series-parallel circuits.
7. Use Kirchhoff's voltage law to calculate voltage drops in series, parallel, and series-parallel circuits.
8. Use the formula for Ohm's law to calculate voltage, current, and resistance.

MODULE 40204-08 – ALTERNATING CURRENT

1. Calculate the peak and effective voltage or current values for an AC waveform.
2. Calculate the phase relationship between two AC waveforms.
3. Describe the voltage and current phase relationship in a resistive AC circuit.
4. Describe the voltage and current transients that occur in an inductive circuit.
5. Define inductive reactance and state how it is affected by frequency.
6. Describe the voltage and current transients that occur in a capacitive circuit.
7. Define capacitive reactance and state how it is affected by frequency.
8. Explain the relationship between voltage and current in the following types of AC circuits:
 - RL circuit
 - RC circuit
 - LC circuit
 - RLC circuit
9. Explain the following terms as they relate to AC circuits:
 - True power
 - Apparent power
 - Reactive power
 - Power factor
10. Explain basic transformer action.

MODULE 40205-08 – E & I TEST EQUIPMENT

1. Identify and explain the purposes of test instruments commonly used to test and troubleshoot E & I equipment.
2. Explain how to read and convert from one scale to another using the above test equipment.
3. Explain the importance of proper meter polarity.
4. Define frequency and explain the use of a frequency meter.
5. Explain the difference between digital and analog meters.

MODULE 40206-08 – FLOW, PRESSURE, LEVEL, AND TEMPERATURE

1. Identify and describe methods of flow measurement.
2. Identify and describe methods of pressure measurement.
3. Identify and describe methods of temperature measurement.
4. Identify and describe methods of level measurement.

MODULE 40207-08 – PROCESS MATHEMATICS

1. Identify different units of pressure measurement.
2. Convert measured values in the English system, using common conversion factor tables, to equivalent SI values.
3. Perform the basic mathematical operations necessary in instrumentation.
4. Square numbers and find the square root of numbers.
5. Perform the mathematical conversions necessary for instrumentation measurements.

MODULE 40208-08 – HAND BENDING

1. Identify the methods for hand bending and installing conduit.
2. Calculate conduit bends.
3. Make 90-degree bends, back-to-back bends, offsets, kicks, and saddle bends using a hand bender.
4. Cut, ream, and thread conduit.

MODULE 40209-08 – TUBING

1. Identify the different kinds of tubing and describe the properties and common uses for each kind.
2. Explain the purpose for tubing standards and specifications.
3. Describe the proper handling and storage of tubing.
4. Cut tubing using the proper tools, cutting methods, and safety procedures.
5. Bend tubing using the proper tools, bending methods, and safety procedures.
6. Identify and select proper tubing fittings for selected instrumentation applications.
7. Flare tubing using the proper tools, flaring methods, and safety procedures.
8. Make and remake a compression fitting.

MODULE 40210-08 – CLEAN, PURGE, AND TEST TUBING AND PIPING SYSTEMS

1. Identify cleaning, flushing, and purging procedures.
2. Describe the general cleaning and purging requirements for piping and tubing.
3. Perform the appropriate cleaning and flushing methods until required cleanliness has been achieved.
4. Describe and select pressure and leak testing methods for piping/tubing systems.
5. Identify precautions associated with testing piping/tubing systems.
6. Perform pressure leak tests per approved procedures.
7. Prepare required test documentation.

MODULE 40211-08 – INSTRUMENT DRAWINGS AND DOCUMENTS, PART ONE

1. Identify and describe standard Instrument Society of America (ISA) instrument symbols and abbreviations.
2. Read and interpret instrument indexes.
3. Read and interpret general instrument specifications.
4. Read and interpret general notes and details included on instrument drawings and documents.
5. Read and interpret installation detail drawings.
6. Read and interpret location drawings.

MODULE 40212-08 – CONDUCTORS AND CABLES

1. From the cable markings, describe the insulation and jacket material, conductor size and type, number of conductors, temperature rating, voltage rating, and permitted uses.
2. Determine the allowable ampacity of a conductor for a given application.
3. Identify the *NEC*[®] requirements for color coding of conductors.
4. Install conductors in a raceway system.

