



INDUSTRIAL MAINTENANCE

Competencies / Objectives

Level One

MODULE 32101 – ELECTRICAL SAFETY

1. Demonstrate safe working procedures in a construction environment.
2. Explain the purpose of OSHA and how it promotes safety on the job.
3. Identify electrical hazards and 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.

MODULE 32102 – HAND BENDING

1. Identify the methods of hand bending conduit.
2. Identify the various methods used to install conduit.
3. Use math formulas to determine conduit bends.
4. Make 90° bends, back-to-back bends, offsets, kicks, and saddle bends using a hand bender.
5. Cut, ream, and thread conduit.

MODULE 32103 – 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. Demonstrate the correct applications for fasteners and anchors.
5. Install fasteners and anchors.

MODULE 32104 – ELECTRICAL THEORY ONE

1. Recognize what atoms are and how they are constructed.
2. Define voltage and identify the ways in which it can be produced.
3. Explain the difference between conductors and insulators.
4. Define the units of measurement that are used to measure the properties of electricity.
5. Explain how voltage, current, and resistance are related to each other.
6. Using the formula for Ohm's Law, calculate an unknown value.
7. Explain the different types of meters used to measure voltage, current, and resistance.
8. Using the power formula, calculate the amount of power used by a circuit.

MODULE 32105 – ELECTRICAL THEORY TWO

1. Explain the basic characteristics of a series circuit.
2. Explain the basic characteristics of a parallel circuit.
3. Explain the basic characteristics of a series-parallel circuit.
4. Calculate, using Kirchoff's Voltage Law, the voltage drop in series, parallel, and series-parallel circuits.
5. Calculate, using Kirchoff's Current Law, the total current in parallel and series-parallel circuits.
6. Find the total amount of resistance in a series circuit.
7. Find the total amount of resistance in a parallel circuit.
8. Find the total amount of resistance in a series-parallel circuit.

MODULE 32106 – ELECTRICAL TEST EQUIPMENT

1. Explain the operation of and describe the following pieces of test equipment:
 - Ammeter
 - Voltmeter
 - Ohmmeter
 - Volt-ohm-milliammeter
 - Wattmeter
 - Megohmmeter
 - Frequency meter
 - Power factor meter
 - Continuity tester
 - Voltage tester
 - Recording instruments
 - Cable-length meters
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 32107 – INTRODUCTION TO THE NATIONAL ELECTRIC 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 testing laboratories.

MODULE 32108 – CONDUCTORS

1. Explain the various sizes and gauges of wire in accordance with American Wire Gauge standards.
2. Identify insulation and jacket types according to conditions and applications.
3. Describe voltage ratings of conductors and cables.
4. Read and identify markings on conductors and cables.
5. Use the tables in the NEC® to determine the ampacity of a conductor.
6. State the purpose of stranded wire.
7. State the purpose of compressed conductors.
8. Describe the different materials from which conductors are made.
9. Describe the different types of conductor insulation.
10. Describe the color coding of insulation.
11. Describe instrumentation control wiring.
12. Describe the equipment required for pulling wire through conduit.
13. Describe the procedure for pulling wire through conduit.
14. Install conductors in conduit.
15. Pull conductors in a conduit system.

MODULE 32109 – INTRODUCTION TO ELECTRICAL BLUEPRINTS

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. Interpret electrical drawings, including site plans, floor plans, and detail drawings.
7. Read equipment schedules found on electrical blueprints.
8. Describe the type of information included in electrical specifications.

MODULE 32110 – OXYFUEL CUTTING

1. Explain oxyfuel cutting safety.
2. Identify and explain oxyfuel cutting equipment.
3. Set up oxyfuel equipment.
4. Light and adjust an oxyfuel torch.
5. Shut down oxyfuel cutting equipment.
6. Disassemble oxyfuel equipment.
7. Change empty cylinders.
8. Perform oxyfuel cutting:
 - Straight line and square shapes
 - Piercing and slot cutting
 - Bevels
 - Washing
 - Gouging

Level Two

MODULE 32201 – WIRING: COMMERCIAL AND INDUSTRIAL

1. Identify and state the functions and ratings of single-pole, double-pole, three-way, four-way, dimmer, special, and safety switches.
2. Explain NEMA classifications as they relate to switches and enclosures.
3. Explain the NEC® requirements concerning wiring devices.
4. Identify and state the functions and ratings of straight blade, twist lock, and pin and sleeve receptacles.
5. Identify and define receptacle terminals and disconnects.
6. Identify and define ground fault circuit interrupters.
7. Explain the box mounting requirements in the NEC®.
8. Use a wire stripper to strip insulation from a wire.
9. Use a solderless connector to splice wires together.
10. Identify and state the functions of limit switches and relays.
11. Identify and state the function of switchgear.

