MPACT Institute

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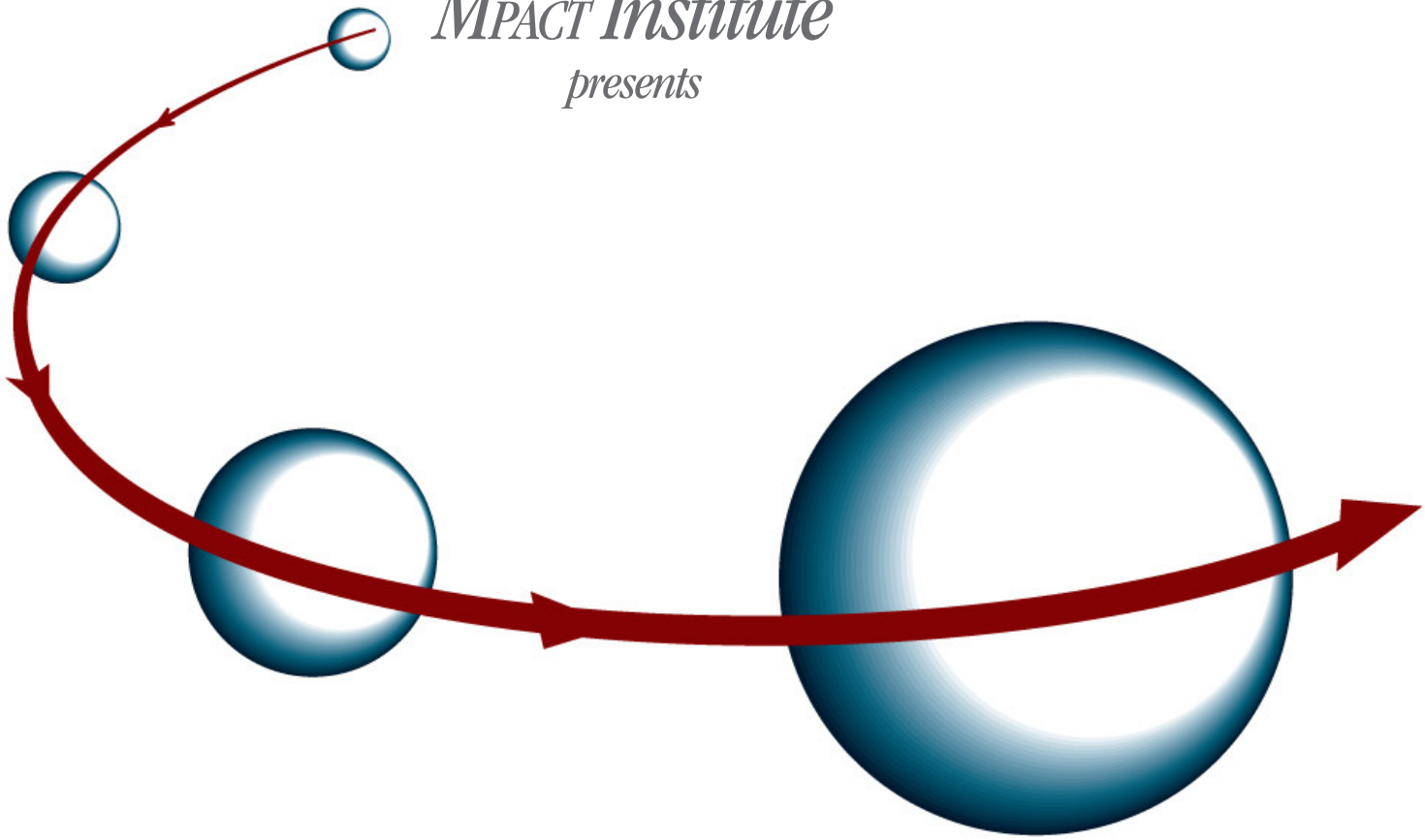

Turning Potential Into Performance

MPACT® INSTITUTE Certified Training Program

Table of Contents

Core Competencies

Specific Competencies

MPACT® INSTITUTE Certified Training Program

Reading Blueprints

Course 101: Reading Blueprints
Covers all types of blueprints used in industrial plants. Discusses machine parts and machine drawings. Features drawings of a compound rest and a clutch-brake control. Examines hydraulic, pneumatic, piping, plumbing, electrical, air-conditioning, and refrigeration drawings. Introduces sketching used in industrial plants.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Introduction to Blueprints

Topics

Detail drawings; Notes and dimensions; Assembly and pictorial drawings; Orthographic projections; Auxiliary views; Sections

Objectives

- Identify details, markings, and machine parts from an assembly drawing.
- Identify an object from an orthographic drawing.
- Identify elements located within the title block of a detail drawing.
- Explain why more than one orthographic projection is needed to show an object on a blueprint.

Lesson 2: Machine Parts

Topics

Simple machines; Screw threads; Heads; Rivets; Welds; Pins; Keys; Springs; Gears;
Bearings; Belts and pulleys

Objectives

- Describe what a machine is, and explain what it does.
- Name the two basic methods of joining machine parts.
- Name and identify from an exhibit several types of threaded fasteners.
- Name the two basic methods of permanent joining.
- Identify gears, bearings, and belt drives on drawings.
- Identify types of screw threads from a specification.

Lesson 3: Machine Drawings

Topics

Machine tools; Exploded views; Assembly and detail drawings; Drafting techniques

Objectives

- Name the main parts of a lathe.
- State the definition of an exploded view.
- Identify an assembly drawing.
- Identify a compound rest swivel on an assembly drawing.
- Identify a specific part on an assembly drawing.

Lesson 4: Sheet Metal Drawings

Topics

Sheet metal; Ventilation systems; Ductwork; Parallel, miter, and radial development; Extra metal for assembly

Objectives

- Describe the difference among coils, strips, and sheet metal.
- Describe how a ventilation system works.
- State the purpose of an arrow on a duct symbol.
- Demonstrate how to lay out a development.
- Define a radial development of a truncated pyramid.

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Lesson 5: Building Drawings

Topics

Buildings and building sites; Symbols and conventions; Plat, site, and floor plans; Working drawings

Objectives

- Name building materials, given their standard symbols.
- Explain how to find useful information on a flow diagram.
- Explain how to find useful information on an industrial plat.
- List the contents of a set of building drawings.
- Describe the purpose of a structural drawing.

Lesson 6: Hydraulic and Pneumatic Drawings

Topics

Fluid systems; Pascal's Law; Multiplying forces; Pistons and cylinders; Fluid system components; Symbols

Objectives

- Name the components represented by common symbols on hydraulic and pneumatic drawings.
- Name the components in a simple hydraulic power system.
- Name the components in a simple pneumatic power system.
- State Pascal's Law.
- Discuss the purposes of the components of hydraulic systems.

Lesson 7: Piping and Plumbing Drawings

Topics

Piping and plumbing materials; Kinds of joints; Drawings; Joining metal pipes

Objectives

- State the definition of piping.
- Explain why joints are sometimes brazed instead of soldered.
- Explain how to assemble a screwed joint.
- Identify different types of pipe joints.
- Identify piping-system components shown in a single-line drawing.
- Define electrochemical corrosion.

Lesson 8: Electrical Drawings

Topics

Importance of electrical drawings; Electric power; Electrical drawings and wiring; Using electrical drawings

Objectives

- Identify different electrical symbols on a drawing.
- Identify the power distribution panels in your plant.
- Identify different types of conduit and cable.
- Select the best electrical drawing to use when looking for a faulty circuit between the basement and the first floor.
- Explain how electricity at 480 volts is reduced by a transformer to 120/240 volts.
- Define the terms voltage, current, and power

Lesson 9: Air Conditioning and Refrigeration Drawings

Topics

Principles of refrigeration; Component drawings; Principles of air conditioning; Air conditioning systems

Objectives

- Explain how a refrigeration system works.
- Describe the types of ac controls.
- Name three kinds of condensers used in air conditioning systems.
- Explain the difference between unitary and central air-conditioning equipment.
- Explain how to find useful information on a duct drawing.

Lesson 10: Sketching

Topics

Using and making sketches; Kinds of sketches; Orthographic, isometric, and perspective sketches

Objectives

- Name the four kinds of sketches.
- Identify an isometric sketch.
- Describe the appearance of a perspective drawing.
- Discuss how to sketch straight lines and curved lines.
- State the definition of a vanishing point.

Reading Schematics and Symbols

Course 102: Reading Schematics and Symbols
Covers schematics and symbols used in commercial and industrial settings. Examines symbols on schematics, electrical symbols and diagrams, piping symbols and diagrams, hydraulic and pneumatic diagrams and symbols. Discusses air conditioning and refrigeration systems, including explanations of electrical/electronic control schematics. Covers welding and joining symbols.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Introduction to Schematics and Symbols

Topics

Using schematics; Electrical, pneumatic, hydraulic, and piping schematics; Looking for flow; Electrical current; Fluid flow

Objectives

- State the definition of a schematic.
- List some characteristics of schematics.
- Identify a schematic among other kinds of technical drawings and diagrams.
- Explain how flow is indicated on a schematic.

Lesson 2: Symbols on Schematics

Topics

Common features in schematics; Creating and using the schematic; Identifying symbols and connections; Reading diagrams

Objectives

- Identify various types of lines on schematics
- Identify the following schematics by their symbols:
  - Electrical
  - Fluid-power
  - Piping
- Give the purpose of legends and other tables of symbols.
- Describe a set-by-step approach to troubleshooting when using a schematic.

Lesson 3: Electrical Symbols

Topics

Wires and connections; Switches; Power supply; Coils and transformers; Fuses and circuit breakers; Grounding; Contacts; Resistors

Objectives

- State the meaning of symbols and lines on an electrical schematic.
- Explain the difference between a fuse and a circuit breaker.
- Explain how to trace an electrical circuit.

Lesson 4: Electrical Diagrams

Topics

Schematic and wiring diagrams; Series and parallel circuits; Reading electrical diagrams and industrial schematics

Objectives

- Explain the difference in current flow between a series circuit and a parallel circuit.
- Explain the purpose of a wiring diagram.
- Demonstrate how to read an electrical schematic.
- Identify the objects represented by the symbols on an industrial schematic.

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Reading Schematics and Symbols

Lesson 5: Piping Symbols

Topics

Piping systems; Kinds of diagrams; Projections; Joints; Fittings; Symbols

Objectives

- Explain the function of a valve in a piping system.
- Name the ways of joining pipe.
- Identify the symbols for various kinds of fittings and describe the function of each fitting.

Lesson 6: Piping Diagrams

Topics

Piping systems; Valves; Identifying symbols; Reading a piping schematic

Objectives

- Give the purpose of a valve in a piping system.
- Explain the difference between a check valve and a cock valve.
- Identify the symbols for various types of valves.
- Demonstrate the ability to determine pipe size from a diagram.

Lesson 7: Hydraulic and Pneumatic Symbols

Topics

Fluid power; Reservoirs and receivers; Pumps and compressors; Actuators; Valves; Piping and tubing

Objectives

- Describe a fluid-power system.
- List and give the purpose of the main parts of a hydraulic system.
- List and give the purpose of the main parts of a pneumatic system.
- Identify pneumatic and hydraulic symbols on schematics.

Lesson 8: Hydraulic and Pneumatic Diagrams

Topics

Composite symbols; Understanding circuits; Hydraulic and pneumatic circuit diagrams; Local areas

Objectives

- Describe a composite symbol.
- Explain the difference between a closed and an open hydraulic or pneumatic system.
- Identify the actuator in a hydraulic diagram.
- Explain the purpose of local areas on a hydraulic or pneumatic diagram.

Lesson 9: Air Conditioning and Refrigeration Systems

Topics

Refrigeration, water, air distribution, and control subsystems; Electric, electronic, and pneumatic control schematics

Objectives

- Describe the subsystems of an air conditioning system.
- Identify the symbols for air conditioning and refrigeration components.
- Explain the operation of an air conditioning and refrigeration control system.

Lesson 10: Welding and Joining Symbols

Topics

Methods of welding; Joints; Welds; Symbols for welds; Assembled welding symbol; Placement of welds

Objectives

- Explain fusion welding.
- Name the main methods of fusion welding.
- Name the five types of joints and three ways of welding each joint.
- Demonstrate how to read and interpret a complete welding symbol.

Mathematics in the Plant

Course 103: Mathematics in the Plant
Begins with mathematical basics—numbers, numerals, subtraction, addition, multiplication, and division. Examines common and decimal fractions, ratios and proportions, powers and roots. Discusses the uses and functions of a calculator. Moves on to geometry, algebra, and formulas for problem solving. Concludes by explaining properties of triangles and trig and inverse trig functions.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Whole Numbers

Topics

Numbers and numerals; Decimal system; Positive and negative numbers; Addition; Multiplication; Subtraction; Division

Objectives

- Describe the difference between a number and a numeral.
- Demonstrate how to add three four-digit numbers, with carrying.
- Demonstrate how to subtract two four-digit numbers, with borrowing.
- Demonstrate how to multiply a four-digit number by a two-digit number.
- Demonstrate how to divide a four-digit number by a two-digit number.

Lesson 2: Common Fractions

Topics

Fraction definition; Improper fractions; Mixed numbers; Reducing fractions; Adding, subtracting, multiplying, and dividing fractions

Objectives

- State the definition of a fraction.
- Demonstrate how to reduce a fraction to its lowest terms.
- Demonstrate how to find the lowest common denominator of two fractions.
- Demonstrate how to add three common fractions having different denominators.

Lesson 3: Decimal Fractions

Topics

Rounding off; Adding, subtracting, multiplying, and dividing decimals; Changing common to decimal and decimal to common fractions

Objectives

- Describe the difference between a decimal fraction and a common fraction.
- Demonstrate how to round off a decimal fraction to a specified number of places.
- Demonstrate how to multiply one decimal fraction by another.
- Demonstrate how to round off the products and quotients of decimal fractions.
- Demonstrate how to change fractions from common form to decimal form, and vice-versa.

Lesson 4: Ratios and Proportions

Topics

Comparing numbers; Expressing and writing ratios; Units in ratios; Proportion

Objectives

- Demonstrate how to calculate the ratio of two numbers.
- Demonstrate how to use a ratio to express a change.
- Demonstrate how to use a ratio to solve a typical plant problem.

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Lesson 5: Powers and Roots

Topics

Repeating multiplication and division; Exponential form; Zero power; Roots; Fractional and decimal exponents

Objectives

- Demonstrate how to calculate the value of a number given in exponential form.
- Demonstrate how to write products and quotients of numbers given in exponential form.
- Demonstrate how to calculate the value of a number raised to a fractional power.
- Demonstrate how to calculate the value of a number raised to a negative power.

Lesson 6: Calculators

Topics

Inside a calculator; Internal logic; Basic and special functions; Special-purpose calculators

Objectives

- Explain the importance of an algorithm in a calculator.
- Describe how a calculator with arithmetic logic performs calculations.
- Describe how a calculator with algebraic logic performs calculations.
- Describe how a calculator with RPN logic differs from other calculators.

Lesson 7: Geometry

Topics

Lines and curves; Circles; Angles; Measuring angles; Polygons; Triangles; Quadrilaterals; Constructions

Objectives

- Explain the differences among a line, a line segment, and a ray.
- Identify a radius, a chord, and a diameter of a circle.
- Demonstrate how to measure an angle with a protractor.
- Define a circle.
- Identify a right triangle, an equilateral triangle, and an isosceles triangle in a drawing.
- Demonstrate how to duplicate an angle using a straightedge and a compass.

Lesson 8: Algebra

Topics

Symbols, expressions, and equations; Order of operations; Numbers and variables; Algebraic laws; Writing and solving equations

Objectives

- Demonstrate how to calculate the value of an expression by performing mixed operations in the correct order.
- Demonstrate how to write an algebraic equation, based on a relationship stated in words.
- Demonstrate how to solve an algebraic equation for a specific variable.

Lesson 9: Using Formulas

Topics

Solving sample problems; Length, area, and volume

Objectives

- Identify values as length, area, or volume, based on their units of measurement.
- Demonstrate how to calculate the surface area and volume of a rectangle, a circle, a cylinder, and a sphere, given the dimensions of each and a list of formulas from which to choose.
- Demonstrate how to calculate the length of one side of a right triangle, given the other two sides.

Lesson 10: Trigonometry

Topics

Properties of triangles; Trig functions; Trig tables; Inverse trig functions; Using trig functions

Objectives

- State the definition of the sine, cosine, and tangent of an angle.
- Demonstrate how to find the value of the sine, cosine, and tangent of a given angle, using either a trig table or a calculator.
- Demonstrate how to find the inverse sine, inverse cosine, and inverse tangent of a given value, using either a trig table or a calculator.
- Demonstrate how to solve a geometric problem, using trigonometry.

Making Measurements

Course 104: Making Measurements
Examines all aspects of basic measurement concepts and procedures, including accuracy and tolerance. Discusses techniques and devices for comparison measurements. Shows common methods for measuring volume, motion, force, temperature, fluid flow, and electricity. Explains how to use scales, rules, combination calipers, and micrometers.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Units of Measurement

Topics

Length; Area; Volume; Angles; Time; Speed and velocity; Mass and weight; Force; Work and power; Pressure; Temperature; Electricity

Objectives

- Identify various units of measurement.
- State the definition of the joule, the coulomb, and the horsepower.
- Explain how to calculate pressure.
- Explain the difference between mass and weight.
- Demonstrate how to measure the volume of an object.
- Explain the difference between the Celsius scale and the Fahrenheit scale.

Lesson 2: Metric Measurement

Topics

Length, area, volume; Mass; Frequency; Speed and velocity; Acceleration; Force and weight; Work, energy, and power; Temperature; Current; Light

Objectives

- List the seven base units in the SI (metric) system.
- Name three derived units.
- Define work and power in SI units.
- Explain what power is and how it is measured.
- Name two metric measuring instruments and their U.S. Standard equivalents.

Lesson 3: Linear Measurement

Topics

Units; Measurement error; Tolerances; Scales and rules; Scribers and dividers; Bevel gauge; Calipers; Combination square; Using a micrometer

Objectives

- List five units used for making linear measurements.
- Demonstrate how to use a micrometer.
- Explain what each head of a combination square is used for.
- State the definition of parallax error.
- Define the different types of tolerance.

Lesson 4: Comparison and Surface Measurement

Topics

Gauge blocks; Measuring screw threads, radius, surface texture; Hardness testing; Testing surface coatings; Detecting defects

Objectives

- Explain the difference between a continuous dial and a balanced dial on a dial indicator.
  the definition of pitch on a screw.
- Name two hardness tests.
- Explain why nondestructive testing is preferable to destructive testing on surface coatings.

Lesson 5: Measuring Bulk Materials

Topics

Storing and handling bulk solids; Conveyors; Measuring area, volume, weight, mass, density; Measuring lumber

Objectives

- Explain why weight-density and the angle of repose are important to workers who handle and store loose bulk material.
- Name the two types of conveyors and list three specific examples of each type.
- Name the three basic measurements of bulk materials.
- Demonstrate how to find the radius of a circle, given its area, and how to find the area of a circle, given its circumference.
- Demonstrate how to convert a typical order of lumber into board feet.

Lesson 6: Measuring Motion

Topics

Relative motion; Displacement; Velocity; Acceleration; Average and instantaneous values; Motion on a curved path; Graphs of motion

Objectives

- Name the three measurements of motion.
- State the definition of speed.
- Explain the difference between average and instantaneous velocity.
- Demonstrate how to interpret a graph of motion.
- Explain of the velocity of an object is shown on a graph of motion.

Lesson 7: Measuring Forces

Topics

How forces act; Combining forces; Force and torque measurement; Analyzing forces

Objectives

- Name both the metric and the U.S. Standard units of measurement for force, mass, and acceleration.
- State the definition of force.
- Demonstrate how to calculate torque.
- State an advantage of using a balance instead of a scale.
- Demonstrate how to draw a force diagram.

Lesson 8: Measuring Temperature

Topics

Temperature and heat; Temperature-sensing materials; Thermometers; Pyrometers; Response time and accuracy

Objectives

- Explain the difference between heat and temperature.
- Name four different scales for measuring temperature.
- Explain the use of heat-sensitive pellets, crayons, and paints.
- Explain how Bourdon tubes work.
- Explain how a pyrometer works.