MODULE 40213-08 – CONDUCTORS TERMINATIONS AND SPLICES

1. Describe how to make a sound conductor termination.
2. Prepare cable ends for terminations and splices and connect the ends using lugs or connectors.
3. Train cable at termination points.
4. Describe the *National Electrical Code*[®] (NEC[®]) requirements for making cable terminations and splices.
5. Demonstrate crimping techniques.
6. Select the proper lug or connector for the job.

Level Three

MODULE 40301-09 – HAZARDOUS LOCATIONS

1. Define the various classifications of hazardous locations.
2. Describe the wiring methods permitted for branch circuits and feeders in specific hazardous locations.
3. Select seals and drains for specific hazardous locations.
4. Select wiring methods for Class I, Class II, and Class III hazardous locations.
5. Follow *National Electrical Code*® (*NEC*®) requirements for installing explosion-proof fittings in specific hazardous locations.

MODULE 40302-09 – ELECTRIC COMPONENTS

1. Identify electronic system components.
2. Describe the electrical characteristics of solid-state devices.
3. Describe the basic materials that make up solid-state devices.
4. Describe and identify the various types of transistors and explain how they operate.
5. Describe and connect diodes, including light-emitting diodes (LEDs) and silicon-controlled rectifiers (SCRs).
6. Use a cross reference manual to find substitutes for electronic components.
7. Identify fuses used in electronic devices.
8. Identify the leads of various solid-state devices.
9. Describe integrated circuits.
10. Identify applicable pin numbers of integrated circuits.
11. Explain the purpose of logic gates.
12. Check diodes.

MODULE 40303-09 – E&I DRAWINGS

1. Identify common types of electrical and instrumentation diagrams and drawings.
2. Read and interpret electrical diagrams used in instrumentation work:
 - Wiring diagrams
 - Ladder diagrams
 - One-line diagrams
 - Motor controller diagrams
3. Read and interpret instrumentation diagrams:
 - P&ID diagrams
 - Loop diagrams
 - Raceway diagrams
4. Draw a loop diagram for a given instrumentation loop.

MODULE 40304-09 – MOTOR CONTROLS

1. Identify contactors and relays both physically and schematically and describe their operating principles.
2. Identify pilot devices both physically and schematically and describe their operating principles.
3. Interpret motor control wiring, connection, and ladder diagrams.
4. Select and size contactors and relays for use in specific electrical motor control systems.
5. Select and size pilot devices for use in specific electrical motor control systems.
6. Connect motor controllers for specific applications according to *National Electrical Code*[®] (*NEC*[®]) requirements.

MODULE 40305-09 – DISTRIBUTION EQUIPMENT

1. Explain the necessity of overcurrent protection devices in electrical circuits.
2. Define the terms associated with fuses and circuit breakers.
3. Describe the purpose of switchgear.
4. Describe the four general classifications of circuit breakers and list the major circuit breaker ratings.
5. Describe switchgear construction, metering layouts, wiring requirements, and maintenance.
6. List *National Electrical Code*[®] (*NEC*[®]) requirements pertaining to switchgear.
7. Describe the visual and mechanical inspections and electrical tests associated with low-voltage and medium-voltage cables, metal-enclosed busways, and metering and instrumentation.
8. Describe a ground fault relay system and explain how to test it.

MODULE 40306-09 – TRANSFORMER APPLICATIONS

1. Identify three-phase transformer connections.
2. Identify specialty transformer applications.
3. Size and select buck-and-boost transformers.
4. Calculate and install overcurrent protection for specialty transformers.
5. Ground specialty transformers in accordance with *National Electrical Code*[®] (*NEC*[®]) requirements.
6. Calculate harmonic derating of transformers.