MODULE 32202 – 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. Describe the effect that resonant frequency has on impedance and current flow in a series or parallel resonant circuit.
10. Define bandwidth and describe how it is affected by resistance in a series or parallel resonant circuit.
11. Explain the following terms as they relate to AC circuits:
 - True power
 - Apparent power
 - Reactive power
 - Power factor
12. Explain basic transformer action.

MODULE 32203 – MOTORS: THEORY AND APPLICATION

1. Define the following terms:
 - Ampacity
 - Branch circuit
 - Circuit breaker
 - Controller
 - Duty
 - Equipment
 - Full-load amps
 - Ground fault circuit interrupter
 - Service factor
 - Thermal cutout
 - Remote control circuit
 - NEMA design letter
 - Nonautomatic
 - Overcurrent
 - Overload
 - Power factor
 - Rated full-load speed
 - Rated horsepower
 - Interrupting rating
 - Motor circuit switch
 - Thermal protector
2. Describe the various types of motor enclosures.
3. Describe how the rated voltage of a motor differs from the system voltage.
4. Describe the basic construction and components of a three-phase squirrel cage induction motor.
5. Explain the relationships among speed, frequency, and the number of poles in a three-phase induction motor.
6. Describe how torque is developed in an induction motor.
7. Explain how and why torque varies with rotor reactance and slip.
8. Define percent slip and speed regulation.
9. Explain how the direction of a three-phase motor is reversed.
10. Describe the component parts and operating characteristics of a three-phase wound rotor induction motor.
11. Describe the component parts and operating characteristics of a three-phase synchronous motor.
12. Define torque, starting current, and armature reaction as they apply to DC motors.
13. Explain how the direction of rotation of a DC motor is changed.
14. Describe the design and characteristics of a DC shunt, series, and compound motor.
15. Describe dual-voltage motors and their applications.
16. Describe the methods for determining various motor connections.
17. Describe general motor protection requirements as delineated in the NEC®.

MODULE 32204 – GROUNDING

1. Explain the purpose of grounding and the scope of NEC® Article 250.
2. Distinguish between a short circuit and a ground fault.
3. Define the NEC® ground-related terms.
4. Distinguish between system grounding and equipment grounding.
5. Use NEC® Table 250-66 to size the grounding electrode conductor for various AC systems.
6. Explain the NEC® requirements for the installation and physical protection of grounding electrode conductors.
7. Explain the function of the grounding electrode system and determine which grounding electrodes must be used.
8. Define made electrodes and explain the resistance requirements for made electrodes using NEC® Section 250-52.
9. Use NEC® Table 250-122 to size the equipment grounding conductor for raceways and equipment.
10. Explain the function of the main bonding jumper in the grounding system and size the main bonding jumper for various applications.
11. Size the main bonding jumper for a service utilizing multiple service disconnecting means.
12. Explain the NEC® requirements for bonding of enclosures and equipment.
13. Explain the NEC® requirements for grounding of enclosures and equipment.
14. Explain effectively grounded and its importance in clearing ground faults and short circuits.
15. Explain the purposes of the grounded conductor (neutral) in the operation of overcurrent devices.
16. Explain the NEC® requirements for grounding separately-derived systems, including transformers and generators.
17. Explain the NEC® requirements for grounding at more than one building.
18. Explain the NEC® grounding requirements for systems over 600 volts.

MODULE 32205 – BOXES AND FITTINGS

1. Describe the different types of nonmetallic and metallic boxes.
2. Understand the NEC® requirements for box fill.
3. Calculate the required box size for any number and size of conductors.
4. Explain the NEC® regulations for volume required per conductor in outlet boxes.
5. Properly locate, install, and support boxes of all types.
6. Describe the NEC® regulations governing pull and junction boxes.
7. Explain the radius rule when installing conductors in pull boxes.
8. Understand the NEC® requirements for boxes supporting lighting fixtures.
9. Describe the purpose of conduit bodies and Type FS boxes.
10. Install the different types of fittings used in conjunction with boxes.
11. Describe the installation rules for installing boxes and fittings in hazardous areas.
12. Explain how boxes and fittings are selected and installed.
13. Describe the various types of box supports.