Lesson 9: Measuring Fluids

Topics

States of matter; Measuring liquid level, viscosity, flow rate, volume of flow, specific gravity, pressure, humidity, density

Objectives

- State the definition of a fluid.
- Describe how liquids differ from gases.
- List the instruments used to measure the level of water.
- Name two instruments that measure the flow of fluids, and explain how they work.

Lesson 10: Measuring Electricity

Topics

Electricity; Electric circuits; Electrical units; Measuring current, potential difference, resistance, power; AC and DC measurements

Objectives

- List the parts of an atom.
- Define potential difference.
- Identify a wattmeter.
- Describe the difference between alternating current and direct current.
- Describe the difference between an ohmmeter and an ammeter.

Metals in the Plant

Course 105: Metals in the Plant
Introduces metals, metallurgy, and metalworking. Discusses the properties of metals, including mechanical properties. Examines several industrial manufacturing processes. Covers iron and standard steels. Explains the different kinds of heat treatment and their usage. Discusses some techniques of working with copper, aluminum, magnesium, titanium, lead, nickel, tin, and zinc.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Introduction to Metals

Topics

Metals and metallurgy; Alloys; Internal structure of metals; Casting; Metalworking; Joining metals

Objectives

- Name five metals or alloys commonly used in industry.
- Name five mechanical properties of metals.
- Describe the uses of three metal alloys.
- Describe the metalworking processes of casting, forming, and machining.

Lesson 2: Properties of Metals

Topics

Hardness; Ductility; Malleability; Toughness; Tensile strength; Stresses; Elasticity; Strain; Metal fatigue; Thermal expansion; Density

Objectives

- State the definitions of four mechanical properties of metals.
- Describe the three kinds of stress.
- List the ways in which a metal can fail.
- State the definition of elasticity.
- Demonstrate how to calculate the density of metal.

Lesson 3: Manufacturing Processes

Topics

Forging; Extrusion; Powder and sheet metal forming; Wire drawing

Objectives

- Name four kinds of molds used in casting.
- List the steps in making a sand mold.
- Describe the differences between hot-chamber and cold-chamber die casting.
- Describe extrusion.
- List the steps involved in making a part by powder metallurgy.

Lesson 4: Iron and Steel

Topics

Iron ore; Pig iron; Smelting; Cast, gray cast, white cast, malleable cast, ductile cast, and high-alloy cast iron; Steel

Objectives

- Name the commercial grades of cast iron.
- List the important mechanical properties of commercial grades of cast iron.
- Describe the forms in which carbon appears in commercial grades of cast iron.
- Describe the process of smelting.

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Lesson 5: Standard Steels

Topics

Carbon in steels; Steel rolling, coding, and classification; Spark testing; Plate, strip, sheet steel; Structural steel; Alloy and stainless steel

Objectives

- State the definition of steel.
- Name the method by which a steel was made, based on its AISI code.
- Demonstrate how to conduct a spark test.
- Identify steel sheets having as-rolled edges and cut edges.
- Describe two differences between alloy steels and steels containing only iron and carbon.

Lesson 6: Heat Treatment

Topics

Welding; Repairing tools and machines; Castings; Forgings; Carbon content of steels; Science of heat treatment

Objectives

- Describe the two basic processes, and state the four major purposes, of heat treatment.
- Explain why distortion and cracking occur during welding.
- Explain how to anneal, harden, and temper a star drill.
- State the definitions of low-carbon, medium-carbon, and high-carbon steels.

Lesson 7: Copper

Topics

Production; Alloys; Machinability ratings; Electrical conductivity; Corrosion resistance; Annealing copper; Brasses; Bronzes; Casting

Objectives

- List the steps in producing copper from ore.
- List the contents of brass, Muntz metal, admiralty brass, bronze, nickel silver, aluminum bronze, and cupro-nickel.
- Describe dezincification in brass.
- Name the three groups of brasses, based on their zinc content, and the three categories of hardness.
- List the contents of red brass, and describe its uses.

Lesson 8: Aluminum

Topics

Properties and production; Alloys; Grades; Forming processes; Anodizing; Welding; Brazing and soldering; Safety

Objectives

- List advantages and disadvantages of the oxide coating on aluminum.
- State the definition of wrought-grade and casting-grade aluminums.
- Describe the advantages of aluminum-silicon alloys.
- Describe how aluminum is anodized.
- Name the classifications of aluminum solders.

Lesson 9: Magnesium and Titanium

Topics

Producing, extracting, melting, refining, alloying, extruding, rolling, forging, machining, and joining magnesium; Uses for and processing of titanium

Objectives

- Name the alloys of magnesium and titanium.
- List the useful properties of magnesium and titanium.
- Describe how to join magnesium alloys.
- Describe the precautions that must be taken when working with magnesium and titanium.
- Describe the uses of magnesium and titanium in industry.

Lesson 10: Lead, Nickel, Tin, and Zinc

Topics

Lead properties, forms, and production; Nickel production and alloys; Tin properties, alloys, solder, babbit, and bronze; Zinc production and machining

Objectives

- Describe the properties and characteristics of lead.
- List the properties that are improved by adding nickel to stainless steel.
- Describe how tinplate is manufactured.
- Describe how zinc is refined and processed.

Nonmetals in the Plant

Course 106: Nonmetals in the Plant
Describes properties, characteristics, and classifications of each material. Covers synthetic and natural materials. Examines various paints and coatings, their proper use, preparation, and application. Surveys industrial chemicals. Chemical safety precautions are covered, along with the proper use of protective equipment.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Introduction to Nonmetals

Topics

Properties and behavior of solids, liquids, and gases; Boyle's Law; Laminar and turbulent flow; Mixed-phase systems

Objectives

- State the definition of a solid, a liquid, and a gas.
- Demonstrate how to change a liquid to a solid.
- Demonstrate buoyancy.
- Identify an object less dense than water, and an object more dense than water.
- List six possible combinations of matter.

Lesson 2: Plastics

Topics

Characteristics; Processing; Molding; Casting; Extruding; Reinforcing; Machining; Welding; Patching

Objectives

- State the definition of a thermoplastic and a thermoset.
- Describe injection molding, foam molding, and extrusion.
- Select the best bonding agent for joining polyethylene parts.
- Describe the steps in patching a damaged area with glass-plastic material.

Lesson 3: Rubber

Topics

Properties; Processing; Kinds and uses; Vulcanizing; Foam rubber; Hose and tubing; Tank linings; Reclaiming rubber

Objectives

- Name four properties of rubber.
- Explain the vulcanizing process.
- Select the best hose for handling oils or gasoline.
- Describe how to use a pinhole locator.
- List the kinds of sheet rubber that should be kept on hand in the storeroom of an industrial maintenance department.

Lesson 4: Wood

Topics

Properties; Grades and defects; Measuring lumber; Plywood; Choosing wood; Joints; Preservation; Industrial uses; Fasteners

Objectives

- State the definition of hardwood and softwood.
- Name the grades of softwoods and hardwoods.
- Describe a radial cut, a crosscut, and a tangential cut.
- Demonstrate how to calculate the number of board feet in a piece of 2 x 8 lumber 10 ft long.

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Lesson 5: Construction Materials

Topics

Concrete; Masonry units; Brick; Mortar; Patching and repairing; Wallboard; Plaster; Glass

Objectives

- List the ingredients in concrete.
- State the definition of spalling, crazing, and dusting.
- Explain how to remove an oil stain from concrete.
- Demonstrate how to mix a small batch of mortar.
- List the steps in repairing a hole in wallboard.

Lesson 6: Insulating Materials

Topics

Heat flow; Thermal, loose-fill, blanket, low-density, and acoustic insulation; Vapor barriers; Electrical insulation; Fire prevention

Objectives

- Name the ways by which heat can be transferred.
- State the formula for determining the thermal conductivity coefficient (k value) of a thermal insulator.
- Demonstrate how to install blanket insulation.
- Select the best materials for use an electrical insulation where resistance to flame and high temperature is important.
- List the safety rules that should be followed when working with insulating materials.

Lesson 7: Paints and Coatings

Topics

Protective materials; Substrates; Paint; Primer; Choosing a coating; Surface preparation; Application; Using colors; Special coatings

Objectives

- List the factors to consider in selecting a protective coating.
- Name the qualities and characteristics of pigments and vehicles.
- List the safety precautions to follow when using paints containing solvent thinners.
- State the definition of primer.
- Demonstrate how to prepare a metal substrate for coating.

Lesson 8: Industrial Chemicals

Topics

Safety; Soaps and detergents; Solvents; Acids; Aerosols; Oils; Refrigerants; Water-treatment chemicals; Fuels; Fire-fighting chemicals

Objectives

- List the safety precautions to follow when working with liquid and solid chemicals.
- Name the general classifications of cleaning agents.
- Select the best acid for cleaning stainless steel and aluminum.
- State the reasons why aerosol spray cans are potentially dangerous.
- List considerations in selecting an oil for a particular use.

Lesson 9: Adhesives

Topics

Kinds of adhesives; Glues; Plastic welding; Acrylic-based adhesives; Other adhesives; Strength of adhesives; Tapes

Objectives

- State the definitions of adhesiveness, curing, drying, joint, pot, life, and tack.
- List the characteristics of thermosetting and themoplastic adhesives.
- Demonstrate the plastic-welding process.
- Select the best tapes for insulating and protecting electrical connections and wires.

Lesson 10: Carbon

Topics

Forms and properties; Electrodes and resistors; Carbon brushes; Industrial diamonds; Carbon seals; Graphite packing; Chemical resistivity

Objectives

- List four uses of carbon and fabricated carbon products in industry.
- List three properties of carbon that make it useful in electrical and mechanical applications.
- Describe the carbon-arc welding process.
- List the most common causes of brush noise.
- Demonstrate the correct method of cutting individual rings from a continuous length of braided packing.

Hand Tools

Course 107: Hand Tools
Begins with measuring tools, including a discussion of units of measurement. Examines the various kinds of wrenches and screwdrivers, their uses and handling techniques. Explains other hand tools by specialty: pipefitting tools, plumbing tools, electrician's tools, sheet metalworking tools, machinists' metal-working tools. Ends with hoisting and pulling tools.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Measuring Tools

Topics

Linear and angular measurement; Rules and measuring tapes; Slide, vernier, and micrometer caliper; Squares

Objectives

- Explain how to hold a rigid rule correctly when measuring an object and show from which point the measurement begins.
- Describe how to set lock joint transfer-type calipers.
- Identify vernier calipers.
- Explain how to take a measurement with a micrometer caliper.
- Name the parts of a combination square.

Lesson 2: Wrenches and Screwdrivers

Topics

Wrenches—open-end, box-end, combination, socket, adjustable, torque; Screwdrivers—standard, cross-slot, spiral, ratchet, offset; Driving and removing screws; Restoring a blade

Objectives

- Identify types of materials used for making wrenches.
- Identify open-end, box-end, socket, socket-head, adjustable, torque, and striking-face wrenches.
- Describe two sizes that are important in identifying a socket wrench.
- Identify standard, Phillips, offset, and spiral-ratchet screwdrivers.
- List the steps to follow when driving a screw.

Lesson 3: Pipefitting Tools

Topics

Pipe wrenches; Vises; Cutting, reaming, threading, and tapping pipe; Cutting tubing and plastic pipe; Flaring tubing; Tool care

Objectives

- Identify a straight pipe wrench, a Stillson wrench, a chain pipe wrench, a strap wrench, and a compound-leverage wrench.
- Explain how to use a pipe wrench.
- Explain why a machinists' vise should not be used for holding pipe.
- Explain how to thread pipe.
- Explain how to clean a pipe tool.
- Explain how to cut and flare tubing.

Lesson 4: Plumbing Tools

Topics

Plumbing systems and codes; Joining pipe; Tube bending; Cutting and assembling pipe; Plungers; Augers; Sewer tapes; Special wrenches

Objectives

- Explain how to use a mechanical tube bender.
- List the steps in joining hubless pipe.
- Explain why the drain pipe should be completely covered by the force cup.
- Name the criteria used in selecting line clearing tools.
- List the steps in measuring pipe when using the center-to-center measuring systems.

Lesson 5: Electrician's Tools

Topics

EMT bender; Bending and assembling conduit; Knockout punches; Fish tapes; Pliers; Wire and cable strippers; Test and safety equipment

Objectives

- Explain how to use an EMT bender and a neon circuit tester.
- List the parts of a knockout punch.
- Name the uses of the all-purpose tool.

Lesson 6: Woodworking Tools

Topics

Planes; Scrapers; Drills and bits; Chisels; Levels; Plumb bobs; Hammers and nail sets

Objectives

- Describe the difference between a ripsaw and a crosscut saw.
- Explain the difference between a compass saw and a keyhole saw.
- Describe the different types of planes.
- Identify a Forstner bit.
- Explain the working of a plumb line.

Lesson 7: Masonry, Plastering, and Glazing Tools

Topics

Working with bricks, mortar, concrete; Tuckpointing; Edging and finishing; Repairing plaster and wallboard; Cutting and installing glass

Objectives

- Explain how to mix a small batch of mortar.
- List the uses of a trowel.
- Define tuckpointing.
- Explain why flat concrete surfaces must be screeded.
- Explain how to repair one of the following problems: (a) small plaster cracks, (b) shrinkage cracks, or (c) loose or bulging plaster.
- Explain how to replace a broken pane of glass in a window.

Lesson 8: Sheet Metalworking Tools

Topics

Gauges; Layout tools; Dividers; Punches; Nibblers; Riveting tools; Metal-cutting chisels; Hammers; Snips; Dressing tools; Bench stakes

Objectives

- Identify different types of snips and punches.
- Identify the bench stakes discussed in this Lesson.
- List six safety practices to follow when working with sheet metal.
- Describe different types of sheet metal.

Lesson 9: Metalworking Tools

Topics

Vises; Hacksaws; Files; Taps; Dies; Thread classes; Reamers

Objectives

- Select the proper hacksaw blades for cutting various materials.
- Explain the difference between single-cut and double-cut files.
- List the types of taps usually found in a tap set.
- Explain how to cut an external thread on a bolt, screw, or stud.
- Explain how to remove a reamer from a hole.

Lesson 10: Hoisting and Pulling Tools

Topics

Knots; Wire rope; Slings, sling angles, hitches; Sling spreader beams; Block and tackle; Chain fall; Pullers

Objectives

- Explain how to prevent synthetic and fiber rope from unraveling.
- Explain how individual wires and strands of wire are formed into wire rope.
- Identify the most appropriate sling for use near corrosive chemicals.
- Identify a slide-hammer puller.
- Describe different kinds of slings and loads.

Portable Power Tools

Course 108: Portable Power Tools
Explains the uses, selection, safety, and care of industrial power tools: electric drills, electric hammers, pneumatic drills and hammers, screwdrivers, nutrunners, wrenches, linear-motion and circular saws, routers and planes, electric sanders, grinders, and shears. Covers tool sharpening techniques for selected tools.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Electric Drills

Topics

Construction; Light- and heavy-duty drills; Accessories; Drill sizes and bits; Use and maintenance; Safety

Objectives

- Name four parts that are common to both the light-duty drill and the heavy-duty drill.
- Name the parts of a drill bit.
- Explain how to drill a blind hole.
- Explain how to inspect a drill bit, both visually and through testing.
- List the safety rules to follow when using electric power tools.

Lesson 2: Electric Hammers

Topics

Operation; Bits and chisels; Self-drilling anchors; Mechanical, electrical, and environmental safety

Objectives

- Explain the difference in hammering action between a percussion hammer and a rotary hammer.
- Select the proper chisel to use for each of the following jobs: brick cleaning; general demolition work; edging, chipping, and channeling; and removing floor tile.
- List the precautions that should be taken to ensure electrical safety when using an electric hammer.
- Name two safety items to use when operating an electric hammer in damp or wet areas.

Lesson 3: Pneumatic Drills and Hammers

Topics

Drill types and sizes; Bits; Operation; Hammer types; Chipping and scaling; Star drilling; Riveting; Tampers; Needle scalers; Diggers; Maintenance

Objectives

- Explain how drill size is determined.
- Describe the chiseling action of a bull point chisel when it is used to clean masonry seams.
- Describe how to use a rivet buster.
- Explain drill speed requirements.
- Identify various types of drill bits used in pneumatic hammers.

Lesson 4: Screwdrivers, Nutrunners, and Wrenches

Topics

Types; Clutch mechanisms; Power wrenches; Bits and sockets; Operation; Lubricators and moisture separators; Safety

Objectives

- Identify the operating advantages of pneumatic tools.
- Define stalling torque.
- Describe the clutch action of direct drive, positive drive, and adjustable torque drive.
- Explain how to install a bit in an electric screwdriver.
- Describe how to install multiple fasteners correctly in a circular pattern.
- List safety rules to follow when using power screwdrivers and wrenches.
- Describe the difference between pneumatic and electric nutrunners.

Lesson 5: Linear-Motion Saws

Topics

Straight-blade power saws; Saber saws; Plunge and straight cutting; Cutting metal; Reciprocating saws and blades; Band saws

Objectives

- List other names for both the saber saw and the reciprocating saw.
- Describe the cutting action of a saber saw.
- Explain how to draw a saw blade with regular set teeth and one with wavy set teeth.
- Explain how to plunge cut a rectangular opening.
- List the types of band saw blades described in this Lesson and a few characteristics of each.

Lesson 6: Circular Saws

Topics

Blades; Crosscutting; Ripping; Angular cutting; Plunge cutting; Notching and grooving; Cut-off wheels; Arbors; Accessories; Safety

Objectives

- Name the major parts of a circular saw.
- Describe the cutting action of a circular saw.
- List the factors that determine feed speed.
- State the definition of an arbor.
- Identify different types of blades.

Lesson 7: Routers and Planes

Topics

Router characteristics; Collet chucks; Bits; Direction of feed; Grooves and dadoes; Rabbet cuts; Trim; Circular cuts; Plane characteristics; Safety

Objectives

- Discuss how to use a router.
- Name the major parts of a router.
- Explain how to use a router and bit.
- Identify a rabbeting joint, a straight joint, and a mortising joint.
- Explain how to adjust and use a power plane.

Lesson 8: Electric Sanders

Topics

Belt, pad, orbital, and oscillating sanders; Use and maintenance; Disk sanders; Safety

Objectives

- Explain how to install a sanding belt.
- Identify different types of sanding belts.
- Explain how to flush the gear chamber of a belt sander.
- Discuss the assembly of a sanding disk.
- List the safety rules to follow when using a disk sander.

Lesson 9: Grinders and Shears

Topics

Grinder selection; Wheel classification; Mounting grinding wheels; Maintenance; Safety; Shears and nibblers selection and use

Objectives

- State the meaning of each symbol in the six-symbol standard marking system for grinding wheels.
- Explain the correct procedure for mounting a grinding wheel.
- List safety rules to follow when using a grinder.
- Discuss how to maintain grinders.

Lesson 10: Tool Sharpening

Topics

Whetstones; Using a bench grinder; Sharpening chisels, drill bits, screwdrivers, pointed tools, reamers, taps, and dies; Other methods

Objectives

- State the reasons for sharpening tools.
- Explain the use of whetstones.
- Identify a bench stone.
- Explain how to sharpen taps, dies, screwdrivers, and chisels.

Industrial Safety and Health

Course 109.1: Industrial Safety and Health
Explains the uses, selection, safety, and care of industrial power tools: electric drills, electric hammers, pneumatic drills and hammers, screwdrivers, nutrunners, wrenches, linear-motion and circular saws, routers and planes, electric sanders, grinders, and shears. Covers tool sharpening techniques for selected tools.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Introduction to Safety and Health

Topics

Responsibility for safety; Unsafe acts and conditions; Recognizing hazards; Types of accidents; Investigation; Handling emergencies

Objectives

- Define the terms accident and hazard.
- Name and define the four main types of hazards.
- List and define various types of accidents.
- Compare meanings of unsafe act and unsafe condition.
- Name the three ways in which a toxic substance can enter your body.
- List ways in which a company must plan for emergencies.
- Tell the main reason for prompt accident investigation.