MODULE 40307-09 – CONDUCTOR SELECTION AND CALCULATIONS

1. Select electrical conductors for specific applications.
2. Calculate voltage drop in both single-phase and three-phase applications.
3. Apply *National Electrical Code*[®] (*NEC*[®]) regulations governing conductors to a specific application.
4. Calculate and apply *NEC*[®] tap rules to a specific application.
5. Size conductors for the load.
6. Derate conductors for fill, temperature, and voltage drop.
7. Select conductors for various temperature ranges and atmospheres.

MODULE 40308-09 – TEMPORARY GROUNDING

1. Explain the purpose of temporary grounding.
2. Explain requirements associated with temporary grounding devices.
3. Identify and explain temporary grounding equipment.
4. Explain how to install and remove temporary grounding devices.

MODULE 40309-09 – LAYOUT AND INSTALLATION OF TUBING AND PIPING SYSTEMS

1. Using prints, specifications, and visual inspections, determine the scope of the layout procedure.
2. Determine the proper methods for routing piping or tubing.
3. Apply fitter's math to measure and bend piping or tubing.
4. Cut piping or tubing.
5. Apply the appropriate calculations and bender to accurately bend piping or tubing to the proper angle in an offset.
6. Identify and state the usage of various piping and tubing supports.
7. Install various piping and tubing supports.
8. Identify and state the usage of various piping and tubing fittings, including:
 - Flare tubing fittings
 - Compression tubing fittings
 - Threaded pipe fittings
 - Pipe flanges

MODULE 40310-09 – MACHINE BENDING OF CONDUIT

1. Describe the process of conduit bending using power tools.
2. Identify all parts of electric and hydraulic benders.
3. Bend offsets, kicks, saddles, segmented, and parallel bends.
4. Explain the requirements of the *National Electrical Code*® (NEC®) for bending conduit.
5. Compute the radius, degrees in bend, developed length, and gain for conduit up to six inches.

MODULE 40311-09 – HYDRAULIC CONTROLS

1. Explain hydraulic system safety.
2. Explain the principles of hydraulics.
3. Identify hydraulic devices and symbols and explain their functions.
4. Explain a hydraulic system in a process application.

MODULE 40312-09 – PNEUMATIC CONTROLS

1. Explain pneumatic system safety.
2. Explain the physical characteristics of gases.
3. Explain compressing gases.
4. Explain the pneumatic transmission of energy.
5. Explain the principles of compressor operation.
6. Identify and explain types of compressors.
7. Explain compressed-air treatment.
8. Identify and explain pneumatic system components and symbols.

MODULE 40313-09 – MOTOR-OPERATED VALVES

1. State safety regulations associated with motor-operated valves (MOVs).
2. Explain the operating principles of various types of MOVs.
3. Identify applications of MOVs.
4. Set up a MOV.
5. Remove and replace a limit switch.

Level Four

MODULE 40401-09 – STANDBY AND EMERGENCY SYSTEMS

1. Explain the basic differences between emergency systems, legally required standby systems, and optional standby systems.
2. Describe the operating principles of an engine-driven standby AC generator.
3. Recognize and describe the operating principles of both automatic and manual transfer switches.
4. Recognize the different types of storage batteries used in emergency and standby systems and explain how batteries charge and discharge.
5. For selected types of batteries, describe their characteristics, applications, maintenance, and testing.
6. Recognize double-conversion and single-conversion types of uninterruptible power supplies (UPSs) and describe how they operate.
7. Describe the *NEC*[®] requirements that pertain to the installation of standby and emergency power systems.
8. Explain normal vs. emergency sources for various applications.

MODULE 40402-09 – BASIC PROCESS CONTROL ELEMENTS, TRANSDUCERS, AND TRANSMITTERS

1. Identify the following primary elements (detectors) and describe their operation:
 - Orifice plate
 - Pitot tube
 - Thermocouple
 - Resistance temperature detector (RTD)
2. Identify the following secondary elements and describe their operation:
 - Bourdon tube
 - Diaphragm device
 - Capacitance-type pressure sensor
 - Bellows device
3. Define various transducer types:
 - I/Ps
 - Strain gauges
 - Linear-variable differential transformer (LVDT)
 - Accelerometers
4. Explain an I/P operation.
5. Describe the operation of a strain gauge.
6. Explain the function and installation of electronic transmitters and temperature detectors.
7. Draw a basic instrument channel diagram including a measuring element, transducer, and transmitter.