MODULE 32206 – CABLE TRAY

1. Describe the components that make up a cable tray assembly.
2. Explain the methods used to hang and secure cable tray.
3. Describe how cable enters and exits cable tray.
4. Select the proper cable tray fitting for the situation.
5. Explain the NEMA standards for cable tray installations.
6. Explain the NEC® requirements for cable tray installations.
7. Select the required fittings to ensure equipment grounding continuity in cable tray systems.
8. Interpret electrical working drawings showing cable tray fittings.
9. Size cable tray for the number and type of conductors contained in the system.
10. Select rollers and sheaves for pulling cable in specific cable tray situations.
11. Designate the required locations of rollers and sheaves for a specific cable pull.
12. Fabricate an offset for a cable tray.

MODULE 32207 – CONDUCTOR TERMINATIONS AND SPLICES

1. Describe how to make a good conductor termination.
2. Prepare cable ends for terminations and splices.
3. Install lugs and connectors onto conductors.
4. Train cable at termination points.
5. Explain the role of the NEC® in making cable terminations and splices.
6. Explain why mechanical stress should be avoided at cable termination points.
7. Describe the importance of using proper bolt torque when bolting lugs onto busbars.
8. Describe crimping techniques.
9. Select the proper lug or connector for the job.
10. Describe splicing techniques.
11. Describe the installation rules for parallel conductors.
12. Explain how to use hand and power crimping tools.

MODULE 32208 – INSTALLATION OF ELECTRIC SERVICES

1. Describe various types of electric services for commercial and industrial installations.
2. Read electrical blueprints and diagrams describing service installations.
3. Calculate and select service-entrance equipment.
4. Explain the role of the NEC® in service installations.
5. Install main disconnect switches, panelboards, and overcurrent protection devices.
6. Identify the circuit loads, number of circuits required, and installation requirements for distribution panels.
7. Explain the types and purposes of service grounding.
8. Explain the purpose of ground fault circuit interrupters and where they must be installed.
9. Describe single-phase service connections.
10. Describe both wye- and delta-connected three-phase services.

MODULE 32209 – CIRCUIT BREAKERS AND FUSES

1. Explain the necessity of overcurrent protection devices in electrical circuits.
2. Define the terms associated with fuses and circuit breakers.
3. Describe the operation of a circuit breaker.
4. Select the most suitable overcurrent device for the application.
5. Explain the role of the NEC® in specifying overcurrent devices.
6. Describe the operation of single-element and time-delay fuses.
7. Explain how ground fault circuit interrupters (GFCIs) can save lives.
8. Replace a renewable fuse link.
9. Calculate short circuit currents.
10. Describe troubleshooting and maintenance techniques for overcurrent devices.

MODULE 32210 – CONTACTORS AND RELAYS

1. Describe the operating principles of contactors and relays.
2. Select contactors and relays for use in specific electrical systems.
3. Explain how mechanical contactors operate.
4. Explain how solid-state contactors operate.
5. Install contactors and relays according to the NEC® requirements.
6. Select and install contactors and relays for lighting control.
7. Read wiring diagrams involving contactors and relays.
8. Describe how overload relays operate.
9. Connect a simple control circuit.
10. Test control circuits.

MODULE 32211 – LUBRICATION

1. Explain OSHA standards.
2. Read and interpret an MSDS.
3. Explain the EPA 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.

MODULE 32212 – INTRODUCTION TO BEARINGS

1. Identify and explain plain bearings.
2. Identify and explain ball bearings.
3. Identify and explain roller bearings.
4. Identify and explain thrust bearings.
5. Identify and explain guide bearings.
6. Identify and explain flanged bearings.
7. Identify and explain pillow block bearings.
8. Identify and explain takeup bearings.
9. Identify and explain bearing materials.
10. Explain bearing designation.

MODULE 32213 – COPPER AND PLASTIC PIPING PRACTICES

1. State the precautions that must be taken when installing refrigerant piping.
2. Select the right tubing for a job.
3. Cut and bend tubing.
4. Join tubing by using flare and compression fittings.
5. Determine the kinds of hangers and support needed for refrigerant piping.
6. Insulate refrigerant piping.
7. State the basic requirements for pressure-testing a system once it has been installed.
8. Follow basic safety precautions for the installation, operation and maintenance of refrigerating and air conditioning equipment.

MODULE 32214 – FERROUS METAL PIPING PRACTICES

1. Identify the types of ferrous metal pipes.
2. Measure the sizes of ferrous metal pipes.
3. Identify the common malleable iron fittings.
4. Cut, ream and thread ferrous metal pipe.
5. Join lengths of threaded pipe together and install fittings.
6. Describe the main points to consider when installing pipe runs.
7. Describe the method used to join grooved piping.