Lesson 2: Government Safety and Health Regulations

Topics

OSHA standards and inspections; Records and reports; Hazard communication; MSDS, NIOSH, EPA; Canadian requirements

Objectives

- State the purpose of the OSHA Act.
- List the specific rights of employees under the Act.
- Explain what to do in a dangerous work situation.
- List things that you can do to help keep your workplace in compliance with OSHA standards.
- Explain the function of each of the following agencies: NIOSH, EPA.
- List the four main objectives of OSHA's Hazard Communication Standard.
- Tell what information can be found on an MSDS.

Lesson 3: Personal Protective Equipment

Topics

Work clothes; Gloves; Head, eye, face, hearing and foot protection; Safety harness and lifeline; Respiratory protection

Objectives

- List employer and employee responsibilities related to PPE.
- Tell why work clothing can be dangerous if it fits poorly.
- Explain the importance of proper glove selection when handling chemicals.
- Describe the proper fit of a hard hat.
- Compare and contrast everyday eyeglasses, industrial safety glasses, and safety goggles.
- Identify noise levels that require hearing protection.
- Name the two basic kinds of respirators.

Lesson 4: Chemical Safety

Topics

Physical and health hazards; Exposure routes; Control of hazards and exposures; Chemical spill response; First aid

Objectives

- Define chemical hazard, physical hazard, and health hazard.
- Name three kinds of physical hazards.
- Name and describe at least four kinds of health hazards.
- Identify common symptoms of chemical exposure.
- List three health hazard exposure routes.
- Name three ways of controlling chemical hazards and exposures.
- Explain first aid procedures to follow when you are exposed to a hazardous chemical.

Lesson 5: Tool Safety

Topics

Screwdrivers; Wrenches; Pliers; Hammers and mallets; Chisels and punches; Knives; Electric tools; Pneumatic and gas-powered tools

Objectives

- Name at least three causes of hand tool accidents.
- List one safety rule to follow when using each of the following: screwdriver, wrench, pliers, hammer, chisel, knife.
- Describe proper and improper dress for working with rotating power tools.
- Explain the importance of grounding electric tools.
- Name two hazards involved in pneumatic tool use and explain how to guard against them.
- Explain proper handling and storage of gasoline.

Lesson 6: Material Handling

Topics

Rules for lifting; Handling various shapes and sizes; Industrial hand trucks; Powered trucks; Dock safety; Conveyors; Hoists and cranes

Objectives

- List simple safety procedures and precautions related to material handling.
- Describe how to lift, carry, and put down a load.
- Explain safety principles for working with or around industrial trucks.
- Discuss safety rules for working with or around conveyors, slings, and hoists.
- Describe how and where to store materials.

Lesson 7: Working Safely with Machinery

Topics

Safety guards; Other safety devices; OSHA lockout/tagout procedures

Objectives

- Identify a machine's point of operation and other pinch points, and explain why they are dangerous.
- Identify different kinds of mechanical safeguards, and explain why they are necessary.
- Define zero energy state.
- Describe the lockout/tagout procedures established by the OSHA energy control standard.

Lesson 8: Working Safely with Electricity

Topics

Electric circuit; Injuries from electricity; First aid for shock victims; National Electrical Code; Static electricity

Objectives

- Define the following terms: electric current, circuit, potential difference, ampere, watt, ohm, and volt.
- State Ohm's Law.
- Explain the function of each wire in a simple electric circuit and tell the color(s) used to identify each.
- List the three factors that affect the severity of an electric shock.
- Describe the effects of electric current on the human body.
- Tell the three most important points about first aid for shock victims.
- Explain how static electricity is generated, why its accumulation can be dangerous, and how it can be avoided.

Lesson 9: Electrical Equipment Safety

Topics

Grounding; Ground faults; Fuses and circuit breakers; Double-insulated tools; Hazardous electrical locations; Basic safety rules

Objectives

- Explain the importance of proper grounding.
- Define the term "ground fault" and explain how ground faults occur.
- Explain the purpose and operation of the following devices: GFCI, fuse, circuit breaker.
- Identify typical hazardous electrical locations.
- Explain the purpose of explosion-proof and intrinsically safe electrical equipment.
- List at least two electrical safety rules in each of the following areas: clothing, equipment, water, lockout/tagout.

Lesson 10: Fire Safety

Topics

How fires start; Classes of fire; Fire and explosion hazards and prevention; Fire-fighting substances; Fire hoses and extinguishers

Objectives

- Name and give the definition of the four classes of fires.
- Define the terms flash point and spontaneous combustion.
- Name the fire-fighting agents, and explain how they work and when to use them.
- Explain the use of at least two different types of portable fire extinguishers.
- List three ways of preventing fires.
- Explain fire hose and fire extinguisher maintenance.

Lesson 11: Protecting Your Health

Topics

Ergonomics; Noise; Radiation; Asbestos and lung disease; Fetal protection; The environment

Objectives

- Define ergonomics and tell how poor ergonomic conditions affect the body.
- List three actions that you can take to protect your hearing.
- Tell the cause of each of the following lung diseases: asbestosis, lung cancer, brown lung, black lung, silicosis.
- Contrast ionizing and nonionizing radiation.
- Compare and contrast personal and background sampling.
- Explain the importance of protecting women from exposure to certain chemicals.
- State the purpose of the EPA.

Lesson 12: A Safe Work Environment

Topics

Housekeeping; Walking and working surfaces; Safety in traffic and at elevations; Ladders and scaffolds; Lighting; Safety in extreme heat; Confined spaces; Welding and cutting

Objectives

- Explain the importance of industrial housekeeping.
- List safety measures related to walkways, stairs, and floor openings.
- Tell how to protect yourself and others when working in traffic paths.
- Describe at least three hazards involved with each of the following and tell how to safeguard against them: working at elevations and working in confined spaces.
- Calculate the proper placement of a straight ladder based on its working length.
- Name two kinds of scaffolds and give at least one safety rule associated with each.
- List symptoms of heatstroke, heat cramps, and heat exhaustion.
- Name two major safeguards necessary when welding.
- Explain how to handle and store cylinders safely.

Troubleshooting Skills

Course 110: Troubleshooting Skills
Explores the subject of troubleshooting and the importance of proper maintenance procedures. Covers working with others, aids in communication, and trade responsibilities. Outlines troubleshooting techniques and aids, using schematics and symbols. Focuses on specific maintenance tasks, breakdown maintenance, and planned maintenance.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Introduction to Troubleshooting

Topics

Troubleshooting skills, duties, aids; Mechanical and electrical troubleshooting; Maintenance organizations and personnel; Scheduling

Objectives

- Tell why efficient troubleshooting is important in a production plant.
- Name the four common troubleshooting aids.
- List the steps in troubleshooting a machine.
- List the steps in troubleshooting a system.
- Describe a typical maintenance organization.

Lesson 2: Working with Other People

Topics

Communication; People skills; Aids to communicating; Differences of opinion; You and your supervisor; Upgrading your skills

Objectives

- Tell why good communication between plant personnel is needed.
- List the ways a person usually sees himself/herself.
- Explain the communication cycle.
- Explain the correct method of delivering a written message from your supervisor to another person.

Lesson 3: Troubleshooting Techniques

Topics

Job responsibilities; Recognizing normal operations; Testing and observation; Reducing downtime; Routine and emergency repairs

Objectives

- List the steps to recognizing normal machine operations.
- List the questions you should ask yourself when a machine fails.
- List the signs of a machine in need of service.

Lesson 4: Aids to Troubleshooting

Topics

Drawings, blueprints, and sketches; Manufacturer's literature; Service reps; Planned-maintenance records; Work orders; Test equipment

Objectives

- Describe a blueprint.
- List the information that should be recorded in a machine equipment record.
- Identify calibration standards.
- Identify a multimeter (VOM).
- Identify different troubleshooting test equipment.

Lesson 5: Preparing for Troubleshooting

Topics

Tools, parts, and supplies; Safety rules; Using charts and diagrams; Correcting malfunctions; Keeping records

Objectives

- List the information you must know about mechanical or electrical systems before you can troubleshoot them successfully.
- Name the commonly used items that should be carried in every troubleshooter's tool box.
- List the steps to follow in reading a pneumatic or hydraulic schematic.
- List the responsibilities of a troubleshooter.

Lesson 6: Using Schematics and Diagrams

Topics

Piping, compressor, and engine schematics; Hydraulic, pneumatic, and electrical schematics; Lighting diagrams; Troubleshooting charts

Objectives

- Discuss how to use schematics when troubleshooting.
- Identify differences in schematics.
- Explain how to use a troubleshooting chart.

Lesson 7: Solving Mechanical Problems

Topics

Bearing, pump, and piping problems; Compressed-air, refrigeration, and pollution-control equipment; Hydraulic systems; HVAC

Objectives

- Identify bearing wear problems.
- Identify pump failure problems and solutions.
- Identify types of hosing.
- Identify different plant equipment and their problems.

Lesson 8: Solving Electrical Problems

Topics

Generation and distribution; Feeders and branch circuits; Fuses and circuit breakers; Testing for continuity; Safety; Troubleshooting

Objectives

- State the definition of switchgear.
- Identify current voltage characteristics of wire.
- List the safety rules to follow when working with electrical equipment.
- Identify a pictorial diagram, a block diagram, and a schematic diagram.
- Explain how to troubleshoot an electric problem.

Lesson 9: Breakdown Maintenance

Topics

Work-order procedures; Preparing for emergencies; Skills for emergency work; Using downtime

Objectives

- Explain what to do if you are the first member of the emergency crew.
- Explain the spare parts requisition form.
- Discuss the four main parts of practical machine maintenance.

Lesson 10: Planned Maintenance

Topics

Frequency and benefits; Unscheduled maintenance; Keeping records, Lubrication charts and tags

Objectives

- State the definition of planned maintenance.
- List the information that should be included on record sheets or file cards as part of the machine inventory.
- List the benefits to be accrued from an effective lubrication program.
- Describe the proper sag in a drive chain.
- Explain how to service a battery properly.

Basic Electricity and Electronics

Course 201: Basic Electricity and Electronics
Covers basic, nonmathematical approach to understanding principles of electricity. Introduces electron theory, static electricity, electrons in motion, and magnetism. Covers basic methods of measuring current, voltage, and resistance. Explains circuit components—conductors, insulators, resistors, capacitors—and simple Ohm's Law calculations for DC and AC circuits.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Introduction to Electricity

Topics

Structure of matter and atoms; Electron shells; Transferring charges; Electrical forces and terms

Objectives

- Describe the structure of an atom.
- Tell the difference between a compound and an element.
- Explain how electrical forces cause objects to attract or repel other objects.
- Describe electron flow.
- State the definition of a cell.

Lesson 2: Static Electricity

Topics

Nature, effects, generation, and elimination of static electricity; Effects of humidity; Static charges on liquids, vehicles, dusts, process machinery

Objectives

- List the conditions that must exist in order for static electricity to cause ignition.
- List the common causes of static electricity in an industrial plant.
- State the definition of bonding.
- Explain how liquid affects a static charge.
- State the definition of grounding.
- Explain the relationship between humidity and static electricity.

Lesson 3: Current Electricity

Topics

Electric current and energy; Electricity from chemical action; Primary and secondary cells; Batteries; Electricity from electromagnetism

Objectives

- List the main methods of producing potential difference.
- State the main difference between a primary cell and a secondary cell.
- Explain how to connect cells in parallel and in series.
- Describe how a photoelectric device works.
- Identify potential hazards when recharging batteries.

Lesson 4: Magnetism

Topics

Magnetic forces; Theory of magnetism; Magnetic fields; Left-hand rules; Electromagnets; Industrial uses of magnets

Objectives

- State the most basic law of magnetic force.
- Describe how magnetic force operates.
- Describe the left-hand rule for magnetic field direction.
- Describe an electromagnet.
- Explain how to use lifting magnets, magnetic pulleys, and magnetic clocks.

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Lesson 5: Current, Resistance, and Potential Difference

Topics

Electric current, resistance, and potential difference; Ohm's Law; Resistance and voltage drop; Electrical measurement

Objectives

- State the characteristics of an electrical conductor and an electrical insulator.
- State the definition of electric current.
- Explain the relationship of potential difference to the flow of electric current.
- State the definition of Ohm's Law.
- Identify the purpose and parts of an ammeter.

Lesson 6: Electrical Components

Topics

Resistors; Color code and power rating; Capacitors; Connecting capacitors; Induction; Inductors; Solenoids and relays

Objectives

- Identify symbols for resistors, capacitors, and relays in an electric circuit diagram.
- Explain the operating principles of resistors, capacitors, and inductors.
- State the meaning of each band in the resistor color-code system.
- List the factors to consider when choosing a resistor.
- Explain how to connect capacitors in parallel and in series.

Lesson 7: Conductors

Topics

Sizes and classifications; Insulation; Protecting conductors; Flexible conduit; Conduit fill; Splicing conductors

Objectives

- Explain the difference between a conductor and an insulator.
- Identify a bare conductor, a covered conductor, an insulated conductor, a stranded conductor, a cable, and a cord.
- State the definitions of insulation resistance and dielectric strength.
- Select the best tapes for insulating splices, restoring the outer protecting covering on a splice, and connecting motor leads.
- Explain how to make a pigtail splice and a fixture splice.
- State the purposes of cable protection.

Lesson 8: DC Circuits

Topics

DC characteristics; Ohm's Law; Circuit power; Series, parallel, series-parallel, open, and short circuits

Objectives

- State the difference between ac and dc.
- Solve for R, E, I, and P in a simple electrical problem.
- Solve for potential difference, current, and resistance in a series and parallel circuit.

Lesson 9: AC Circuits

Topics

Advantages of AC; Generating alternating current; Resistance, inductance, capacitance, current, and power in AC circuits

Objectives

- Explain the importance of the transformer in ac electricity.
- Explain what a complete cycle of ac consists of and how it is produced.
- State the definition of ac inductance.
- List the ways inductive reactance differs from resistance.
- Explain the difference between the terms in-phase and out-of-phase in an ac circuit.

Lesson 10: Electronics

Topics

Electron motion in a vacuum tube; Cathodes; Vacuum-tube diode and triode; Semiconductors; Transistors; Microprocessors

Objectives

- Name the parts of a vacuum tube, and describe the function of each part.
- Explain the difference between p-type semiconductor materials and n-type semiconductor material.
- List the parts of a transistor.
- State the definition of an integrated circuit.

Batteries and DC Circuits

Course 202: Batteries and DC Circuits
Covers how electrochemical action is used. Covers batteries, electrolytic action, electroplating, characteristics of storage batteries, application and maintenance of lead-acid, nickel-alkaline, and nickel-cadmium batteries, putting batteries in service, charging batteries, maintaining records, fundamentals of DC circuits, and using Ohm's Law to solve problems in DC series, parallel, and series-parallel circuits.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Electrochemical Action

Topics

Battery characteristics; Electrolysis; Electroplating; Extracting and refining metals; Electrolytic corrosion; Choosing a battery

Objectives

- State the difference between a primary cell and a secondary cell.
- Discuss electrochemical action.
- Explain how battery polarization works.
- State the definition of an electrolyte.
- List the factors to consider in selecting a battery.

Lesson 2: Battery Characteristics

Topics

Care and maintenance of dry cells; New kinds of primary cells; Secondary cells; Stationary batteries; Storage batteries

Objectives

- List advantages of dry cells.
- State the characteristics of dry cells.
- Explain how to create a six-volt battery from 1.5 volt dry cells.
- Name the basic kinds of storage cells in use today.
- Explain how to calculate the rating required in a battery for a specific application.

Lesson 3: Kinds of Batteries

Topics

Lead-acid batteries; Lead-calcium batteries; Nickel-iron alkaline cells; Nickel-cadmium alkaline cell

Objectives

- Name the items necessary to form a cell.
- Explain how plates in a cell are commonly assembled.
- List the advantages of nickel-cadmium battery.
- Discuss the construction of storage cells.

Lesson 4: Maintaining Lead-Acid Batteries

Topics

Placing a new battery in service; Care of dry- and wet-charged batteries; Battery testing; Industrial truck batteries; Battery problems

Objectives

- List the steps in placing a new dry-charged battery in service.
- Name the three basic methods of charging batteries.
- Explain how to measure a cell's specific gravity.
- List causes of low specific gravity in a cell.
- Tell how to clean a wet, dirty battery cover.

Lesson 5: Charging Lead-Acid Batteries

Topics

Battery charging; Initial and normal charge; Equalizing, trickle, emergency, boost, and freshening charge; Test discharge; Cell failure

Objectives

- Explain how to conduct an initial charge.
- Discuss the different types of battery charges.
- List the common causes of cell failure.
- Explain how to mix electrolyte correctly.
- Explain how to treat both skin and eyes that have been splashed with acid.

Lesson 6: Solving Problems in DC Circuits

Topics

Sources of DC electricity; Ohm's Law; Work; Torque; Power; Efficiency; Branch points and loops

Objectives

- Define Ohm's Law and use it to solve a problem.
- State the definition of a branch point.
- Solve a problem using the power formula.
- State the definition of Kirchhoff's rules.
- Define work, power, torque, and efficiency.

Lesson 7: DC Series Circuits

Topics

Ohm's Law for series circuits; Current control; Voltage drop; Using equations; Using Kirchhoff's Rules

Objectives

- Describe a series circuit.
- Solve for E, I, and R in series circuits.
- State the basic rule you must follow when making changes in an equation.

Lesson 8: Parallel Circuits

Topics

Recognizing parallel circuits; Resistance, voltage drop, and current in parallel circuits; Calculating resistance and power; Conductance

Objectives

- State the definition of a parallel circuit.
- Explain how to calculate the current in each branch of a parallel circuit.
- Explain how to calculate resistance in a parallel circuit.
- Calculate power in a parallel circuit.
- Find the reciprocal of any value.

Lesson 9: Series-Parallel Circuits

Topics

DC motors and generators; Voltage dividers; Lighting circuits; Three- and four-way switch circuits

Objectives

- State the definition of a series-parallel circuit.
- Identify series, parallel, and series-parallel circuits.
- Explain how to calculate resistances in a series-parallel circuit.
- Demonstrate how to trace and simplify a circuit.

Lesson 10: DC Circuits in Use

Topics

AC and DC electricity; AC waveform; Peak-to-peak, average, and effective values; Energy storage; Faraday's Law; Basic circuit concepts

Objectives

- Explain how the three types of dc motors differ.
- Demonstrate how to increase and decrease the speed of a dc motor by adding resistors.
- Identify a three-way switch.
- Calculate current and resistance using voltage divider circuits.

Transformers and AC Circuits

Course 203: Transformers and AC Circuits
Covers differences between DC and AC circuits. Explains AC sine wave, using vectors to solve AC problems, calculating impedance in circuits having inductance, capacitance, and resistance, AC power relationships in single-phase and three-phase circuits, and principles of transformer maintenance.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Principles of Alternating Current

Topics

AC and DC electricity; AC waveform; Peak-to-peak, average, effective values; Energy storage; Faraday's Law; Basic circuit concepts

Objectives

- State of definition of a waveform.
- Demonstrate how to calculate the frequency of an alternator's output.
- Explain how to calculate an effective value.
- Name the kinds of values that must be used when applying the dc rules and laws to ac circuits.

Lesson 2: Mathematics in AC Circuits

Topics

Potential difference; Angles and degrees; Vectors applied to AC circuits; Graphic and math solutions; Calculating instantaneous values

Objectives

- Describe a triangle.
- State the definition of a vector.
- Identify the vector representing resistance in a vector diagram.
- Demonstrate how to calculate the total impedance in an ac circuit.

Lesson 3: Inductance and Inductive Reactance

Topics

Factors affecting inductance; CEMF; Inductive reactance and time delay; Phase angles; Impedance; Mutual induction; Inductors

Objectives

- Name the property of a coil that makes it resist changes in current.
- List the factors that determine inductance in a coil.
- State the definition of counter electromotive force.
- Demonstrate how to convert a frequency in Hz to a frequency in radians per second.