MODULE 40403-09 – INSTRUMENT CALIBRATION AND CONFIGURATION

1. Define calibration.
2. Discuss the three-point and five-point methods of calibration.
3. Explain zero suppression and elevation.
4. Calibrate the following pneumatic instruments using the proper equipment:
 - Differential pressure transmitters
 - Temperature transmitters
5. Calibrate the following 4–20mA instruments using the proper calibration equipment:
 - Differential pressure transmitters
 - Temperature transmitters
6. Define Smart instruments.
7. Identify a HART[®] communicator.
8. Calibrate a Smart transmitter using a HART[®] communicator.

MODULE 40404-09 – PNEUMATIC CONTROL VALVES, ACTUATORS, AND POSITIONERS

1. Identify the various parts of control valves.
2. Describe the various types of control valve trims.
3. Describe what conditions determine the type of valve trim to be used.
4. Describe how actuators work and are bench set.
5. Describe how various positioners work and are calibrated.
6. Describe the various signals used to control inputs to valve positioners.
7. Describe how Smart positioners work and are calibrated.
8. Describe the operation of Tri-Loop and HIM signal converters.
9. Safely perform common maintenance practices for control valves and actuators.
10. Troubleshoot control valve failures.
11. Calibrate a pneumatic positioner.

MODULE 40405-09 – PERFORMING LOOP CHECKS

1. Verify mechanical installation.
2. Verify correct tag numbers according to loop sheets.
3. Perform continuity checks on both electrical and pneumatic loops.
4. Prove a loop.

MODULE 40406-09 – TROUBLESHOOTING AND COMMISSIONING A LOOP

1. Practice universal and methodical troubleshooting techniques in a loop.
2. Troubleshoot an oscillating process.
3. Troubleshoot a newly installed control loop.
4. Practice safety procedures when troubleshooting a loop.
5. Commission a loop.

MODULE 40407-09 – PROCESS CONTROL LOOPS AND TUNING

1. Describe basic process control theory.
2. Describe the function and applications of various PID controllers.
3. Describe how pneumatic controllers work.
4. Describe how electronic single loop controllers work.
5. Set up and maintain pneumatic controllers.
6. Apply the appropriate equations and perform closed-loop tuning.
7. Perform open-loop tuning.
8. Perform visual loop tuning.

MODULE 40408-09 – DATA NETWORKS

1. Describe how data networks are used in industrial facilities.
2. Identify the types of data networks used in industrial facilities and describe the methods used to control information flow within a network.
3. Describe how open connectivity is used in industrial data networks.
4. Identify the types of cables used to connect computers and other devices within a network and explain their applications.
5. Describe the physical layer of two or more device buses.
6. Apply connectors to UTP and coaxial cable.

MODULE 40409-09 – PROGRAMMABLE LOGIC CONTROLLERS

1. Describe the function and purpose of a programmable logic controller (PLC).
2. Compare hardwired and PLC systems.
3. Explain number systems.
4. Explain the general function of an input/output (I/O) module, including the following types:
 - Discrete
 - Numerical and analog data
 - Special
 - Remote
5. Explain the power supply and ground connections to I/O modules.
6. Explain PLC architecture.
7. Explain the purpose of PLC software and firmware.
8. Describe the features and the differences between PLC programming languages.
9. Describe the features of relay ladder logic instruction categories.
10. Explain the principles used to correlate PLC hardware components to software instructions.

MODULE 40410-09 – DISTRIBUTED CONTROL SYSTEMS

1. Define distributed control systems and explain how they are applied in an industrial facility.
2. Identify and describe components of a DCS.
3. Describe network configurations for a DCS.
4. Describe basic service procedures that may have to be performed on a field device.
5. Describe installation practices of a DCS.
6. Describe power distribution requirements for a DCS.
7. Describe power supplies and their applications in a DCS.
8. Describe how to use a DCS interface to obtain process data and to troubleshoot plant equipment.