MODULE 32215 – PIPING SYSTEMS

1. Identify and explain the types of piping systems.
2. Identify piping systems according to color-coding.
3. Explain thermal expansion.
4. Explain types and applications of pipe insulation.

MODULE 32216 – SMAW - EQUIPMENT AND SETUP

1. Identify and explain shielded metal arc welding (SMAW) safety.
2. Identify and explain welding electrical current.
3. Identify and explain arc welding machines.
4. Explain setting up arc welding equipment.
5. Identify and explain tools for weld cleaning.

Level Three

MODULE 32301 – OVERCURRENT PROTECTION

1. Explain the importance of overcurrent protection.
2. Understand the key NEC® requirements regarding overcurrent protection.
3. Check electrical drawings for conformance to NEC® sections that cover short circuit current, fault currents, interrupting ratings, and other sections relating to overcurrent protection.
4. Determine let-through current values (peak and rms) when current-limiting overcurrent devices are used.
5. Select and size overcurrent protection for specific applications.

MODULE 32302 – DISTRIBUTION EQUIPMENT

1. List the voltage classifications used in the industry.
2. Describe the purpose of switchgear.
3. Describe the basic physical makeup of a switchboard.
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 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.
9. Describe an HVL switch.
10. Describe a bolted pressure switch and list its maintenance requirements.
11. Describe a typical switchgear transformer and lists its testing and maintenance requirements.
12. List the safety precautions associated with instrument transformers and describe their maintenance requirements.

MODULE 32303 – MOTOR CONTROLS

1. Describe the operating principles of motor controls and control circuits.
2. Select motor controls for specific applications.
3. Connect motor controllers for specific applications.
4. Explain NEC® regulations governing the installation of motor controls.
5. Follow NEC® requirements when installing motor control circuits.
6. Interpret motor control diagrams.
7. Size and select thermal overload relays and other protective devices for motor controls.
8. Connect control transformers in conjunction with motor control circuits.

MODULE 32304 – MOTOR MAINTENANCE, PART ONE

1. Properly store motors and generators.
2. Test motors and generators.
3. Make connections for specific types of motors and generators.
4. Clean open-frame motors.
5. Lubricate motors that require this type of maintenance.
6. Collect and record motor data.
7. Select tools for motor maintenance.
8. Select instruments for motor testing.

MODULE 32305 – MOTOR MAINTENANCE, PART TWO

1. Test motor winding resistance upon receiving a motor and after setting it in place.
2. Select and use motor testing equipment.
3. Change the rotation of single-phase, three-phase, and DC motors.
4. Clean and test open frame motors.
5. Meter motor circuits for measuring power factor.
6. Clean, dry, and test motors that have been subjected to water damage.
7. Describe motor wrapping techniques.
8. Properly ground flexible wiring systems and motor frames.
9. Troubleshoot electric motors.

MODULE 32306 – INSTALLING COUPLINGS

1. Identify and explain coupling types.
2. Install couplings.
3. Remove couplings.

MODULE 32307 – INSTALLING MECHANICAL SEALS

1. Identify and explain types of mechanical seals.
2. Explain mechanical seal classification.
3. Safely and accurately remove and inspect mechanical seals.
4. Safely and accurately install mechanical seals.

MODULE 32308 – INSTALLING BELT AND CHAIN DRIVES

1. Identify and explain belt drive types.
2. Install belt drives.
3. Identify and explain chain drive types.
4. Install chain drives.

MODULE 32309 – INSTALLING BEARINGS

1. Remove bearings.
2. Troubleshoot bearings.
3. Install bearings.

MODULE 32310 – GASKETS AND PACKING

1. Identify various types of gaskets and gasket material.
2. Identify various types of packing.
3. Describe uses of packing.
4. Describe uses of O-rings.
5. Describe uses of gaskets.
6. Fabricate gaskets.

MODULE 32311 – INSTALLING SEALS

1. Identify and explain types of seals.
2. Identify and explain seal materials.
3. Remove and install seals.

MODULE 32312 - PUMPS

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. Install pumps.

MODULE 32313 – BASIC HYDRAULIC SYSTEMS

1. Explain hydraulic system safety.
2. Explain the principles of hydraulics.
3. Identify and explain hydraulic fluids.
4. Identify and explain hydraulic system parts.
5. Identify and explain hydraulic pumps.
6. Identify and explain hydraulic motors.