Lesson 4: Capacitance and Capacitive Reactance

Topics

How a capacitor works; Factors controlling capacitance; Kinds of capacitors; Time constants; Capacitive reactance; Phase angle

Objectives

- Name the parts of a capacitor.
- List the factors that affect the amount of charge stored in a capacitor at a given potential difference.
- Demonstrate how to install a multisection electrolytic capacitor.
- State the definition of capacitive reactance.

Lesson 5: Impedance

Topics

Impedance in series circuits; Phase angles; Resonance in series circuits; Impedance in parallel circuits

Objectives

- State the definition of impedance.
- Explain how to calculate the impedance in a series ac circuit.
- Demonstrate how to find the value of a phase angle for a circuit.
- Explain how to calculate the impedance in a parallel circuit.

Lesson 6: Power and Energy in AC Circuits

Topics

Work and energy; Power in resistive, inductive, and capacitive circuits; Power factor correction; Power capacitors; Capacitor installation

Objectives

- State the definition of power.
- Demonstrate how to calculate power in an inductive circuit.
- State the reason why capacitors are added to circuits to increase the power factor.
- Explain how to install capacitors correctly.

Lesson 7: Three-Phase Circuits

Topics

Three-phase alternators; Y- and delta-connected alternators; Power in three-phase circuits; Load connections; Measuring power

Objectives

- List the main advantages of the three-phase ac system.
- State the definition of phase sequence.
- Demonstrate how to calculate the RMS power in a single-phase circuit.
- Explain how to measure the total power consumed by the load in a three-phase circuit.

Lesson 8: Principles of Transformers

Topics

Magnetic field; No-load operation; Transformer construction, losses, and efficiency; Autotransformers; Instrument transformers

Objectives

- Explain the difference between the primary winding and the secondary winding in a transformer.
- Explain how the windings are positioned in a core-type transformer.
- List the kinds of losses that occur in transformers.
- State the definition of a current transformer.
- List the functions of an instrument transformer.

Lesson 9: Transformer Applications

Topics

Transformer designation, insulation, cooling, and polarity; Single-and three-phase transformer connections; Installing transformers

Objectives

- Name general kinds of transformers.
- List the temperature limits for each class of transformer insulation.
- Explain how oil-immersed transformers are cooled.
- Name the common methods of connecting three single-phase transformers for three-phase operation.
- Explain how to select the correct location for a transformer.

Lesson 10: Maintaining Transformers

Topics

Preventive maintenance; Inspection; Transformer liquids; Transformer failure; Testing; Disassembly and inspection

Objectives

- Explain what to look for during an inspection of sealed transformers.
- List problems that are indicated by an increase in transformer operating temperature.
- Demonstrate how to perform a breakdown test.
- Explain how to locate the exact point of a leak in a welded joint below the liquid level.
- List the steps in inspecting a transformer when a winding fails.

Electrical Measuring Instruments

Course 204.1: Electrical Measuring Instruments
Covers the principles on which electrical test instruments operate. Basic instruments covered include voltmeter, ammeter, wattmeter, ohmmeter, and megohmmeter. Covers AC metering, split-core ammeter, use of current and potential transformers. Includes detailed coverage of modern multimeters. Explains functions and uses of oscilloscopes.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Principles of Meter Operation

Topics

Digital meter design; Integrated ADCs; Displays; Introduction to analog meters; D'Arsonval movement; Magnetic shielding; Parallax error; Accuracy

Objectives

- Define the terms digital meter and analog meter.
- Describe the purpose of the analog-to-digital converter in a digital meter.
- Identify and label graphs of integrator output from a dual-slope integrating meter.
- Explain how time is related to voltage measurement in an integrating digital meter.
- Differentiate among the terms accuracy, sensitivity, and resolution.
- Explain how a D'Arsonval meter movement works.
- Describe the parallax effect, and explain how to avoid it when using an analog meter.
- State the sensitivity formula for an analog meter.

Lesson 2: Ammeters, Voltmeters, and Wattmeters

Topics

Measurement considerations; Measuring direct current; Multirange ammeters; Measuring alternating current; Voltmeters; Wattmeters

Objectives

- Describe the differences and similarities between an analog ammeter and a voltmeter.
- Explain how ammeters and voltmeters are protected internally from overcurrent.
- Explain how a make-then-break switch works.
- Identify which meters should be connected in series in a circuit and which should be connected in parallel.
- Describe how an analog wattmeter works.
- Explain how it is possible to overload a wattmeter, even with the meter's pointer at less than full-scale deflection.

Lesson 3: Resistance Measurement

Topics

Measuring resistance with an ohmmeter; Checking and calibrating an ohmmeter; Shunt ohmmeters; Megohmmeters

Objectives

- Explain characteristic differences between a series ohmmeter and a shunt ohmmeter.
- Explain why ohmmeter scales read from right to left, instead of left to right, and why they are nonlinear.
- Describe the internal circuits and basic operation of an opposed-coil megohmmeter.
- State the primary safety precaution to take when using an ohmmeter.
- Describe two methods used by ohmmeter manufacturers to extend the range of their instruments.
- Explain how to test for opens, shorts, and grounds, using a megohmmeter.
- Describe how to make zero-adjustments on ohmmeters and megohmmeters.
- Explain why variable resistors are needed in battery-powered ohmmeters.

Lesson 4: Multimeters

Topics

Graphical DMM; Advanced meter functions; Multimeter accessories and safety

Objectives

- Demonstrate how to measure ac and dc current and voltage with a multimeter.
- Describe the function of a current probe.
- Explain how to isolate the source of a glitch with a graphical multimeter.
- Demonstrate how to read the screen display of a graphical multimeter in the Trend mode.
- Explain why you set a meter to its highest range before taking your first measurement.
- Define autoranging and auto-polarity.
- List three safety precautions to take when using multimeters.

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Lesson 5: Oscilloscopes

Topics

Kinds of oscilloscopes; Triggering; Digital oscilloscopes; Dual-trace oscilloscopes; Controls; Probes; Oscilloscopes in troubleshooting

Objectives

- Describe how an analog oscilloscope works.
- Describe advantages of a digital oscilloscope over an analog oscilloscope.
- Demonstrate how to measure voltage with an oscilloscope.
- Show two methods of determining phase angles with an oscilloscope.

Electrical Safety and Protection

Course 205.1: Electrical Safety and Protection
Examines electrical hazards and stresses the importance of electrical safety. Covers the equipment and procedures necessary to work safely with electricity, including PPE, lockout/tagout, and first aid. Explains the importance of grounding. Describes many kinds of fuses, circuit breakers, and motor protection devices and their uses.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Electrical Hazards

Topics

Electrical safety, shock, arc; Hazardous electrical locations

Objectives

- List the three main factors that determine the effect of electric current on the human body.
- Explain what to do if a person is a victim of electric shock.
- Name four precautions you can take to guard against electric shock.
- Define the term qualified person.
- Summarize the basic rules of electrical safety.

Lesson 2: Electrical Safety Equipment

Topics

Work clothes; PPE; Foot, head, eye, and face protection; Gloves; Respiratory protection; Lockout devices; Voltage testers

Objectives

- Describe appropriate clothing and PPE to wear when working with electricity.
- Explain first aid procedures for eyes.
- Describe the devices used to lock out power.
- Tell how to keep plant personnel out of an area where electrical work is being performed.
- Explain the purpose of a voltage tester.

Lesson 3: Electrical Safety Procedures

Topics

Energy control; Lockout/tagout procedures; Power tool safety; First aid for shock victims; CPR overview

Objectives

- Explain the concepts of energy control and zero energy state.
- Summarize the OSHA lockout procedure.
- Explain how portable power tools are grounded.
- List some common symptoms of electric shock.
- Summarize the steps involved in administering CPR.

Lesson 4: The *National Electrical Code*®

Topics

Overview of the NEC; Chapter 1: General NEC; Chapter 2: Wiring and Protection; Chapter 3: Wiring Methods and Materials; Chapter 4: Equipment for General Use; Chapter 5: Special Occupancies; Chapter 6: Special Equipment; Chapter 7: Special Conditions; Chapter 8: Communications Systems; Chapter 9: Tables; Annexes

Objectives

- Understand the purpose and scope of the National Electrical Code.
- Define key terms related to the National Electrical Code.
- Determine requirements for electrical installations.
- Locate and reference common National Electrical Code articles.
- Identify common calculation tables.

Lesson 5: Grounding, Ground Faults, and Short Circuits

Topics

Equipment, circuit, and transformer grounding; Effects of impedance; Grounded conductor alarms; Detecting faults automatically; Static electricity

Objectives

- State the reason why circuits should be grounded.
- Explain how to test a circuit for proper grounding.
- Explain how a ground-fault circuit interrupter works.
- Contrast current electricity and static electricity and explain why each can be hazardous.
- Identify the correct extinguisher to use on flammable liquid fires and on energized electrical equipment fires.

Lesson 6: Fuses and Circuit Breakers

Topics

Purpose of a fuse; Lead-wire, cartridge, power, plug, and glass-tube fuses; Thermal magnetic and low-voltage power circuit breakers; Circuit breaker tripping

Objectives

- Explain how a dual-element cartridge fuse works.
- List the NEC rules on installing fuses.
- Explain how a circuit breaker works.
- Describe molded-case circuit breakers.
- Explain the steps involved in fuse replacement and/or circuit breaker reset.

Lesson 7: Motor Protection

Topics

Feeder size; Branch circuits; Motor-running overcurrent protection; Inherent thermal protection; Temperature-sensing devices; Melting-alloy and bimetallic relays; Selecting motor protection; Single phasing; Overload relays

Objectives

- List the steps in determining the correct rating of the motor feeder protection.
- Explain how to select a thermal overload relay.
- Explain how thermostatic, resistance, and thermocouple detectors work.
- Contrast temperature-sensing devices and current-sensing devices.
- Explain how various relays provide motor protection.
- Define single phasing.

DC Equipment and Controls

Course 206: DC Equipment and Controls
Covers DC power applications in industry, types of DC generators, operating characteristics of DC motors, DC armature principles, and armature maintenance and repair. Includes types of DC relays, DC controllers, overspeed and overload protection, drum and reversing controllers, dynamic braking, DC power supplies, diodes, semiconductors, SCR principles, and DC maintenance practices.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: DC Power in Industry

Topics

DC generators and motors; Rectifiers; SCR speed control; Storage batteries; Electroplating; Electrolytic refining; Arc welding

Objectives

- List the advantages of dc over ac.
- List the brush problems caused by eddy currents.
- Name three types of batteries commonly used in the plant.
- Explain how the electroplating process works.
- Explain the difference between straight polarity and reversed polarity in arc welding.

Lesson 2: DC Electromagnets

Topics

Magnetic forces and fields; Magnetic shielding; Solenoids; Residual magnetism; Relays; Polarized relays; Protecting relay contacts

Objectives

- State the definition of residual magnetism.
- Explain the effects of distance on magnetic field strength.
- Discuss the characteristics and uses of solenoids.
- Discuss the characteristics of relays.

Lesson 3: DC Generators

Topics

Parts and action of DC generators; Armature reaction; Commutation; Interpoles; Types of generators; Losses; Parallel operation

Objectives

- Explain the function of each of the main parts of the dc generator.
- Explain how to increase the number of pulses during each rotation of an armature.
- Demonstrate how to combine the shunt field and series field to produce a compound generator.
- State the reasons why electrical losses, magnetic losses, and mechanical losses occur in the dc generator.

Lesson 4: DC Motors

Topics

CEMF; Armature reaction; Self-induction and commutation; Interpoles; Torque; Speed regulation; Shunt, series, and compound motors

Objectives

- Explain what happens during self-induction and commutation.
- Define CEMF.
- State the difference between speed regulation and speed control.
- Name the kinds of dc motors.
- Explain the different operating characteristics of series, shunt, and compound motors.

Lesson 5: DC Armatures

Topics

Windings; Armature, copper, eddy-current, and hysteresis loss; Commutation; Armature maintenance

Objectives

- Name the basic parts of an armature assembly.
- Describe the main differences between a lap winding and a wave winding.
- List the characteristics of a single-reentrant simplex-lap winding.
- State the definition of copper loss, eddy-current loss, and hysteresis loss.
- Demonstrate how to perform preventive maintenance on an armature.

Lesson 6: DC Relays

Topics

Operating characteristics; Shunt, series, lockout, and inductive time-delay relays; Magnetic blowout coils; Dynamic braking

Objectives

- Name three factors that determine the performance and reliability of a relay.
- Name the six types of commonly used relays.
- Explain the operation of each type of relay.
- Explain dynamic braking.
- Describe how a disc brake is attached to a motor.

Lesson 7: DC Controllers

Topics

Classification; Factors affecting motor speed; Protection; Temperature compensation; Manual starters; Overload reset; Magnetic and drum controllers

Objectives

- List the kinds of functions performed by motor-control devices.
- Name the types of motor controllers and discuss their operating characteristics.
- Explain how each of the three kinds of thermal overload relays works.
- Name the kinds of resets for overload relays.

Lesson 8: DC Power Supplies

Topics

Electron emission; Electron tubes; Vacuum-tube diode and rectifier; Mercury-vapor diodes; Semiconductors; Checking diodes; Identifying replacement semiconductors

Objectives

- Discuss the operating principles of vacuum tubes and rectifiers
- Name the four types of filters commonly used in rectifier circuits.
- Identify a mercury-vapor diode.
- List common causes of semiconductor failure.
- State the criteria for selecting replacement semiconductors.

Lesson 9: Silicon Controlled Rectifiers

Topics

Principles of SCRs; Pulse timing in DC circuits; Trigger pulses; SCR motor control; AC and DC applications; AC-DC conversion

Objectives

- State the definition of a silicon controlled rectifier.
- Explain how an SCR works.
- Explain how to increase the effective current and the power delivered to a motor by an SCR motor control.
- List four dc applications of SCRs.
- List four ac applications of SCRs.

Lesson 10: Maintenance of DC Equipment

Topics

Inspection; Replacing field coils; DC motor controllers; Relay contacts; Commutation; Brush selection and care; Maintaining relays and armatures

Objectives

- Explain how to test field coils to determine the condition of the insulation.
- List the signs of a short-circuited field coil in a machine.
- Explain how to replace a field coil in a machine.
- Discuss how to maintain relay control.
- Name the criteria for satisfactory commutation.

Single-Phase Motors

Course 207: Single-Phase Motors
Covers the types and operating principles of common single-phase motors. Explains NEMA motor standards. Explains how to identify motor leads on split-phase, capacitor-start, capacitor-run, permanent split capacitor, and repulsion motors. Covers universal motors, shaded-pole motors, synchro motors, and servo systems. Gives general maintenance procedures on all single-phase motors.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Introduction to Single-Phase Motors

Topics

Motor parts; NEMA motor standards and enclosures; Nameplate data; Induction motors; Stator, rotor field; Split-phase starting; Synchronous speed; Starting switches

Objectives

- List the parts of a rotor.
- List the data given on a typical motor nameplate.
- Explain how an induction motor works.
- Demonstrate how to calculate the number of electrical degrees in one complete rotation of a motor.
- Explain how a centrifugal switch works.

Lesson 2: Split-Phase Motors

Topics

Motor connections; Skein and consequent-pole windings; Two-speed, three-, four-winding, and dual-voltage motors; Troubleshooting

Objectives

- State the reason why a second stator winding is important in the single-phase induction motor.
- Explain how to identify motor leads when there are no tags or colors to identify them.
- Describe a skein winding.
- List the ways to change the speed of a motor by changing the number of poles.
- Discuss some common motor problems.

Lesson 3: Capacitor Motors

Topics

Kinds and operation; Rotating magnetic fields; Single-voltage, dual-voltage, reversible, capacitor-start, and capacitor-run motors

Objectives

- State the definition of a capacitor.
- Explain how to make a split-phase motor operate as a capacitor-start motor.
- Explain how the running windings are connected to make a dual-voltage motor run on either 120 or 240 volts.
- Select the best capacitor to use as a substitute for a defective capacitor when an identical unit is not available.
- List problems that cause the circuit breaker to trip when you turn on a capacitor motor.

Lesson 4: Repulsion Motors

Topics

Repulsion principle; Purpose of brushes; Short circuiter; Commutator; Repulsion, compensated repulsion, and repulsion-induction motors

Objectives

- Discuss the operating principles of a repulsion-start induction-run motor.
- Explain how to seat new brushes on the commutator.
- Discuss the functions of the major motor components.
- List the reasons a repulsion motor might fail to start.

Lesson 5: Universal Motors

Topics

Performance characteristics; Speed control; Motor life; Universal motor assemblies; Ventilation; Brush mounting and selection

Objectives

- Explain eddy current loss in the universal motor.
- List the advantages of a universal motor.
- Explain how the speed of the universal motor is controlled.
- List the criteria for selecting carbon brushes for universal motors.
- State reasons why a universal motor might have poor torque.

Lesson 6: Special Motors

Topics

Shaded-pole, synchronous, hysteresis, unexcited synchronous, induction, reluctance, and permanent-magnet motors

Objectives

- State the definition of a salient pole.
- Explain the operating principles of a shaded-pole motor.
- Discuss the operating principles of a hysteresis motor.
- Explain the difference between an unexcited synchronous motor and an excited synchronous motor.

Lesson 7: Synchros

Topics

Rotor and stator construction; Synchro assembly and transmitter operation; Receivers; Control synchro systems; Control transformer

Objectives

- State the definition of the term synchro.
- Describe motor construction in a synchro.
- Demonstrate how to calculate terminal-to-terminal stator voltage.
- State the reason why the control transformer is important in a synchro control system.
- Explain how to connect a differential synchro system.

Lesson 8: Servos

Topics

Servomechanisms; Amplidyne operation; Overtravel control; DC and AC servomotors; Servo-control bridges; Servo actuators

Objectives

- State the definition of a servomechanism.
- List the four characteristics needed to keep a regulated quantity matched to a reference valve in a servomechanism.
- Explain how an amplidyne control system works.
- Discuss how to control overtravel in a servomechanism.

Lesson 9: Motor Installation

Topics

Conductor size; Preventing shorts and grounds; Controllers; Overcurrent protection; Guards; Grounding; Fuses; Starters; Service factor

Objectives

- Explain how to determine conductor size for motors.
- State the definition of a controller.
- List the conditions under which the frames of stationary motors must be grounded.
- Demonstrate how to determine the size of a dual-element when two or more motors are connected to one feeder.
- List the electrical and mechanical factors to consider in selecting a motor for a specific application.

Lesson 10: Motor Maintenance

Topics

Procedures; Testing capacitors and stator windings; Armature defects; Noisy operation; Bearing problems; High temperatures; Incorrect speed

Objectives

- Demonstrate how to test bearings for wear.
- Explain how to test capacitors.
- State the reason why proper belt tension in important.
- List the common causes of excessive brush sparking.

Three-Phase Systems

Course 208: Three-Phase Systems
Covers three-phase motor principles for induction, synchronous, and multi-speed dual-voltage motors. Gives recommended maintenance practices for large AC motors. Covers principles of three-phase motor starters, part winding, reversing, jogging, alternator principles and operation. Describes three-phase power distribution.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Principles of Three-Phase Motors

Topics

Induction motors; Squirrel-cage rotors; Pole-phase relationships; Torque, rotor speed, slip, frequency, resistance, reactance, and power factor

Objectives

- Describe a squirrel-cage rotor.
- List the factors that determine the strength of the magnetic field in an induction motor.
- Discuss pole-phase relationships.
- Demonstrate how to reverse the rotation direction of the magnetic field.
- Discuss the relationship between rotor speed and frequency.

Lesson 2: Induction Motors

Topics

Squirrel-cage motors; Stator and rotor construction; Air gap; Operating features; Wound-rotor motors; Brushes and slip rings; Maintenance

Objectives

- List the main parts of the stator.
- List operating characteristics of a wound-rotor motor.
- Demonstrate how to check rotor windings for short circuits.
- State the definition of a standard motor.

Lesson 3: Synchronous Motors

Topics

Motor fields, characteristics, and applications; Pull-in torque; Slipping pole; Power factor; Brushless motors; Motor efficiency and care

Objectives

- List factors that contribute to the torque of an industrial synchronous motor during starting.
- Explain the effects of an amortisseur winding in a synchronous motor.
- State the definition of pull-in torque.
- State the reason why using synchronous motors can increase a low power factor in a plant.
- List the characteristics of brushless synchronous motors.