MODULE 32314 – BASIC PNEUMATIC SYSTEMS

1. Explain pneumatic 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 32315 – BASIC ELECTRONIC THEORY

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. Interpret electronic schematic diagrams.
6. Describe and connect diodes.
7. Describe and connect light-emitting diodes (LEDs).
8. Describe and connect silicon-controlled rectifiers (SCRs).
9. Identify the leads of various solid-state devices.
10. Describe the three basic operational amplifier circuits.

Level Four

MODULE 32401 – PRACTICAL APPLICATIONS OF LIGHTING

1. Explain how the lighting terms lumen, candlepower, and footcandle relate to one another.
2. Classify lighting fixtures by layout, location, fixture type, and type of service.
3. Identify the basic design configurations of incandescent, fluorescent, and HID lighting fixtures and describe the general lighting pattern (direct, indirect, etc.) produced by each type.
4. Identify the main lighting requirements associated with lighting systems used in selected applications such as office buildings, schools, theaters, etc.
5. Identify the special wiring and dimming system components used with incandescent, fluorescent, and HID lighting systems.
6. Use manufacturer's lighting fixture catalogs to select the appropriate lighting fixtures for specific lighting applications.

MODULE 32402 – 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. Describe the different types and characteristics of standby and emergency generators. Interpret manufacturer's maintenance and service schedules pertaining to the various types of generator sets.
4. Recognize and describe the operating principles of both automatic and manual transfer switches.
5. Recognize the different types of storage batteries used in emergency and standby systems and explain how batteries charge and discharge.
6. For selected types of batteries, describe their characteristics, applications, maintenance, and testing.
7. Recognize double-conversion and single-conversion types of uninterruptible power supplies (UPSs) and describe how they operate.
8. Understand the NEC[®] requirements that pertain to the installation of standby and emergency power systems.

MODULE 32403 – ADVANCED CONTROLS

1. Recognize components in control circuits, both physically and schematically.
2. Interpret motor control wiring diagrams, schematics, one-line, loop, and ladder diagrams.
3. Identify components in wiring diagrams using ANSI/IEEE and ISA symbols.
4. Describe packaged unit controls.
5. Align and assemble electronic controls per manufacturer's drawings and specifications.
6. Describe the practical applications of jogging, plugging, etc., and make appropriate connections.
7. Describe the types of motor braking and explain the operating principles of motor brakes.
8. Connect and program programmable motor circuit protectors.
9. Describe environmental and process analyzers.
10. Describe special precautions that must be taken when working with solid-state motor controls.

MODULE 32404 – COMMERCIAL AND INDUSTRIAL REFRIGERATION

1. Recognize the different types of refrigerated coolers and display cases. For each type, give its common application.
2. Compare the basic components used in commercial/industrial refrigeration systems with those used in comfort air conditioning systems.
3. Recognize single, multiple, and satellite compressor systems. Describe the application, installation considerations, and advantages and disadvantages of each.
4. Recognize packaged condensing units and unit coolers. Describe their application, operation, and installation considerations.
5. Recognize two-stage compressors. Explain their operation and applications.
6. Recognize the various accessories used in commercial refrigeration systems. Explain why each is used and where it should be installed in the system.
7. Recognize the various refrigeration control devices. Explain the purpose of each type and how it works.
8. Describe the various methods used to defrost evaporators.
9. Recognize ice cube and ice flake making machines. Describe their application, operation, and installation considerations.
10. Describe the characteristics and properties of the refrigerants and oils being used to replace CFC refrigerants and mineral oils in existing systems.
11. Demonstrate or describe the general procedure for retrofitting a CFC refrigeration system to use an HCFC or HFC refrigerant.
12. Recognize basic ammonia refrigeration systems. Compare the components used in ammonia systems with those used in halocarbon-based refrigerant systems.

MODULE 32405 – ELECTRICITY IN HVAC SYSTEMS

1. Describe the basic operating principles of air conditioning systems.
2. Explain how refrigeration systems operate.
3. Interpret nameplate data on heating, ventilation, and air conditioning (HVAC) equipment.
4. Describe the various types of heating systems used in residential and commercial applications.
5. Explain the role of the NEC® in HVAC power and control wiring.
6. Describe the operating principles of compressors as they relate to refrigeration.
7. Troubleshoot HVAC systems.
8. Install electrical circuits and related components to HVAC equipment in accordance with NEC® Articles 220, 424, and 440.