Lesson 4: Multispeed Motors

Topics

Consequent-pole, constant-horsepower, constant-torque, variable-torque, and dual-voltage motors and connections

Objectives

- Discuss the operating characteristics of multispeed induction motors.
- Select the best motor for driving equipment that requires the same torque at both high and low speeds.
- State the definition of a variable-torque motor.
- Explain the difference between a constant-horsepower motor and a constant-torque motor.

Lesson 5: Maintaining Three-Phase Motors

Topics

Cleaning; Care of stator and rotor windings; Air gap; Overload and single-phase operation; Motor shaft currents; Bearings; Maintenance schedule

Objectives

- List the steps in measuring the resistance of the insulation on motor windings.
- Explain how to raise the temperature of a motor winding.
- List the steps in lubricating motor bearings.
- List the conditions that must exist before you can lubricate bearings.

Lesson 6: Motor Starters

Topics

Limitations; Full-voltage and across-the-line starting; Reducing starting current; Primary- and secondary-resistance starters; Maintenance

Objectives

- Explain how a motor starter works.
- Explain the difference between open transition and closed transition.
- Name the common kinds of reduced-voltage starters.
- List the steps in inspecting motor starters.

Lesson 7: Three-Phase Motor Controllers

Topics

Multiple start-stop controls; Across-the-line reversing starters; Plugging control; Jogging; Controlling surge and backspin

Objectives

- Explain how to select the best motor starter for a particular application.
- Explain the difference between low-voltage release and low-voltage protection.
- Describe the plugging process.
- Explain how to prevent backspin.

Lesson 8: Alternators

Topics

Characteristics, ratings, and windings; Three-phase alternators; Air gap; Slip rings; Exciters; Voltage regulation; Load characteristics and effects

Objectives

- Describe a three-phase alternator.
- Discuss the operating characteristics of alternators.
- List the characteristics that must be considered when you work on alternator windings.
- Name the causes of change in potential difference between terminals as the load changes.
- Demonstrate how to calculate three-phase power in an alternator.

Lesson 9: Auxiliary Generator Systems

Topics

Requirements; Control equipment; Transfer systems; Safety switches; Engine protection; Prime movers and output control; Maintenance

Objectives

- Explain how an automatic auxiliary generator works.
- List the methods of overcoming voltage-drop problems when starting loads.
- List the parts of a hydraulic starting system.
- State the definition of a prime mover.
- List the four guidelines to follow when troubleshooting or performing routine maintenance on generators.

Lesson 10: Power Distribution Systems

Topics

Distribution voltages; Heat loss; System grounding; Overcurrent protection; Ground relays; Tripping; Network protection

Objectives

- State the reasons why 240-volt systems are not as widely used as are 480-volt systems.
- Explain the difference between system grounding and equipment grounding.
- List the benefits of system grounding.
- Explain how an overcurrent relay works.
- Name common circuit-opening devices.

AC Control Equipment

Course 209: AC Control Equipment
Covers the broad range of industrial motor starting and control equipment, including NEMA sizes and ratings. Includes pushbutton control stations, limit switches, mercury switches, mechanical and magnetic plugging, foot switches, and pressure, temperature, and float switches. Covers control panel wiring and special applications.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Motor Starters

Topics

Motor controllers; Controller enclosures; Starters; Magnetic controls; Interlocks, Reversing and combination starters

Objectives

- Describe the difference between a manual starter and a magnetic starter.
- Explain the function of a shading coil in a magnetic starter.
- Explain the effects of low voltage on a controller.
- State the reason why holding-circuit interlocks are required on magnetic starters and contactors.
- Demonstrate how to reverse the shaft rotation of a three-phase motor.

Lesson 2: Switches and Controls

Topics

Pushbuttons; Selector switches; Wall boxes; Contact blocks; Indicating lights; Circuit diagrams; Legend plates

Objectives

- Discuss the characteristics of industrial switches and controls.
- Identify the five most commonly used NEMA pushbutton stations.
- Demonstrate how to mount an oil-tight control station both vertically and horizontally.
- Explain the difference between standard and press-to-test indicating lights.
- Explain how a three-wire control circuit works.

Lesson 3: Limit Switches

Topics

Precision snapswitches; Limit switches; Mercury-tilt switches; Switch installation and failure

Objectives

- List the main parts of a precision snap-action limit switch.
- Describe the contact arrangement of a snapswitch.
- Describe the kinds of actuators used in limit switches.
- List the rules for the proper design and application of limit switch cams.
- Explain how a mercury switch works.

Lesson 4: Special Control Switches

Topics

Reversing drum, foot, transfer, plugging, mechanical, magnetic plugging, pressure, temperature, and float switches

Objectives

- Explain how a drum switch works.
- Select the best switch for stopping a motor quickly.
- List the criteria for selecting a plugging switch.
- Identify different types of pressure switches.
- State the definition of pressure differential.

Lesson 5: Timers and Counters

Topics

Interval and reset timers; Time-delay relays; Repeat-cycle, pulse, and percentage timers; Impulse, electric, and revolution counters; Time totalizers

Objectives

- Explain how a reset timer works.
- Describe the different types of timers.
- Compare and contrast an electric counter and a time totalizer.
- Select the best control device for use where a machine cannot be controlled by time.
- Demonstrate how to set up a chart for a programed control circuit.

Lesson 6: Control Relays

Topics

Contact operation; Mountings, enclosures, terminals, and definitions; NEMA classes; Causes of failure

Objectives

- State the definition of a relay.
- Explain the function of relay contacts.
- Select the best relay for use where large movement of the contacts or high contact force is required.
- List the advantages of a reed relay.
- Tell why industrial relays usually have double-break contacts.

Lesson 7: Equipment for Hazardous Locations

Topics

Enclosures; Sources of ignition; Switchgear and industrial controls; Lighting; Motors and generators; Plugs and receptacles, Portable equipment; Conduit

Objectives

- List the requirements an enclosure must meet in order to be called explosion proof.
- List the characteristics of switchgear and industrial controls in hazardous conditions.
- List three situations in hazardous locations that require the use of seals.
- List the three basic conditions that can cause fire or explosion.
- Demonstrate how to terminate armored cable that enters an explosion proof housing.

Lesson 8: Special Motor Controls

Topics

Synchronous motor control; Sequence-accelerating and decelerating relays; Transformer starters

Objectives

- Name the two relays required for automatic starting of a synchronous motor.
- Explain how an automatic sequence-accelerating relay works.
- Select the best starter for use where the highest possible starting torque per ampere of line current is required.
- List the characteristics of different types of resistance starters.
- Describe a Y-delta starter.

Lesson 9: Motor Control Centers

Topics

Features and advantages; MCC bus; NEMA standards; Enclosure construction; Wiring; Circuit protection; Installation

Objectives

- Define the term motor control center.
- Name the main advantages and disadvantages of back-to-back MCC construction.
- Explain how to install an MCC.
- Define a note, a caution, and a warning as each relates to MCC equipment.
- List the checks to conduct prior to releasing an MCC for plant operation.

Lesson 10: Control Panel Wiring

Topics

Enclosures; Terminal blocks; Wire identification; Connections; Connectors; Wire dressing

Objectives

- State the function of terminal blocks.
- Demonstrate how to make a terminal connection.
- Tell when to use different types of connectors.
- Describe the proper lacing of wires in a control panel.
- Explain when and how to use a wiring duct.

Electrical Troubleshooting

Course 210: Electrical Troubleshooting
Covers use of schematic diagrams, determining sequence of operation, and use of building diagrams and single-line diagrams. Includes troubleshooting procedures for control circuits and combination starters. Explains troubleshooting practices on DC and AC motors, identifying unmarked leads on three-phase delta and Y-connected motors, and troubleshooting lighting systems.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Troubleshooting with Electrical Schematics

Topics

Symbols; Elementary diagrams; Power control and motor-starting circuits; Identifying conductors; Control panel layout; Sequence of operation

Objectives

- Identify a control relay on an electrical schematic.
- State the NEC requirements for fuses in ungrounded conductors.
- Explain component numbering on electrical schematics.
- Explain how conductors in a motor-control circuit are identified.

Lesson 2: Troubleshooting with Building Drawings

Topics

Architectural drawings; Installation diagrams; Electrical symbols on blueprints; Substation and power-installation drawings; Circuit tracing

Objectives

- Name the kinds of drawings used by electrical specialists.
- Identify electrical symbols commonly used for building diagrams.
- Describe a one-line diagram.
- Discuss the different types of drawing characteristics.

Lesson 3: Troubleshooting Control Circuits

Topics

Control-circuit functions; Conditions of protection; Troubleshooting pushbutton, sequence/control, motor, and overload circuits

Objectives

- Explain how severe three-phase voltage unbalance affects a three-phase motor.
- List the advantages of inherent protection.
- Explain how undervoltage release works.
- Describe how to troubleshoot a motor circuit.

Lesson 4: Troubleshooting Combination Starters

Topics

Using relay-troubleshooting charts; Latching-relay and timing-relay checks; Replacing relay coils; Troubleshooting control circuits, starters, and relays

Objectives

- List the reasons why a magnet coil burns or short-circuits.
- List the steps in troubleshooting a defective motor.
- Explain how a mechanical latching relay works.
- Explain how an electronic timing relay operates.

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Lesson 5: Troubleshooting Control Devices

Topics

Reversing controllers; Using a checking-sequence chart; Autotransformer starters; Multi-speed motor starter controls

Objectives

- Demonstrate how to reverse the rotation of a three-phase induction motor.
- Explain the function of limit switches in reversing-motor applications.
- Describe how to use a checking-sequence chart.
- Select the best starter for use where it is undesirable to put a heavy load on the power supply.
- Explain how to change the speed of a squirrel-cage motor.

Lesson 6: Troubleshooting Special Controls

Topics

Selenium rectifiers; Testing rectifier diodes and three-phase rectifiers; Control-system logic; Static control; Time delay element

Objectives

- Explain the effects of age on a selenium rectifier.
- Name the protective devices used in electrical systems and pneumatic systems.
- State the definition of a bistable device.
- List the functions of a static control device.

Lesson 7: Troubleshooting DC Motors

Topics

Commutator discoloration; Brush sparking; Open winding; Vibration; Bearings; DC motor controls; Drum controllers

Objectives

- List causes of electrical and mechanical vibration in a dc motor.
- Explain how oil saturation affects brushes in a dc motor.
- Explain how maximum bearing operating temperature is determined.
- List problems in the motor control that can cause sudden or unexpected changes in motor speed.
- Explain how to salvage a water-soaked motor.

Lesson 8: Troubleshooting AC Motors

Topics

Grounded stator windings; Short-circuited and reversed phases; Open circuits; Incorrect voltage connections

Objectives

- Identify various kinds of three-phase motor failures.
- Demonstrate how to conduct a balanced-current test on a three-phase, Y-connected winding.
- List the symptoms of a reversed phase in a three-phase winding.
- Explain how to identify external leads that have become defaced.
- Demonstrate how to test for an open circuit in a split-phase motor.

Lesson 9: Troubleshooting Lighting Systems

Topics

Planned lighting maintenance; Troubleshooting basics; Troubleshooting fluorescent lighting systems; Troubleshooting dimmable fluorescent lighting systems; Troubleshooting HID lighting systems; Troubleshooting dimmable HID lighting systems; Troubleshooting incandescent lamps; Troubleshooting occupancy sensors and other switching controls

Objectives

- Describe the elements of a planned maintenance program.
- Explain the function of lamps, ballasts, and lighting controls.
- Describe the basic troubleshooting process.
- Detail how to troubleshoot common lamp ballast system problems.
- Describe lighting system commissioning.
- Detail how to troubleshoot common occupancy sensor and dimming system problems.

Lesson 10: Saving Time in Troubleshooting

Topics

Tracing circuit problems; Equipment changes and modifications; Motor-location file

Objectives

- Name and describe the elements of a sequence of operation.
- List the features that must appear on an elementary wiring diagram to make it comply with JIC standards.
- List the steps in troubleshooting a new machine.
- List the information to be included in a motor location file.
- Select the best method for identifying a motor.

Electrical Safety in the Workplace—Understanding NFPA 70E®

Course 211: Electrical Safety in the Workplace
Introduces the trainee to the purpose of *NFPA 70E* and explains the history of its creation. After discussing the relationship between OSHA and *NFPA 70E*, the course moves through the standard, article by article, highlighting the important points in each. Concludes with a lesson on the annexes and supplemental material found in the *NFPA 70E Handbook*.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Article 90: Introduction and Purpose

Topics

Introduction to *NFPA 70E*; Enforcement of *NFPA 70E*; National Electrical Code; Electrical Hazards; Purpose of *NFPA 70E*; Scope of *NFPA 70E*; Arrangement of *NFPA 70E*; Organization of *NFPA 70E*; Rules; Interpretation and Application

Objectives

- Explain how and why *NFPA 70E* was created.
- State the purpose of *NFPA 70E*.
- Understand how OSHA can use *NFPA 70E* in enforcement actions.
- Explain which areas are covered by *NFPA 70E* and which are not covered.
- Explain how *NFPA 70E* is arranged and organized.
- State the differences among mandatory rules, permissive rules, and explanatory material.

Lesson 2: Articles 100 and 105: Terms and Definitions

Topics

Overview of Article 100; Electrical Safety and Hazards; Electrical Equipment; Accessibility and Boundaries; Grounding and Ground Faults; *National Electrical Code (NEC)*; Overview of Article 105

Objectives

- Understand the importance of terms described in Article 100.
- Define terms related to electrical safety and hazards.
- Define terms related to electrical grounding and ground fault equipment.
- Define and understand accessibility terms.
- Recognize terms that are common to *NFPA 70E* and the *NEC*.
- State the purpose and scope of *NFPA 70E* Chapter 1 and the responsibilities of employer and employee.

Lesson 3: Article 110: General Requirements for Work Practices

Topics

Overview of Article 110; Host and Contract Employers; Training Procedures and Requirements; Establishing an Electrical Safety Program; Working with Electrical Equipment

Objectives

- Give an overview of the contents of Article 110.
- Describe the relationship between host employers and contract employers.
- Identify the training requirements, types of training, and documentation procedures covered in the article.
- Explain how to develop an electrical safety program.
- Identify the risks of working with electrical hazards.
- Explain how to use test equipment and instruments safely.
- Describe the precautions that must be taken before working near underground electrical lines.

Lesson 4: Article 120: Establishing an Electrically Safe Work Condition

Topics

Overview of Article 120; Achieving an Electrically Safe Work Condition; Principles of Lockout/Tagout; Types of Hazard Control Procedures; Lockout/Tagout Equipment; Lockout/Tagout Application Procedures; Temporary Grounding Equipment

Objectives

- Understand the process of achieving an electrically safe work condition.
- Explain lockout/tagout principles and procedures.
- Describe the different forms of control procedures.
- Define the requirements for lockout/tagout devices.
- Identify the procedures for removing and releasing lockout/tagout devices.
- Understand the requirements for temporary grounding equipment.

NOTE: *This course should not be considered a substitute for the standard itself.*

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Electrical Safety in the Workplace—Understanding NFPA 70E®

Lesson 5: Article 130: Work Involving Electrical Hazards

Topics

Overview of Article 130; Electrical Work Permits; Working with Electrical Hazards; Approach Boundaries; Arc Flash Hazard Analysis and Boundary; Personal Activity Precautions; Personal Protective Equipment (PPE); Other Protective Equipment; Overhead Lines within the Limited Approach or Arc Flash Boundary

Objectives

- Recognize electrical hazards and know when it is justifiable to work near such hazards.
- Understand the purpose and use of energized electrical work permits.
- Determine shock hazards associated with approach boundaries.
- Determine required arc flash protection.
- Determine the type of personal protective equipment required for a task.
- Develop an understanding of insulated tools and other protective equipment.
- Identify alerting techniques.
- Learn safety procedures to follow while working with overhead lines.

Lesson 6: Articles 200-250: Safety-Related Maintenance Requirements

Topics

Overview of Chapter 2; Article 200: Introduction; Article 205: General Maintenance; Article 210: Enclosures; Article 215: Wiring Systems; Article 220: Controllers; Article 225: Overcurrent Devices; Article 230: Rotating Equipment; Article 235: Hazardous Locations; Article 240: Batteries; Article 245: Portable Equipment; Article 250: Protective Equipment

Objectives

- Determine the general maintenance requirements for electrical equipment.
- Identify safety-related maintenance practices.
- Describe the electrical maintenance requirements for facilities.
- Determine to what degree fuses and circuit breakers should be maintained.
- Understand the maintenance of equipment in hazardous locations.
- Explain the requirements for maintaining and testing personal protective equipment.

Lesson 7: Articles 300-350: Safety Requirements for Special Equipment

Topics

Overview of Chapter 3; Article 300: Introduction; Article 310: Electrolytic Cells; Article 320: Batteries and Battery Rooms; Article 330: Lasers; Article 340: Power Electronic Equipment; Article 350: Research and Development Laboratories

Objectives

- Understand the hazards of working with special electrical equipment.
- Determine the safety requirements for special equipment
- Identify safe work practices for electrolytic cells.
- Identify safe work practices for installing and maintaining batteries.
- Identify safe work practices for lasers.
- Identify safe work practices for power electronic equipment.
- Identify safe work practices for laboratories.

Lesson 8: Annexes and Supplemental Materials

Topics

Annexes A and B: References; Annexes C and D: Distances and Boundaries; Annexes E and F: Safety Program and Hazard Evaluation; Annex G: Lockout/Tagout; Annex H: Protective Clothing and PPE; Annexes I and J: Job Planning and Energized Work Permits; Annexes K and L: Hazards and Cell Line Safeguards; Annex M: Layering of Protective Clothing; Annexes N and O: Overhead Lines and Design Requirements; Annex P: *NFPA 70E* and Other Standards; Supplemental Information

Objectives

- Reference publications related to *NFPA 70E.*
- Obtain additional information related to *NFPA 70E*.
- Identify examples of approach and arc flash boundaries.
- Develop a safety program and hazard/risk forms.
- Discuss lockout/tagout procedures.
- Be aware of the National Electrical Code references related to *NFPA 70E.*

Basic Mechanics

Course 301: Basic Mechanics
Covers force, motion, work, energy, and fluid mechanics as applied in industrial maintenance. Explains principles of operation for simple machines. Explains the basic elements of industrial machines, as well as common measurement tools used to monitor and adjust equipment. Covers hand tools, power tools and fasteners, ending with a discussion of ways to reduce friction and wear.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Forces and Motion

Topics

Measuring forces; Describing motion; Acceleration; Types of motion; Newton's Laws of Motion

Objectives

- Name five ways forces originate.
- Explain how forces are measured.
- Define velocity, acceleration, and elastic distortion.
- Define rotary motion and reciprocating motion.
- State and explain Newton's Laws of Motion

Lesson 2: Work, Energy, and Power

Topics

Defining and measuring work; Torque; Energy; Law of Conservation of Energy; Kinetic and potential energy; Power; Horsepower; Calories; BTU

Objectives

- Define work, and explain how to calculate it.
- Define the terms torque and prime mover.
- Define energy, and tell how it is measured.
- Differentiate between kinetic and potential energy, and give an example of each one.
- Define power and horsepower, and tell how each is measured.

Lesson 3: Fluid Mechanics

Topics

Fluids and forces; Measuring fluid pressure; Velocity head vs static pressure head; Bernoulli effect; Venturi tubes; Friction head; The siphon

Objectives

- Define a fluid.
- Define pressure, and identify common units of pressure measurement.
- State Pascal's Law, and give an example of its application.
- Explain the difference between gauge pressure and absolute pressure.
- Explain the Bernoulli Effect, and give three examples of how it is utilized in industry.
- Explain how a siphon works.

Lesson 4: Simple Machines

Topics

Levers; Wheel and axle; Gear trains; Inclined planes; Wedges; Cam-and- follower devices; The screw; Pulleys; Mechanical efficiency

Objectives

- Identify and name six types of simple machines.
- Calculate the ideal mechanical advantage of each of six simple machines.
- Describe the action and purpose of cam-and-follower mechanisms.
- Determine the ideal mechanical advantage of several simple gear trains.
- Explain mechanical efficiency and show how to calculate it.

Lesson 5: Machine Elements

Topics

Machine motions; Mechanisms; Lever and four-bar linkages; Devices for producing linear motion; Ratchet-and-pawl and fluid-power mechanisms

Objectives

- List the four classifications of mechanisms.
- Name the six basic motion conversions, and give an example of each.
- Explain the functions of bell cranks, Pitman arms, and toggle bars.
- Name three types of four-bar linkages, and explain how they function.
- Describe the ratchet-and-pawl mechanism.

Lesson 6: Measurement Tools and Instruments

Topics

Classification of instruments; Measurements in maintenance; Process monitoring and quality assurance; Predictive maintenance

Objectives

- Define measurement, parameter, accuracy, precision, sensitivity, and range.
- Explain why measurements are important to maintenance operations.
- Describe the general features of a portable measurement instrument.
- List the basic measurement instruments most often used in mechanical maintenance, and describe the operating principles of each.

Lesson 7: The Safe Use of Hand Tools

Topics

Screwdrivers; Wrenches; Hammers and mallets; Chisels; Punches; Saws; Files and rasps; Snips, nippers, and cutters; Pliers; Organizing tools

Objectives

- Name the major hand tools used in maintenance.
- State criteria for selecting the proper tools for specific jobs.
- Identify safe/unsafe practices in the use of hand tools and explain why they are safe/unsafe.
- Explain how to prolong the useful life of selected hand tools.
- Explain the advantages of having a well-organized tool box.

Lesson 8: The Safe Use of Portable Power Tools

Topics

Hazards; Protection against shock; Drills, sanders, grinders, saws, shears, impact wrenches, and rotary hammers; Pneumatic tools

Objectives

- State three precautions to take before using any power tool.
- Describe the safe use of each of the following power tools: electric drills, sanders, grinders, and saws; electric impact tools; pneumatic impact wrenches and hammers.
- State three general guidelines for the safe operation of any portable power tool.
- Describe the potential electrical hazards associated with electric power tools.

Lesson 9: Fasteners

Topics

Threaded fasteners; Screw threads; Types of nuts; Washers; Safety wiring; Keys and pins; Rivets

Objectives

- Identify seven major types of threaded fasteners.
- Read and interpret common screw thread and threaded fastener specifications.
- Describe the three actions in a manual riveting operation, and explain why each action must be done properly.
- Demonstrate the proper technique for safety wiring a group of threaded fasteners.
- Identify three kinds of washers.

Lesson 10: Friction and Wear

Topics

Nature of friction, its causes and importance; Static and kinetic friction; Measuring friction; Coefficients of friction; Wear; Static electricity

Objectives

- Define friction, identify the forces that cause it, and describe its effects.
- Differentiate between static friction and kinetic friction.
- Define coefficient of friction.
- Calculate the expected friction force between two surfaces, given the normal force and the coefficient of friction.
- Describe four types of wear.

Lubricants and Lubrication

Course 302: Lubricants and Lubrication
Covers a complete lubrication training program, including functions and characteristics of lubricants, factors in selection of lubricants, and effects of additives. Oils, greases, and other compounds used for lubrication are described, as well as their applications. Lubrication methods and recommended storage and handling procedures are included.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Principles of Lubrication

Topics

Lubricant classification; Friction; Cooling and sealing action of lubricants; Corrosion prevention; Preventive maintenance

Objectives

- Define lubrication and describe the four forms of lubricants.
- Discuss the characteristics of static, kinetic, fluid, and rolling friction.
- Explain how a lubricant reduces wear and dampens shock.
- Discuss the cooling action of lubricants and explain how they prevent corrosion.
- Explain the importance of a lubricant's sealing action, and explain how it works.

Lesson 2: Lubricant Characteristics

Topics

Properties of oils; Viscosity; Flash point; Pour point; Fire point; Oxidation resistance; Emulsification; Greases; Lubricant selection

Objectives

- Describe how lubricating oils are obtained and processed and briefly discuss the chemistry of petroleum.
- Explain how viscosity is rated and measured in lubricating oils.
- Explain how flash point, fire point, pour point, oxidation resistance, and emulsification affect a lubricant.
- Describe the five major properties of greases.
- Name four factors that affect lubricant selection.

Lesson 3: Additives, Lubricating Action, and Bearing Lubrication

Topics

Types of additives; Multipurpose lubricants; Mixed and full-film lubrication; Boundary and bearing lubrication

Objectives

- Describe the nature and purpose of pour-point depressants, oxidation inhibitors, viscosity-index improvers, and antifoam agents.
- Explain how rust and corrosion inhibitors, extreme-pressure additives, and detergent-dispersants work.
- Discuss the use of emulsifying and demulsifying agents, oiliness and antiwear agents, tackiness agents, and other additives.
- Describe the differences between mixed-film, boundary, and full-film lubrication.
- Discuss elements which determine proper bearing lubricant selection.
- Identify common bearing lubrication problems and ways to avoid them.

Lesson 4: Oils and Their Applications

Topics

General- and special-purpose oils; Oil bases; Circulating, gear, machine, spindle, refrigeration, steam cylinder, and engine oils; Wire rope lube

Objectives

- Describe the four types of oil bases.
- Name three types of circulating oils and describe their properties.
- Compare the characteristics and uses of gear oils, machine oils, and spindle oils.
- Discuss the special properties of refrigeration oils, steam cylinder oils, and internal combustion engine oils.

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Lesson 5: General-Purpose Greases

Topics

Characteristics of greases; Calcium-, soda-, barium-, lithium-, and aluminum-soap greases; Grease selection; Bearing relubrication

Objectives

- Define grease and compare the advantages of using greases and using oils.
- Describe methods for making grease and compare the uses and properties of at least five soap-based greases.
- State the advantages and disadvantages of using nonsoap-based greases.
- Discuss grease selection and application for plain and antifriction bearings.

Lesson 6: Special-Purpose Greases and Dry-Film Lubricants

Topics

Multipurpose greases; Additives; Extreme-pressure, water-repellent, high-, low-temp, lamellar, and silicone greases; Dry-film lubricants

Objectives

- List three purposes for grease additives and explain how extreme-pressure greases accomplish their purpose.
- Compare uses and characteristics of water-repellent and high- and low-temperature greases.
- Describe lamellar greases, giving an example, and list some special uses for silicone greases.
- Compare three types of dry-film lubricants and describe how and where to use them

Lesson 7: Lubrication Systems and Methods

Topics

Lubrication system reliability and design factors; Manual and gravity lubrication; Drip-feed oilers; Natural and pressure lubrication; Air line lubrication

Objectives

- Name four main considerations for selecting a lubrication system and explain the importance of each.
- Explain how manual and drip lubrication methods work.
- Describe the operating principles of natural and pressure lubrication methods.

Lesson 8: Automatic Lubrication Methods

Topics

Sight glass flow indicators; Spray nozzles and valves; Metered and header systems; Single- and two-line metering; Progressive metering

Objectives

- Describe a typical positive feed oil lubrication system.
- Compare three types of sight glass flow indicators.
- Describe types and operation of various spray nozzles and valves used in automatic lubrication systems.
- Compare the operation of header and progressive metering systems.

Lesson 9: Lubricant Storage and Handling

Topics

Inside and outside storage; Dispensing; Inventory and rotating stock; Purification and reclamation; Gravity separation; Centrifuges; Strainers; Filters

Objectives

- Explain the importance of proper lubricant storage and describe good inside and outside storage practices.
- Describe various methods of dispensing lubricants.
- Discuss proper inventory and stock rotation procedures and define lubricant purification and reclamation.
- Explain how gravity separation, centrifuges, strainers, and filters work.

Lesson 10: Lubrication Management

Topics

Lubrication control; Establishing oiler routes; Coding lubrication points; Computer-managed programs; Installation; Computer reports

Objectives

- Explain the importance of good lubrication management practices and describe seven different kinds of information that should be included on an equipment lubrication survey form.
- Explain how to set up an oiler route and how to color-code the lubrication points.
- Discuss the considerations involved in establishing and installing a computerized lubrication program.
- Describe the purposes of several types of basic computer lubrication forms and list advantages of expanded programs.

Power Transmission Equipment

Course 303.1: Power Transmission Equipment
Covers belt drives, chain drives, gears and gear drives, adjustable-speed drives, shaft alignment, shaft coupling devices, and clutches and brakes.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Belt Drives

Topics

V-belts; Timing and flat belts; Sheaves; Pulleys; Installation

Objectives

- List the factors that affect the power transmitted by a belt drive.
- Name the main components of a belt drive.
- List the standard V-belt designations.
- Explain the reason for using group belts.
- Describe installation and replacement procedures for V-belts.

Lesson 2: Chain Drives

Topics

Terminology; Roller, double-pitch, leaf, and silent chains; Cast drive chains; Sprockets; Installation

Objectives

- Explain the differences between chain drives and belt drives in transmitting power.
- Explain how a roller chain drive works.
- Describe the construction of offset roller chain.
- Explain the differences between sprocket types A, B, and C.
- List the steps in installing a chain drive.

Lesson 3: Gears

Topics

Gear definitions and drives; Tooth contour and diametral pitch; Spur, helical, single-, double-cut, herringbone, bevel, and worm gears; Maintenance

Objectives

- Define the following terms used to describe gear drives: pitch circle, pitch diameter, working depth, tooth face, tooth flank.
- Calculate the diametral pitch of a gear.
- List advantages and disadvantages of helical gears.
- Explain the differences between herringbone gears and double-cut helical gears.
- Define the following terms used in discussing worm gears: worm lead, worm lead angle, normal worm pitch, worm axial pitch.

Lesson 4: Gear Drives

Topics

Shaft-mounted, worm-gear drives; Miter-gear boxes; Gear drive installation, maintenance, and definitions; Concentric, parallel, right-angle, vertical-shaft gear drives

Objectives

- Explain how additional speed reduction can be obtained with shaft-mounted gear drives.
- Describe a worm-gear drive and a miter-gear box.
- Give a general explanation of gear drive installation and maintenance.
- Define mechanical power, thermal power, and overload capacity.
- Explain what determines the service factor of a gear drive.
- Describe a concentric-shaft gear drive and a right-angle-shaft gear drive.
- Explain how parallel-shaft gear drives are lubricated.

Lesson 5: Adjustable-Speed Drives

Topics

Belt- and disk-type adjustable-speed drives, Roller-type, hydraulic, and electric adjustable-speed drives

Objectives

- Identify the main criteria for selecting adjustable-speed drives for industrial plants.
- Explain the operation of a variable-speed belt drive.
- Describe how to control variable-speed drives.
- Describe the belts and chains used for variable-speed drives.
- Explain the operation of a roller-type variable-speed drive.

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Lesson 6: Shaft Alignment

Topics

Geometry of shaft alignment; Preparation; Reverse-indicator method; Aligning multiple machines; Face-rim, long-span, and laser alignment

Objectives

- Determine the corrections needed to align two machines, using the reverse-indicator method.
- Determine the corrections needed to align two machines, using the face-rim indicator method.
- Determine the corrections needed to align three machines on a common centerline.
- Determine the corrections needed to align two machines separated by a long floating shaft.
- State at least three advantages of using laser alignment equipment over using dial indicators.

Lesson 7: Shaft Coupling Devices

Topics

Solid, jaw, molded-rubber, chain, gear, metal-disk, shear-pin, torque-limiting,
brake-wheel, floating-shaft, spacer, insulated, and other couplings

Objectives

- List three functions usually performed by a coupling.
- Describe two types of jaw couplings.
- Name an application for molded rubber couplings.
- State an advantage of chain couplings.
- Explain the operation of a shear pin coupling.
- Describe a torque limiting coupling.
- Name an application that involves a floating shaft.
- Describe a limited end float coupling.
- List advantages and disadvantages of spacer couplings.

Lesson 8: Clutches and Brakes

Topics

Jaw, friction, torque-limiting, tooth-type, centrifugal-type, overrunning, electric, and fluid clutches; Friction shoe, disk, electric brakes

Objectives

- Explain the purposes of a clutch.
- Describe the operation of a friction clutch.
- Explain the need for overrunning clutches.
- Name at least one application for an electric clutch.
- Explain how a fluid clutch works.

Bearings

Course 304: Bearings
Covers principles and applications of various types of bearings, including plain journal, ball, and roller bearings. Explains installation, inspection and repair of bearings. Deals with specialized bearings, including powdered-metal, nonmetallic, and hydrostatic bearings. Covers bearing seals, lubrication, and maintenance practices.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Bearings and Shafts

Topics

Bearing classification and selection; Shaft materials and stresses; Vibration; Critical speed; Fits and clearances

Objectives

- Name the two main categories of bearings and cite their advantages.
- Identify bearings by the kind of support they provide.
- Describe the three kinds of stresses acting on shafts.
- Explain natural frequency of vibration and critical speed.
- Name and describe three classes of fits.

Lesson 2: Plain Journal Bearings I

Topics

Features, types, and advantages; Lubrication; Lubricating grooves; Seals; Split bearings; Bearing design; selection

Objectives

- Explain the function of lubricating grooves.
- State two reasons for using seals on plain bearings.
- Name the principal types of plain journal bearings.
- Describe the structure of two kinds of precision inserts.
- Define crush and spread.

Lesson 3: Plain Journal Bearings II

Topics

Materials; Score resistance; Load capacity; Fatigue strength; Conformability; Embeddability; Corrosion and temperature resistance; Relining

Objectives

- Name and explain the characteristics that are most important in materials for bearings.
- State advantages and disadvantages of the standard types of bearing materials.
- Describe standard practices for inspecting bearings.
- Explain bearing repair procedures.

Lesson 4: Antifriction Bearings I

Topics

Operating principles; Bearing and cage materials; Lubrication; Seals and shields; Tolerances; Fits; Standard and precision bearings; Running accuracy

Objectives

- Identify the functions of the various parts of a typical rolling-element bearing.
- Explain the three elements of the AFBMA code.
- Define the categories of tolerances for ball bearings.
- Describe the factors that influence running accuracy of bearings.

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Lesson 5: Antifriction Bearings II

Topics

Environment; Mounting; Radial and axial clearance; Fixed and floating bearings; Fits; Alignment; Mounting methods; Selection

Objectives

- Name the factors that must be considered in the design of antifriction bearings.
- Describe the process of checking adequate running clearances for bearings.
- Explain the reasons for using fixed and floating bearings together.
- Describe the common methods of mounting bearings.

Lesson 6: Ball and Roller Bearings

Topics

Ball and roller bearing design; Single-row radial, single- and double-row angular contact bearings; Two-piece, inner-ring bearings; Roller bearings

Objectives

- Name the three basic ball bearing designs and describe their characteristics.
- Explain the purposes served by the basic roller bearing shapes and their variations in typical applications.

Lesson 7: Specialized Bearings

Topics

Thrust, self-aligning, linear-motion, mounted, instrument, ungrounded ball, powdered-metal, nonmetallic, and hydrostatic bearings

Objectives

- Identify ten specialized bearings.
- Describe a specific function or application of each of these bearing types.

Lesson 8: Bearing Seals

Topics

Seal functions; Terminology and classifications; Labyrinth seals; Special seals; Selection and application; Seal materials; Mechanical seals

Objectives

- Identify the functions of bearing seals.
- Describe the construction and operation of labyrinth and oil seals.
- Explain the two classification systems for oil seals.
- Name typical applications for the different kinds of seals.

Lesson 9: Lubrication

Topics

Lubrication practices and equipment; Oil and grease lubrication; Packing; Manual, natural, and automatic lubrication devices and systems

Objectives

- State typical applications for oil lubrication of bearings.
- Detail the cleaning procedures for different oil lubrication systems.
- Discuss the three qualities that are the bases for selecting a grease lubricant.
- Give five easy rules for lubricating bearings.

Lesson 10: Bearing Maintenance

Topics

Maintenance, cleaning, and installation; Mounting and removing bearings; Loading patterns; Failure terminology

Objectives

- Identify a principal cause of early bearing failure.
- Describe installation procedures for antifriction and plain journal bearings.
- Name the different types of bearing failure and their causes.
- Tell how bearings should be cleaned and lubricated after inspection.

Pumps

Course 305: Pumps
Covers typical applications of various types of pumps. Describes factors affecting pump selection. Explains operating principles of centrifugal, propeller, and turbine, rotary, reciprocating, and metering pumps. Includes special-purpose pumps, diaphragm pumps, and others designed to handle corrosive and abrasive substances. Covers pump maintenance, packing gland, seal, and bearing replacement.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Pump Development and Application

Topics

Development of pumps; Pumping systems; Water, chemical, waste, high-viscosity, and solids pumping systems

Objectives

- Describe dead-end and recirculating hot water distribution systems.
- List several special considerations involved in chemical pumping systems.
- Define the term viscosity and give examples of high-viscosity materials.
- Tell the effects of heat on the pumping of high-viscosity materials.
- List some special problems involved in the pumping of solids.

Lesson 2: Basic Pump Hydraulics

Topics

Terminology; Calculating total head, horsepower, and available vs required NPSH; Pump performance; Head capacity; Efficiency; Horsepower curves; Pump selection

Objectives

- Describe suction head and suction lift pumping conditions.
- Tell what three elements make up total dynamic head.
- Define static suction head.
- Contrast liquid, brake, and electrical horsepower.
- Tell what useful information can be gained from pump curves.

Lesson 3: End-Suction Centrifugal Pumps

Topics

Operation; Part definitions; Casing materials; End-suction casing configurations; Impeller types; Wearing rings; Shafts, bearings, and sleeves

Objectives

- Describe the function of the following: pump casing, shaft, impeller, wearing rings, and stuffing box.
- Contrast frame-mounted and close-coupled end-suction pumps.
- Give characteristics of fluids pumped with open, semi-open, and closed impellers.
- Name an advantage and a disadvantage each for stainless steel and brass shaft sleeves.

Lesson 4: Propeller and Turbine Pumps

Topics

Line-shaft, can, and submersible turbines; Flow patterns; Axial- and mixed-flow propeller pumps; Turbine pump construction and applications

Objectives

- Explain the construction of a line-shaft turbine pump.
- Name the two types of flow possible in a propeller pump.
- Tell the function of diffuser vanes in an axial-flow propeller pump.
- Define electrochemical corrosion and state its cause.
- Describe fluids that can be pumped by a regenerative turbine pump.

Lesson 5: Rotary Pumps

Topics

External-gear, internal-gear, lobe, screw, vane, rotary piston, and flexible-member pumps; Rotary pump installation

Objectives

- Describe the fluids that can be pumped by a rotary pump.
- Explain the operation of external- and internal-gear pumps.
- Describe the parts and construction of a lobe pump.
- Compare and contrast timed and untimed screw pumps.
- Tell why sealed bearings might be used in a vane pump.

Lesson 6: Reciprocating Pumps

Topics

Reciprocating pump applications, parts, classification, and operation; Horizontal and vertical plunger pumps; Air-driven pump operation

Objectives

- Name the parts that make up the power end of a reciprocating pump and describe their operation.
- Define the terms single-acting pump and double-acting pump.
- Compare simplex and duplex pumps.
- Explain how the pumped fluid lubricates a reciprocating pump.
- Calculate the discharge pressure of an air-driven pump when given the piston ration and motor air supply.

Lesson 7: Metering Pumps

Topics

Uses and classes of metering pumps; Plunger, piston, diaphragm, air-operated, and rotary metering pumps

Objectives

- Tell what kinds of pumps are used for metering applications.
- Describe metering pump lubrication techniques.
- Name the parts of a diagram metering pump and state the function of each.
- Explain the operation of a diaphragm metering pump.

Lesson 8: Special-Purpose Pumps

Topics

Handling difficult materials; Chemical, magnetic-drive, canned-motor, slurry, pulp-handling, trash, sewage, diaphragm, and vortex pumps

Objectives

- Describe the operation of a flexible-tube pump.
- Give an application for a progressing-cavity pump.
- Name one disadvantage of a seal-less magnetic-drive pump.
- Explain how to prepare a new centrifugal pump for operation.
- Tell which parts of a reciprocating slurry pump require the most maintenance.