MODULE 32406 – HVAC CONTROLS

1. Explain the function of a thermostat in an HVAC system.
2. Describe different types of thermostats and explain how they are used.
3. Demonstrate the correct installation and adjustment of a thermostat using proper siting and wiring techniques.
4. Explain the basic principles applicable to all control systems.
5. Identify the various types of electromechanical and electronic HVAC controls, and explain their function and operation.
6. State the NEC® requirements applicable to HVAC controls.

MODULE 32407 – CONVENTIONAL ALIGNMENT

1. Explain types of misalignment.
2. Align couplings, using the straightedge and feeler gauge method.
3. Identify and eliminate coupling stress.
4. Align couplings, using the dial indicator method.

MODULE 32408 – MAINTAINING VALVES

1. Remove and install threaded valves.
2. Remove and install flanged valves.
3. Replace valve stem O-rings.
4. Replace bonnet gaskets.
5. Explain the purpose of valve packing.
6. Repack a valve.

MODULE 32409 – IDENTIFYING AND INSTALLING 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. Identify types of valve actuators.
6. Explain how to properly store and handle valves.
7. Explain valve locations and positions.
8. Install valves with threaded ends.
9. Install valves with welded ends.
10. Install valves with flanged ends.

MODULE 32410 – STEAM TRAPS

1. Identify types of steam traps.
2. Install steam traps.
3. Troubleshoot steam trap systems.

MODULE 32411 – STEAM SYSTEMS

1. Demonstrate an understanding of the terms and concepts used to describe steam and steam systems.
2. Describe the basic steam heating cycle.
3. Recognize the components of a basic steam heating system and describe their function(s).
4. Demonstrate or describe how to perform selected operating procedures on low-pressure steam boilers and systems.
5. Demonstrate or describe how to install and maintain selected steam traps.
6. Recognize the basic one-pipe and two-pipe steam heating systems and describe how they work.

MODULE 32412 – PROGRAMMABLE LOGIC CONTROLLERS

1. Describe the function and purpose of a programmable logic controller.
2. Compare hardwired and PLC systems.
3. Count and convert between the following number systems:
 - Decimal
 - Octal
 - Binary
 - Hexadecimal
4. Explain the purpose of the following binary codes:
 - ASCII
 - BCD
 - Gray
5. Describe the purpose of the various power supplies used within a PLC.
6. Explain the general function of an Input/Output module including the following types:
 - Discrete
 - Numerical data
 - Special
 - Remote
7. Explain the power supply and ground connections to I/O modules.
8. State the function of the PLC processor module.
9. Explain the interrelations between the following microprocessor components:
 - Communication buses
 - Microprocessor IC
 - Memory
10. State the characteristics of the following types of memory:
 - RAM
 - ROM
 - PROM
 - EPROM
 - EEPROM/UVPROM
11. Describe the characteristics and features of a PLC processor module including: Front panel features, Scanning, Memory.
12. Explain the purpose of PLC software and firmware.
13. Describe the features and the differences between the following PLC programming languages:
 - Relay
 - English statements
 - ladder logic
 - Functional blocks
 - Boolean mnemonics
 - Machine stage
14. Describe the features of the following Relay ladder logic instruction categories:
 - Relay
 - Data manipulation
 - Timer/Counter
 - Data transfer
 - Arithmetic
 - Program control
15. Explain the principles used to correlate PLC hardware components to software instructions.
16. Explain the purpose and use of the following MS-DOS commands:
 - Selecting the drive
 - Copying files
 - Directories
 - Deleting files
 - Subdirectories
 - Wildcards

MODULE 32413 – HIGH-VOLTAGE TERMINATIONS/SPLICES

1. Select the proper materials and tools for high-voltage terminations and splices.
2. Check the manufacturer's specifications for cable splicing up to 15kV.
3. Calculate the spacing for high-voltage cable.
4. Calculate the bending and training radii of high-voltage cable.
5. Prepare high-voltage cable for terminations and splices.
6. Complete cable assemblies with terminations and splices.
7. Inspect and test high-voltage terminations and splices.

MODULE 32414 – VIBRATION ANALYSIS

1. Explain the causes of vibration.
2. Explain vibration analysis.
3. Identify and explain the different kinds of basic vibration test equipment.
4. Explain vibration monitoring.
5. Explain field balancing of machines.