Lesson 9: Packings and Seals

Topics

Sealing requirements; Stuffing boxes; Packing materials and recommendations; Installing packing; Mechanical, cartridge, balanced, and special seals

Objectives

- Tell why slight leakage through shaft seals is necessary.
- Name the type of stuffing box required for pumps operating under suction lift conditions.
- Give a typical application each for cotton, Teflon®, and aluminum packing.
- Describe the procedure involved in replacing pump packing.
- Describe a packingless seal.

Lesson 10: Pump Maintenance

Topics

Pump bearings, lubrication, and seals; Pump installation and maintenance; Centrifugal, turbine, rotary, and reciprocating pump maintenance

Objectives

- Name three types of antifriction bearings.
- Name three factors to consider when preparing pump lubrication schedules.
- Describe a typical application for each of the following bearing seals: felt, leather, synthetic.
- Tell the two major maintenance problems encountered in rotary pumps.
- Explain how to identify worn piston rings in a reciprocating pump.

Piping Systems

Course 306: Piping Systems
Covers piping and tubing systems used for fluid transport in the plant: hydraulic fluids, steam, liquefied product, refrigerant, and water. Shows typical metallic and nonmetallic piping systems, pipe-joining methods, and how tubing and hoses differ from piping. Covers valves, pipe fittings, hangers, supports, and insulation. Shows how tubing is sized, fitted, bent, and joined. Explains uses of traps, filters, and strainers.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Introduction to Piping Systems

Topics

Nature of fluids; Keeping fluids clean and moving; Piping system maintenance, insulation, and layout; Valves, fittings, supports, and hangers

Objectives

- Describe what typical piping systems consist of, and explain their importance to plant operations.
- Identify common valves and fittings, pipe hangers and supports.
- Describe the effects of temperature on piping system components, and explain the need for insulation.
- List routine maintenance considerations for piping systems.

Lesson 2: Metal Piping

Topics

Pipe sizes, schedules, and codes; Process and utility lines; Metallurgy; Pipe manufacturing methods; Fluid behavior in pipes; Joining and maintaining pipe

Objectives

- Explain how metal pipes are sized and designated according to standard codes and schedules.
- Identify the characteristics of metals that make them suitable for a variety of piping applications.
- Describe the different methods of connecting sections of metal pipe, including bell-and-spigot joints, welded, soldered, or brazed joints, screwed or threaded joints, and flanged joints.
- Discuss the major considerations involved in the maintenance of metal piping.

Lesson 3: Nonmetallic Piping

Topics

Clay, concrete, reinforced concrete, asbestos-cement, plastic, and thermoplastic pipe; Joining, limitations, and maintenance, Glass piping

Objectives

- Name the basic nonmetallic piping materials, and discuss the advantages and disadvantages of each.
- Identify the different forms of clay pipe and concrete pipe.
- Explain the difference between thermoplastic and thermosetting plastic pipe.
- Discuss the limitations of plastic pipe.
- Describe how to join sections of nonmetallic pipe, and how to maintain them.

Lesson 4: Tubing

Topics

Sizing, applications, and advantages of tubing; Laminar flow; Tube cutting, joining, and bending; Tubing materials, manufacturing, and maintenance

Objectives

- Compare piping and tubing, and list the major advantages of tubing.
- Describe the methods of cutting, bending, and joining sections of tubing.
- List the main types of metal tubing, and describe the kinds of industrial applications in which they are used.
- List the main types of plastic tubing, and describe the kinds of industrial applications in which they are used.

Lesson 5: Hoses

Topics

Hose characteristics, codes, sizes, and terminology; Vacuum rating; Metallic and nonmetallic hose; Reinforcement materials and patterns; Couplings

Objectives

- Explain how hoses are sized, classified, and constructed.
- Define basic hose terminology.
- Discuss the respective advantages of metallic hose, nonmetallic hose, and reinforced nonmetallic hose.
- Describe the common types of hose couplings used in industrial service.
- List the primary maintenance requirements of hoses.

Lesson 6: Fittings

Topics

Elbows, return bends, tees, cross-fittings, reducers, caps, plugs, and couplings; Screwed, welded, and flanged connections; Expansion joints; Vibration dampeners; Schematic symbols

Objectives

- Discuss the main functions of fittings.
- Identify common pipe and tube fittings.
- Contrast screwed, flanged, and welded connections, and tell why one type of joint may be preferred for a given application.
- Explain how expansion joints and vibration dampeners work.
- Demonstrate a knowledge of the symbols used to represent joints and fittings on schematic drawings of piping systems.

Lesson 7: Common Valves

Topics

Valve function, terminology, construction, and sizes; Gate, globe, needle, ball, butterfly, plug, check, and quick-opening valves; Connections and maintenance

Objectives

- Explain the various ways in which valves control fluid flow in piping systems.
- Identify gate, globe, needle, ball, butterfly, plug, and check valves, and tell what each is used for.
- Explain how and why quick-opening valves are used in industrial piping applications.
- Describe routine inspection, lubrication, and maintenance procedures for common valves.

Lesson 8: Special Valves

Topics

Resistance to corrosion, pressure, and temperature; Diaphragm, pressure-, temperature-regulating, safety, relief, and reducing valves; Actuators

Objectives

- Explain how diaphragm valves work.
- Describe the functions of the three main types of blowoff valves.
- Tell how regulating valves, relief valves, and reducing valves are used in industrial piping systems.
- Describe how different kinds of actuators open and close valves in response to pneumatic, hydraulic, or electrical signals.

Lesson 9: Strainers, Filters, and Traps

Topics

System protection; Wire screens and strainers; Magnetic traps; Cartridge and edge filters; Steam traps; Vent valves; Inspection and maintenance

Objectives

- Discuss the protective uses of strainers and filters in piping systems.
- Explain how the relationship between pressure and temperature affects steam lines, and creates the need for steam traps.
- Describe proper steam trap maintenance.
- Explain how and why air-vent and water-drain valves are used.
- Describe how a heat exchanger works in a fluid system.

Lesson 10: Accessories

Topics

Gauges; Pressure joints; Vacuum breakers; Accumulators; Receivers; Actuators; Heat exchangers; Intensifiers; Aftercoolers

Objectives

- Describe how different types of gauges are used to measure pressure and temperature in piping systems.
- Explain why rotary pressure joints are necessary in some applications.
- Describe the functions of accumulators and receivers.
- Tell how actuators and intensifiers are used in fluid-power systems.
- Discuss the principles of preventive maintenance and repair maintenance as they apply to piping systems.

Basic Hydraulics

Course 307: Basic Hydraulics
Covers hydraulic principles, types of hydraulic fluids and their characteristics. Describes components of the hydraulic system and their functions, including filters and strainers, reservoirs and accumulators, pumps, piping, tubing and hoses, control valves, relief valves, and actuating devices. Covers a variety of cylinders and hydraulic motors.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Principles of Hydraulics

Topics

Force, weight, mass, pressure, work, power, and energy; Incompressibility; Nondiffusion; Hydrostatic pressure; Pascal's Law; Fluid power transmission; Bernoulli's principle

Objectives

- Explain the difference between absolute and gauge pressure.
- Demonstrate how power is calculated.
- Explain Pascal's Law.
- Describe the difference between laminar and turbulent flow.
- Name the main components of a hydraulic system.

Lesson 2: Hydraulic Fluids

Topics

Viscosity; Pour point; Fluid selection; Chemical properties; System contamination; Dissolved air; Foaming; Corrosion and rusting

Objectives

- List the most important properties of hydraulic fluids.
- Explain how viscosity is measured.
- Explain the meaning of the viscosity index.
- Describe the effect of fluid temperature on viscosity.
- Name the causes of corrosion and fluid oxidation.
- Identify various types of hydraulic fluids.

Lesson 3: Strainers and Filters

Topics

Contaminant removal; Strainer performance; Types of strainers; Fibrous and nonfibrous filter media; Magnetic media; Installation

Objectives

- Name contaminants found in hydraulic systems.
- Explain the difference between a strainer and a filter, and describe the main function of each.
- Describe the two basic types of filter/strainer media.
- Draw graphic symbols for strainers and filters.

Lesson 4: Reservoirs and Accumulators

Topics

Reservoir, air separation requirements; Baffles; Reservoir cooling methods and accessories; Accumulators; Schematic symbols

Objectives

- Explain the functions of fluid reservoirs.
- Explain the purpose of reservoir baffles.
- Describe various methods of counteracting high operating temperatures.
- Identify important accessories used with reservoirs.
- Demonstrate pressure ratio calculation for a differential-piston accumulator.

Lesson 5: Hydraulic Pumps

Topics

Pump varieties, functions, and selection; Gear, screw, cycloidal, vane, axial-piston, and radial-piston pumps

Objectives

- Name the main classification of hydraulic pumps.
- List factors affecting pump selection and pump performance.
- Define volumetric efficiency and overall efficiency.
- Identify the most common types of positive-displacement pumps, and describe their operation.

Lesson 6: Piping, Tubing, and Fittings

Topics

Fluid flow and velocity; Hydraulic pressure; Pressure loss; Steel pipe and fittings; Tubing and tube bending; Hoses; Hose fittings and couplings

Objectives

- Discuss the chief considerations in hydraulic line selection.
- Demonstrate how flow velocity and pressure loss are calculated.
- Explain pipe size schedules.
- Describe various types of fittings used in hydraulic systems.
- Explain the reason for using steel pipe.
- List the main advantages of tubing.

Lesson 7: Directional Control Valves

Topics

Valve classification; Automatic, two-way, check, pilot-operated, and spool valves; Hydraulic motors; NO, NC, holding valves; Symbols; Flow ratings

Objectives

- Explain the classification of directional control valves.
- Describe how manually operated valves work.
- Explain the difference between direct-acting and pilot-operated valves.
- Describe the operation of a check valve, a spool valve, a three-way valve, a four-way valve, and a rotary valve.
- Explain the difference between normally closed and normally open valves.

Lesson 8: Pressure-Control Valves

Topics

Poppet, spool, sequence, counterbalance, holding, unloading, and pressure-reducing valves; Shock suppressors; Flow-control valves

Objectives

- Explain the functions of a pressure-control valve, a pressure-relief valve, and a pressure-reducing valve.
- Describe the operation of a spool valve, a poppet valve, and a sequence valve.
- Explain the purpose of holding valves, unloading valves, and counterbalance valves.
- Name the operations performed by flow-control valves.
- Describe how pressure compensation and temperature compensation work.

Lesson 9: Cylinders

Topics

Double-, single-acting cylinders; Two-piston cylinders; Positional cylinders; Cylinder construction; Rings, seals, and packing; Cylinder mounting and selection; Flow capacity; Cushioning

Objectives

- Describe the purpose of a hydraulic cylinder, and explain how a double-acting cylinder works.
- Explain the difference between “pull-type” and “push-type” single-acting cylinders.
- Describe the construction of a hydraulic cylinder.
- Explain the various methods of mounting cylinders.
- Demonstrate how to calculate the flow capacity of a hydraulic cylinder.

Lesson 10: Hydraulic Motors

Topics

Performance specifications; Starting, running, and stalling torque; Volumetric efficiency; Hydraulic motor construction; Gear, vane, and piston motors

Objectives

- Explain the classification of hydraulic motors.
- Demonstrate how the torque of a hydraulic motor is calculated.
- Calculate the horsepower output of a hydraulic motor.
- Discuss cost factors and other considerations affecting motor selection.
- Describe the construction of a hydraulic motor.
- Explain the operating principles of a gear motor, a vane motor, and a piston motor.

Hydraulic Troubleshooting

Course 308: Hydraulic Troubleshooting
Covers understanding the systems, using schematic diagrams, installation procedures, cleanliness and safety. Includes tubing cutting, bending, and flaring, identification and selection of proper fluid, and charging the system. Discusses planned maintenance, specific repair/replacement recommendations, system diagnosis, and troubleshooting.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Hydraulic Systems

Topics

System components; Hydraulic fluids; Tracing the system; Schematics; Cutaway drawings; Mechanical setup

Objectives

- Name the six basic elements of a hydraulic system.
- Explain the functions of hydraulic pumps, actuators, control valves, conductors and connectors, hydraulic fluid, and fluid storage and conditioning equipment.
- Describe how to trace a system.

Lesson 2: Hydraulic Schematic Diagrams

Topics

Definition, kinds, and characteristics of schematics; Lines; Symbols; Flow patterns; Tracing a circuit; Sequence valve circuit

Objectives

- Name three basic types of hydraulic diagrams, and explain the purposes of each.
- Describe how a valve symbol is constructed.
- List the steps to follow when reading a schematic diagram.
- Identify common hydraulic symbols.

Lesson 3: Installing Hydraulic Components

Topics

Safety; Cleanliness; Pump, drive, control valves, and mechanical valve installations; Pump start-up; Valve port identification

Objectives

- Explain the importance of cleanliness in hydraulic installations.
- Describe possible consequences of neglecting safety precautions.
- Explain how motor and pump shafts are aligned before coupling.
- Explain the correct method for checking direction of pump rotation.
- List several useful hints for solenoid valve installation.

Lesson 4: Installing Pipes and Tubes

Topics

General installation procedures; Tube flaring; Checking the flare; Tube bending and assembly; Hose, seal, reservoir, filter, heat exchanger, and actuator installation

Objectives

- Explain how pipe sizes are specified.
- Name the common types of pipe joints.
- List six important rules for good piping installation.
- Describe the advantages of hydraulic tubing over pipes.
- Describe the correct methods for bending and flaring tubing.
- List the key points for correctly installing hydraulic hoses, seals, reservoirs, filters, and actuators.

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Lesson 5: Selecting Hydraulic Fluids

Topics

Viscosity; Resistance to chemical and physical changes; Low-temperature properties; Demulsibility; Antirust properties; Compatibility

Objectives

- List ten important properties of hydraulic fluids.
- Explain the difference between hydrodynamic and boundary lubrication.
- Explain what a fluid's viscosity index means.
- Define demulsibility and emulsibility.
- Describe how to read a viscosity-temperature chart.
- List the proper procedures for installing hydraulic fluid.

Lesson 6: Planning System Maintenance

Topics

Inspections; Maintenance requirements; Fluid level; External leaks; Operating pressure; Fluid quality; Filter maintenance; Reconditioning

Objectives

- List the major categories of hydraulic system maintenance.
- Name and describe the six essential items in a maintenance file.
- List the steps involved in reconditioning a hydraulic component.
- Explain how to set up a maintenance plan for a typical hydraulic system.

Lesson 7: Troubleshooting Systems

Topics

Diagnosis and symptoms; Evaluating machine history; Determining the cause; Providing the solution; Tools and gauges; Troubleshooting charts

Objectives

- Describe the troubleshooting process.
- Explain how to evaluate recent maintenance history.
- List typical symptoms of common hydraulic system problems.
- Explain how to determine the cause of and provide a solution to a problem.
- Explain how a portable tester works.
- Describe how to keep and use troubleshooting charts.

Lesson 8: Troubleshooting Valves

Topics

Valve problems and test procedures; Disassembly, cleaning, and inspection; Repair and replacement; Solenoid problems; Reassembly and testing

Objectives

- Name five common valve problems and explain the sequence of steps to be followed in troubleshooting them.
- Describe the proper procedures for valve disassembly, cleaning, and inspection.
- Explain how to determine whether to repair or replace a malfunctioning valve.
- Describe the reasons for hydraulic "wire drawing."
- List the reasons for electrical and mechanical failures of solenoid valves.
- Explain the procedures for reassembling, reinstalling, and testing valves.

Lesson 9: Troubleshooting Cylinders

Topics

Cylinder descriptions; Troubleshooting procedures; Cylinder testing, repair, and installation; Shock absorbers

Objectives

- Name the most common types of hydraulic cylinders and identify their major parts.
- List the symptoms of internal and external cylinder misalignment.
- Explain what to do if you find internal leakage in a cylinder.
- Name the cylinder components most frequently replaced.
- Explain the purpose of a piston rod boot.
- Describe the symptoms of shock absorber failure.

Lesson 10: Troubleshooting Pumps and Motors

Topics

Gear and vane pump problems; Vane motors; Axial-and radial-piston pump problems; Pump and motor repair; Pump maintenance checks

Objectives

- List the proper procedures for troubleshooting pumps and motors.
- Name some common causes of pump failure.
- Describe typical causes of cavitation.
- Discuss the major sources of problems in gear pumps and vane pumps.
- Describe the effects of contaminants in axial-piston and radial-piston pumps.
- Explain the differences between a vane motor and a vane pump.

Basic Pneumatics

Course 309: Basic Pneumatics
Covers how work, force, and energy are applied to principles of pneumatics. Shows operating principles of reciprocating, positive displacement, rotary, and dynamic air compressors. Covers primary and secondary air treatment. Includes valves, logic devices, cylinders, and air motors.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Pneumatic Principles

Topics

Fluid power systems; Force, weight, and mass; Pressure; Work and energy; Diffusion and dispersion; Compressibility; Laws of pneumatics; Leverage; Air properties and flow; Bernoulli's Law; Components

Objectives

- Explain how force is transmitted in a pneumatic system.
- Calculate force and work.
- List two factors that affect the results of pressure calculations.
- Explain pneumatic leverage.
- Briefly explain the physical laws affecting the behavior of a confined gas.

Lesson 2: Reciprocating Compressors

Topics

Compressor construction, classification, and operation; Single-, double-acting compressors; Cooling requirements; Lubrication; Controls

Objectives

- Differentiate between a positive-displacement compressor and a dynamic compressor.
- Describe the operation of a reciprocating compressor.
- List one advantage of using a multistage compressor.
- Identify the cooling arrangements for reciprocating compressors.
- Compare the operation of compressor controls in large and small units.

Lesson 3: Rotary Compressors

Topics

Vane, rotary-screw, low-pressure, high-volume, diaphragm, centrifugal, and axial-flow compressors; Compressor capacity; Accessories

Objectives

- Compare the power output of a single-stage vs a two-stage vane compressor.
- Describe the main types of positive-displacement rotary air compressors.
- Explain the advantages and disadvantages of both types of dynamic compressors.
- Describe four methods of controlling centrifugal compressor output.
- Tell how to compensate for a low-speed drive in rotary screw compressors.

Lesson 4: Primary Air Treatment

Topics

Preliminary filtering; Relative humidity; Effects of moisture; Moisture separators; Oil scrubbers; Air dryers and receivers; Using a nomograph

Objectives

- Describe techniques for cleaning compressor filters.
- Define relative humidity and dew point.
- Explain the effects of temperature and pressure on the air's ability to hold moisture.
- Describe aftercooler operation.
- Explain the functions of separators, oil scrubbers, and air dryers.

Lesson 5: Secondary Air Treatment

Topics

Contaminant separation and filtration; Filter classification and rating; Surface, depth, adsorption, and absorption filters; Lubricating the air

Objectives

- Describe the two main methods of contaminant separation.
- Explain how filters are classified.
- List contaminant particle sizes and particle contamination categories as they occur in filters.
- List applications for the most common types of filter media.
- Identify system location for lubrication equipment installation.

Lesson 6: Piping, Hoses, and Fittings

Topics

Piping requirements and dimensions; Safety; Connections; Metallic tubing; Tube bending, fittings, and installation; Hoses, fittings, and installation

Objectives

- State the importance of laminar flow.
- List the factors that affect pressure loss in a pipe.
- State direction and amount of slope for compressor discharge pipes.
- Discuss procedures for pipe, tube, and hose installation.
- Describe safe working procedures for disconnecting air hoses.

Lesson 7: Directional Control Valves

Topics

Manually and automatically operated valves; Control valve elements: spools, poppets, disks, and plates; Two-, three-, four-, and five-way valves; Accessories

Objectives

- Describe the four methods of identifying control valves.
- List four basic types of manually operated, two-way valves.
- Describe the operation of a two-position, direct acting, normally closed solenoid valve.
- Explain one major advantage of using a four-way valve.
- Describe the construction of a three-way valve.

Lesson 8: Pressure-Control Valves

Topics

Safety vs relief valves; Relief valve construction; Pressure regulators; Pilot-operated, remote-controlled regulators; Logic functions

Objectives

- List two ways a valve can control compressor pressure output.
- Describe construction of two basic types of pressure-relief valves.
- Contrast a pressure regulator with a pressure-relief valve.
- State the limit imposed by Federal Law on the pressure allowed when an air hose is used to blow off chips.