MODULE 32415 – COMMERCIAL HEATING AND COOLING SYSTEMS

1. Demonstrate an understanding of the terms and concepts used when working with hot water heating and chilled water cooling systems.
2. Recognize the components of hot water heating systems and explain the purpose of each component.
3. Demonstrate or describe how to turn on, operate and turn off a hot water heating system.
4. Recognize the components of chilled water cooling system and explain the purpose of each component.
5. Demonstrate or describe how to turn on, operate, and turn off a chilled water cooling system.
6. Recognize the components of dual-temperature water systems and explain the purpose of each component.
7. Define the preventative maintenance procedures associated with hot water and chilled water systems.
8. Recognize the common piping configurations used with hot water heating and chilled water cooling systems.

Level Five

MODULE 32501 – PREVENTIVE AND PREDICTIVE MAINTENANCE

1. Explain preventive maintenance.
2. Explain predictive maintenance.
3. Explain nondestructive testing.
4. Explain ultrasonics.
5. Explain radiography.
6. Explain eddy current inspection.
7. Explain visual and optical inspection.
8. Explain liquid penetrant inspection.
9. Explain magnetic particle inspection.
10. Explain acoustic emissions.
11. Explain infrared testing.
12. Explain vibration analysis.
13. Explain tribology.

MODULE 32502 – PERFORMING REVERSE ALIGNMENT

1. Explain how machinery can be misaligned.
2. Explain the conditions that can cause misalignment.
3. Measure shaft runout, using a dial indicator.
4. Set up complex reverse dial indicator jigs.
5. Measure indicator sag using complex reverse dial indicator jigs.
6. Perform reverse dial indicator alignment, using a graphical alignment chart.
7. Perform reverse dial indicator alignment, using the mathematical equation.

MODULE 32503 – PERFORMING LASER ALIGNMENT

1. Explain lasers and laser alignment systems.
2. Operate a laser alignment system.
3. Align machinery trains.
4. Measure shaft sag.
5. Explain soft foot, thermal growth, and coupling stress.
6. Troubleshoot repeatability and laser problems.

MODULE 32504 - TROUBLESHOOTING AND REPAIRING PNEUMATIC EQUIPMENT

1. Perform pneumatic system preventive maintenance procedures.
2. Inspect pneumatic system components.
3. Read pneumatic system schematic diagrams.
4. Troubleshoot pneumatic systems.
5. Repair pneumatic system components.

MODULE 32505 – TROUBLESHOOTING AND REPAIRING PUMPS

1. Inspect pumps.
2. Troubleshoot pumps.
3. Prepare pumps for shutdown and repair.
4. Remove pumps from system.
5. Disassemble pumps.
6. Reassemble pumps.
7. Install mechanical seals.
8. Install pump in system.
9. Perform pump start-up checks.

MODULE 32506 – TROUBLESHOOTING AND REPAIRING HYDRAULIC EQUIPMENT

1. Inspect hydraulic system equipment.
2. Read hydraulic system schematic diagrams.
3. Explain the basic hydraulic principles that must be considered before troubleshooting.
4. Troubleshoot hydraulic systems.
5. Repair hydraulic system components.

MODULE 32507 – TROUBLESHOOTING AND REPAIRING GEARBOXES

1. Identify and explain gearboxes.
2. Explain how gears operate and identify types of gears.
3. Identify types of gearboxes and use diagnostic charts.
4. Troubleshoot gearboxes.
5. Remove and disassemble gearboxes.
6. Identify gear wear patterns.
7. Measure and adjust backlash and bearing clearance.
8. Install and maintain gearboxes.

MODULE 32508 – PROGRAMMABLE LOGIC CONTROLLERS

1. Describe the function and purpose of a programmable logic controller (PLC).
2. Compare hardwired and PLC systems.
3. Count and convert between number systems.
4. Explain the purpose of binary codes.
5. Describe the purpose of the various power supplies used within a PLC.
6. Explain the general function of input/output (I/O) modules.
7. Explain the power supply and ground connections to I/O modules.
8. State the function of the PLC processor module.
9. Explain the interrelations between microprocessor components.
10. State the characteristics of the different types of memory.
11. Describe the characteristics and features of a PLC processor module.
12. Explain the purpose of PLC software and firmware.
13. Describe the features and the differences between the different PLC programming languages.
14. Describe the features of relay ladder logic instruction categories.
15. Explain the principles used to correlate PLC hardware components to software instructions.

MODULE 32509 – INSTRUMENT DRAWINGS AND DOCUMENTS

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 32510 – FLOW, PRESSURE, LEVEL, AND TEMPERATURE

1. Define flow.
2. Identify and describe types of flow measurement.
3. Identify and use flow measurement units.
4. Describe conditions that affect flow.
5. Define pressure.
6. Identify and describe types of pressure measurement.
7. Identify and use pressure measurement units.
8. Describe conditions that affect pressure.
9. Define temperature.
10. Identify and describe types of temperature measurement.
11. Identify and use temperature measurement units.
12. Describe conditions that affect temperature.
13. Define level.
14. Identify and describe types of level measurement.
15. Identify and use level measurement units.
16. Describe conditions that affect level.

MODULE 35211 – PROCESS CONTROL THEORY

1. Draw and label a block diagram of a basic control channel.
2. Contrast the terms direct and inferred measurement.
3. Discriminate between the terms range and span and between the terms elevated zero and suppressed zero.
4. Define the following commonly encountered static characteristics of a process measurement channel:
 - Accuracy
 - Resolution
 - Sensitivity
 - Deadband
 - Hysteresis
 - Linearity
 - Conformity
5. Given a diagram, explain each of the following characteristics of an instrument channel:
 - Dead time
 - Time constant
6. Define the term process control.
7. Given a simplified block diagram of a process loop, identify the controlled variable, the measured variable, the manipulated variable, and the final control element.
8. Describe how feedback is used in closed-loop process control.
9. Define open-loop control.
10. List the three criteria for evaluating the performance of closed-loop control.
11. Define process gain.
12. Define dead time.
13. Describe the response of a single capacity process to a step change disturbance.
14. Describe the inputs and output of a two-position controller.
15. Describe the effect of varying the neutral zone in a two-position control system.
16. Describe the effect of system delays on two-position control.
17. List the advantages and disadvantages of two-position control.
18. List one common application of two-position control.
19. List three important characteristics of two-position control.
20. Define integral control.
21. Describe the relationship between the following terms: integration time constant, minutes per repeat, and repeats per minute.
22. List an advantage and a disadvantage of integral control.
23. Define proportional control.
24. Describe the relationship between proportional band and gain.
25. List an advantage and a disadvantage of proportional control.
26. Describe why offset error occurs in a proportional controller.
27. Explain the effect of changing the controller gain on offset error.
28. List an advantage and a disadvantage of PI control.
29. Describe the effect of changing the integral time on the proportional band.
30. Describe the effect of changing the proportional band on the integral action.
31. Define reset wind-up.
32. Describe the effect of changing integral time and proportional band on system stability.
33. Define derivative control.
34. Define derivative time.
35. Discuss the effect of changing the proportional band on the derivative action.
36. Discuss the effect of changing the derivative time on the proportional action.
37. Discuss the effect of derivative action on system stability and zero offset.
38. List the advantage gained by the use of each mode in a PID controller.
39. Describe the effect of each mode of a PID controller on stability.
40. State the primary advantage of cascade control.
41. Define the following control modes:
 - Cascade control
 - Ratio control
 - Feedforward control

MODULE 32512 – PRECISION MEASURING TOOLS

1. Use levels.
2. Use feeler gauges.
3. Use calipers.
4. Use micrometers.
5. Use dial indicators.
6. Use protractors.
7. Use parallels and gauge blocks.
8. Use trammels.
9. Use precision straightedges.
10. Use speed measurement tools.
11. Use pyrometers.

MODULE 32513 - FORKLIFTS

1. Differentiate between fixed mast and telescoping boom forklifts.
2. Read a capacity chart for a given forklift.
3. Discuss general forklift safety before and during operation.
4. Pick up and place a load with a forklift.
5. Travel with a load.
6. Discuss special safety considerations for placing elevated loads.
7. Discuss special safety considerations for traveling with long loads.
8. Discuss general preventive maintenance for forklifts.
9. Discuss procedures for transportation, highway operation, and parking.

MODULE 32514 – FIBER OPTICS

1. Explain the basic principles of fiber optic technology.
2. Discuss the fundamentals, benefits, and applications of a fiber optic system.
3. Discuss the operational considerations for a fiber optic system.
4. Explain the construction of an optical fiber.
5. Describe the various types of fiber optic cable.
6. Discuss the design, operation, and performance of a fiber optic transmitter.
7. Discuss the design, operation, and performance of a fiber optic receiver.
8. State the types and construction of fiber optic detectors.
9. Explain the desirable features and connector losses of a fiber optic connector or splice.
10. Give examples of fiber optic connectors and splices.
11. Discuss the different types and construction of fiber optic couplers.
12. Discuss the installation of fiber optic cabling and support equipment.
13. Describe the mechanical considerations of a fiber optic cable.
14. Explain the applications and types of fiber optic splicing.
15. Explain the testing procedures for fiber optic systems.