Lesson 9: Pneumatic Cylinders

Topics

Double-, single-acting cylinders; Two-piston cylinders; Cylinder construction, mounting, and selection; Performance charts; Cushioning

Objectives

- Tell the difference between pneumatic and hydraulic cylinders.
- Describe the construction and operation of a single-acting cylinder.
- State the purpose of an exhaust flow control metering valve.
- Describe the action of a pivoted cylinder.
- Explain the size relationship between a cylinder port and a valve port.

Lesson 10: Pneumatic Motors and Rotary Actuators

Topics

Motor rating; Selection factors: pressure, speed, torque, horsepower, reliability, and service life; Rotary vane and piston motors; Air boosters

Objectives

- Explain pneumatic motor classification.
- Define torque.
- Describe pneumatic motor construction.
- Calculate a motor's horsepower, given its torque and speed.
- Differentiate between a pneumatic motor and a rotary actuator.

Pneumatic Troubleshooting

Course 310: Pneumatic Troubleshooting
Covers pneumatic systems, schematic symbols and diagrams, installing system components, planned maintenance, system diagnosis, and troubleshooting. Includes maintenance of air compressors, control valves, air motors, electrical components, and hybrid systems.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Pneumatic Systems

Topics

Air supply system; Reciprocating and rotary compressors; Cooling; Compressor maintenance; Air-line filters and lubrication

Objectives

- Explain the operation of linear actuators—cylinders—in a typical pneumatic circuit.
- Describe the various types of compressors and how they work.
- Define intercooling and aftercooling.
- Describe basic preventive maintenance procedures for compressors.
- List the components of an effective delivered-air system and explain how they work together.
- Describe the three main types of air-line lubrication.

Lesson 2: Pneumatic Schematic Diagrams

Topics

Schematic symbol construction; Diagramming an air supply; Simple pneumatic systems; Timing and safety circuits; System schematics

Objectives

- Explain the different types of symbols used in pneumatic schematic diagrams—how they are constructed and what they show.
- Describe the operation of timing and safety circuits.
- Analyze the schematic diagram of a fluid-power system.

Lesson 3: Installation of System Components

Topics

Compressor intakes and foundations; Aftercoolers; Receivers; Dryers; Pipe installation and support; Tubing and hose fittings; System installation

Objectives

- Describe the proper installation of the compressor and its auxiliaries.
- Describe the installation of aftercoolers, receivers, and dryers.
- Explain the correct procedures for installing pipes, tubes, and hoses in pneumatic systems.
- Describe the installation of control valves, solenoid coils, and cylinders.

Lesson 4: System Maintenance

Topics

Control system maintenance; Cylinder maintenance; Tool maintenance; Logs and records; Automatic recorders and recording charts

Objectives

- Explain the concept of planned maintenance.
- Describe the basic procedures for maintaining the compressor and other important components in a pneumatic system.
- Describe the maintenance of industrial control circuit components.
- Explain the proper maintenance of pneumatic tools.
- Discuss the various types of maintenance logs and explain what kind of information is recorded in each.

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Lesson 5: Determining System Failures

Topics

Locating troubles; Operations manual; Checking the air supply; Troubleshooting valves and actuators; Interlocks; Final adjustments

Objectives

- List, in proper sequence, the steps to be taken in troubleshooting a pneumatic system.
- Name and describe the five important parts of every pneumatic system's operations manual.
- Describe procedures for troubleshooting the actuator.
- Explain how to check control valves, sequence valves, and interlocks.

Lesson 6: Troubleshooting Air Compressors

Topics

Compressor cooling, lubrication, and valves; Crankcase ventilation; Piston rings; Bearings; Control systems; Troubleshooting

Objectives

- Describe methods of cooling and lubricating reciprocating compressors.
- Explain the proper maintenance of compressor valves.
- Identify problems associated with the control system of a compressor.
- Describe the basic maintenance requirements of rotary, vane, rotary-screw, and centrifugal compressors.

Lesson 7: Troubleshooting Control Valves

Topics

Checking manual overrides, circuit sequence, and solenoids; Improper sequence and valve shifting; Control timing; Lubrication problems

Objectives

- Outline how to isolate a control malfunction in a pneumatic circuit.
- Explain how to troubleshoot a nonstarting or nonoperating circuit, improper sequencing of the circuit, and miscellaneous problems related to the equipment.
- Describe the proper procedures for checking electric solenoids.
- Explain how to check for problems related to valve shifting, control timing, and lubrication.

Lesson 8: Troubleshooting Cylinders

Topics

Cylinder construction; Checking for correct size, clogged filters, frozen air lines, and cylinder misalignment; Worn packings and seals; Controls

Objectives

- Define the different types of pneumatic cylinders.
- Describe the construction of a typical cylinder.
- Describe the proper procedures for troubleshooting cylinders, including checking for misalignment, worn packings, and adequate air pressure.
- Explain general installation techniques for cylinders and accessories.

Lesson 9: Troubleshooting Air Motors

Topics

Checking for sufficient air; Contamination; Lubrication; Air motor abuse; Hose and clamp maintenance; Vane and piston motors

Objectives

- Explain how to check for sufficient clean air when troubleshooting an inoperative air motor.
- Explain how to keep hoses, clamps, and couplings in good condition.
- Describe the operation and maintenance of vane, radial piston, and axial-piston air motors.

Lesson 10: Pneumatic/Hydraulic Systems

Topics

Air-oil tanks; Pressure boosters; Hydraulic control; Pneumatic cushioning; System interlock; Pneumatic servos; Troubleshooting

Objectives

- Explain why and how compressed air and hydraulic pressure are combined.
- Describe the role of boosters in pneumatic/hydraulic systems.
- Explain how single-pressure and dual-pressure booster systems work.
- Describe the advantages and disadvantages of combined air-oil cylinders.
- Explain how pneumatic and hydraulic actions can be interlocked.
- Discuss the proper troubleshooting procedures for air-oil systems.

The Refrigeration Cycle

Course 431: Refrigeration Cycle
Introduces the basic concepts needed for an understanding of refrigeration. Traces the basic refrigeration cycle. Explains the concepts of heat, temperature, humidity, dewpoint, enthalpy, and simple psychrometrics. Concludes with a lesson on the tools and instruments needed for refrigeration servicing and safe work practices.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Refrigeration and Air Conditioning Basics

Topics

Definition of refrigeration and air conditioning; Composition of matter; States of matter

Objectives

- Define refrigeration and air conditioning and explain how they differ.
- Describe the two methods of lowering the temperature of a material.
- Name the three physical states of matter.
- Identify what causes matter to change its state.

Lesson 2: Heat, Pressure, and Change of State

Topics

Heat; Temperature; Heat transfer; Sensible and latent heat; Heat quantity; Pressure; Importance of pressure in refrigeration

Objectives

- Explain the difference between sensible and latent heat.
- Compare the Fahrenheit and Celsius temperature scales and convert temperatures from one to another.
- Name and describe the three methods of heat transfer.
- Define latent heat of fusion and latent heat of vaporization.
- Explain the difference between absolute pressure and gauge pressure.
- Describe the effect of pressure changes on boiling point.

Lesson 3: The Basic Refrigeration Cycle

Topics

Vapor-compression refrigeration cycle; Refrigerant in action; Types of evaporators, compressors, condensers, and metering devices

Objectives

- Explain the function of each of the major refrigeration system components: evaporator, compressor, condenser, and metering device.
- Define the terms subcooling and superheating.
- Explain the function of the refrigerant in a refrigeration system and trace its path.
- Contrast dry-expansion and flooded evaporators.
- Name the five main types of compressors.
- Define cooling medium and name the two most commonly used.
- Explain the operation of the six most common metering devices.

Lesson 4: Air Properties and Simple Psychrometrics

Topics

Temperature; Humidity; Specific volume; Enthalpy; Psychrometric chart; Dewpoint temperature; Relative humidity

Objectives

- State the definition of psychrometrics.
- List the four air properties important in psychrometrics.
- Differentiate between dry- and wet-bulb temperature and tell how each is measured.
- Define the term saturated air.
- Define specific humidity and relative humidity.
- Define enthalpy and explain how it is calculated.
- Demonstrate how to use the psychrometric chart to determine dewpoint temperature, specific humidity, relative humidity, and enthalpy.

Lesson 5: Tools, Test Instruments, and Safe Work Practices

Topics

Pressure gauges; Vacuum-measuring instruments; Leak detection; Thermometers; Hygrometers; Electric test equipment; Recording instruments; Safety

Objectives

- Describe a gauge manifold and tell how it is used.
- Tell what it means to evacuate a refrigeration system and tell how it is done.
- List and describe at least three methods of leak detection.
- Explain the construction of a sling psychrometer and tell how and why it is used.
- Name the instrument used to measure relative humidity.
- Name the instrument used to measure each of the following electrical values: potential difference, current, resistance, and electric power.
- List the four classes of work area hazards, and give an example of each.

Refrigerants and Refrigerant Oils

Course 432: Refrigerants and Refrigerant Oils
Covers physical properties of refrigerants, including pressure-temperature relationships. Discusses various kinds of refrigerant and their safe handling. Examines effects of refrigerants on the atmosphere and related EPA requirements. Discusses filters, driers, leak detection equipment, gauge manifold set. Explains system charging, evacuation and dehydration, refrigerant recovery/recycling, and oil maintenance and servicing.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Physical Properties of Refrigerants

Topics

Pressure-temperature relationship; Enthalpy; Pressure-enthalpy diagrams; Liquid subcooling

Topics

- Explain the relationship between pressure and boiling point in a liquid.
- Define the term enthalpy, and differentiate between the enthalpy of saturated liquid, the enthalpy of evaporation, and the enthalpy of saturated vapor.
- Use a P-H diagram to show the process of evaporation, compression, condensation, and liquid metering.
- Calculate the compression ratio, refrigerating effect, refrigerant flow rate, heat of compression, compressor horsepower, and coefficient of performance for a system.
- Determine compressor discharge temperature, compressor volume displacement, superheat, subcooling, and total heat rejection in the condenser, using a P-H diagram.
- Explain the purpose and methods of liquid subcooling.

Lesson 2: Refrigerant Classification and Applications

Topics

Refrigerant identification; Refrigerant/oil mixtures; Common refrigerants and mixtures; Ammonia; Safety; Handling containers

Objectives

- Identify several properties of the ideal refrigerant.
- Explain the ASHRAE standard for refrigeration identification.
- Discuss in detail some common refrigerants in use today—their advantages, disadvantages, characteristics, and applications.
- Define the terms blend, fractionation, temperature glide, and azeotrope.
- Describe how refrigerants are classified for safety purposes.
- Explain the safety precautions that must be taken when handling and storing refrigerants.

Lesson 3: Refrigerants and the Atmosphere

Topics

Ozone hole; CFCs and ozone; Greenhouse effect; Alternative refrigerants; Changes in servicing, installation practices

Topics

- Define ozone and tell why it is important.
- Explain how CFCs deplete the ozone layer and contribute to the greenhouse effect.
- Explain how refrigeration system servicing procedures have changed in response to the discovery of ozone depletion.
- Name the “three Rs” and define each term.
- Identify several ways in which good installation practices can prevent refrigerant leaks.

Lesson 4: Refrigerants and the EPA

Topics

Clean Air Act; Section 608 overview; Refrigerant recovery; Releases and leaks; Enforcement; Logs; Certification testing; Purchasing refrigerant

Topics

- Name some of the steps being taken by the United States government to control the depletion of stratospheric ozone.
- List the five main elements of the EPA regulations concerning recycling, emission reduction, and disposal.
- Contrast active and passive recovery equipment.
- Define the three types of refrigerant releases permitted by EPA regulations.
- List the reports you should keep concerning refrigerant purchase and use.
- Explain the levels of technician certification.

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Lesson 5: Refrigerant Filters and Driers

Topics

System contaminants; Types of filters, driers, and filter-driers; Desiccants; Strainers; Suction filters; Installation precautions

Topics

- List the contaminants that can infiltrate or form within a refrigeration system.
- Describe the various types of filters, driers, filter-driers, and strainers used in mechanical refrigeration systems.
- Distinguish between absorption-type and adsorption-type desiccants.
- Explain the importance of proper location when installing filters, filter-driers, and strainers.
- List the important factors to consider when selecting a filter-drier.
- List several safety precautions to follow when working with filter-driers.

Lesson 6: Tools and Procedures for Working with Refrigerants

Topics

Leak detection; Vacuum pump; Gauge manifold; Checking refrigerant charge; Evacuation and dehydration; Charging; Recovery/recycling

Topics

- Describe the various methods of locating leaks in a refrigeration system.
- Explain how to connect a gauge manifold to a system and how to remove air from the manifold.
- Explain how to check the refrigerant charge in a system.
- Name and describe the two methods of evacuating and dehydrating a refrigeration system.
- Describe the procedures for vapor charging and liquid charging a system.
- Identify and explain the various methods of adding the correct amount of refrigerant to a system.
- Contrast active and passive refrigerant recovery.

Lesson 7: Refrigerant Oils, Oil Maintenance, and Service Procedures

Topics

Oil properties; Compressor lubrication; Oil-related problems; Oil separators; Contaminants; Maintenance and servicing; Adding and removing oil

Topics

- Explain the purposes oil serves in a refrigeration system.
- Define the following properties of oil: stability, viscosity, miscibility, floc point, and flash point.
- Name the two broad categories of oils and the sub-categories of each.
- Explain how oil becomes mixed with the refrigerant and the problems its presence can cause in a refrigeration system.
- Describe the function of an oil separator.
- List several problems that can be caused by water in a refrigeration system.
- Describe the procedures for checking oil level and adding or removing oil.

Compressors

Course 433: Compressors
Explains the function of the compressor in a refrigeration system. Introduces information on the construction and use of reciprocating, rotary, helical, scroll, and centrifugal compressors. Covers compressor motors, control, and protection. Concludes with a lesson on preventive maintenance for compressors as well as troubleshooting and repair.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Introduction to Compressors

Topics

Open and hermetic compressors; Reciprocating, rotary, helical, scroll, and centrifugal compressors; Multiple compressor applications; Replacement

Objectives

- List the five kinds of air conditioning and refrigeration compressors.
- Contrast the operation of positive-displacement and kinetic-displacement compressors.
- Explain how each kind of the five kinds of compressor raises the pressure of the refrigerant vapor.
- Define staging and cascading and explain why each is used.
- List important considerations in compressor replacement.

Lesson 2: Reciprocating Compressors

Topics

Reciprocating compressor housings, pistons, rods, crankshafts, bearings, seals, oil pumps, cylinder heads, and valves; Vibration control

Objectives

- Describe the general construction of open, semi-hermetic, and full-hermetic reciprocating compressors.
- Explain how the basic parts of a reciprocating compressor are assembled.
- Identify common designs of housings, pistons, connecting rods, crankshafts, bearings, seals, cylinder heads, and valves used in reciprocating compressors.
- Explain how a cylinder unloader controls the capacity of a reciprocating compressor.
- Explain how compressors are lubricated.
- Explain how compressor vibration and noise are controlled.

Lesson 3: Rotary, Helical, and Scroll Compressors

Topics

Rotary compressor advantages; Rotary vane, helical, and scroll compressors; Accumulators; Bearings; Lubrication

Objectives

- Describe the operation of single-vane and multiple-vane rotary compressors, including how each raises refrigerant pressure.
- List several advantages of rotary compressors over reciprocating compressors.
- Define slugging and cavitation.
- Tell the two functions of an accumulator in a rotary compressor.
- Compare and contrast rotary and helical compressors.
- Describe the operation of the single-screw and twin-screw helical compressor.
- Describe the operation of a scroll compressor.

Lesson 4: Centrifugal Compressors

Topics

Centrifugal compressor characteristics, construction, bearings, lubrication, and purging; Capacity control; Compressor repair

Objectives

- Describe the operating principle of a kinetic-displacement compressor.
- List advantages and disadvantages of centrifugal compressors as compared to positive-displacement types.
- Explain reverse hydrostatic sealing.
- Explain how centrifugal compressors deal with thrust forces.
- Trace the operation of a typical centrifugal compressor lubrication system.
- Tell the purpose of a purge system.
- Describe the capacity control methods used in centrifugal compressors.

Lesson 5: Compressor Motors

Topics

Basic requirements; Single-phase, split-phase, capacitor, dual-voltage, repulsion, and three-phase motors; Starting switches

Objectives

- Explain the basic requirements of a compressor motor.
- Name the different types of single-phase and three-phase motors used to power compressors and tell which ones can be used in hermetic compressors.
- Explain how to reverse the direction of rotation of a motor.
- Explain how to change voltages on a dual-voltage motor.
- Describe the operation of the current and potential relays used for starting single-phase hermetic compressor motors.

Lesson 6: Compressor Control and Protection

Topics

Motor starting devices; Overload protection; High-pressure and low-pressure protection; Oil-pressure safety switches; Crankcase heaters

Objectives

- Name the two basic categories of motor-starting devices and tell how each operates.
- Explain the function of a reduced-voltage starter and name the five kinds used with compressor motors.
- Describe the three kinds of motor overload protection commonly used with compressor motors.
- Discuss the causes of, effects of, and solutions for high discharge pressure, low suction pressure, and low oil pressure.
- Explain the function of a suction-line accumulator.
- Explain why crankcase heaters are sometimes necessary.
- Explain how heat exchangers improve the performance of a compressor.

Lesson 7: Compressor Maintenance, Troubleshooting, and Repair

Topics

Importance of PM; Common mechanical problems; Repair basics; Disassembling, cleaning, inspecting, and reassembling compressors

Objectives

- State the first rule of preventive maintenance for compressors and related components.
- List preventive maintenance procedures common to most compressors.
- Explain how to calculate voltage imbalance in a three-phase motor.
- Name at least three possible causes of a low compressor oil level.
- Name at least three possible causes of compressor overheating.
- Explain how electrical problems can cause various system malfunctions
- Explain how to pump down a compressor for repairs.
- Describe compressor disassembly, cleaning, inspection, and reassembly procedures.
- Describe motor spot burnouts and cookouts, list their possible causes, and explain how to determine the severity of a burnout.
- Explain how to clean up a system after a motor burnout.

Evaporators and Metering Devices

Course 434: Evaporators and Metering Devices
Explains function and construction of evaporators. Covers: direct-expansion, dry-expansion, and flooded evaporators; and, systems using multiple evaporators. Discusses boosting evaporator performance. Explains evaporator defrosting, maintenance, and troubleshooting. Describes function, operation, and maintenance of metering devices, including hand-operated, automatic, thermostatic, thermal-electric.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Introduction to Evaporators

Topics

Evaporator operation; Latent and sensible heat; Evaporator capacity; Temperature differential; Circulation velocity

Objectives

- Explain the function of the evaporator in a refrigeration system.
- List five main factors affecting evaporator capacity, and explain how each can be optimized to gain the greatest possible evaporator capacity.
- Describe the basic evaporator configurations.
- Explain the function of headers and distributors in multiple-circuit evaporators.
- Explain how comfort coolers reduce both air temperature and humidity.

Lesson 2: Direct Expansion Evaporators and Secondary Refrigeration Systems

Topics

Dry and flooded evaporators; Evaporator configurations; Secondary-refrigeration systems; Multiple staging; Cascade systems

Objectives

- Compare and contrast dry-expansion and flooded evaporators.
- List the main types of flooded evaporators.
- Explain the process of secondary refrigeration.
- Define eutectic solution and eutectic temperature.
- Describe three types of multiple-evaporator systems.
- Identify cascade and multiple-staging refrigeration systems.

Lesson 3: Improving Evaporator Performance

Topics

Net refrigeration effect; Superheating; Subcooling; Accumulators; Heat exchangers; Headers; Oil separation

Objectives

- Explain how the laws of thermodynamics apply to refrigeration.
- Describe how to increase the net refrigerating effect of an evaporator.
- Demonstrate—using simple arithmetic—the amount of increase in net refrigerating effect caused by subcooling.
- List several advantages of using a heat exchanger in a refrigeration system.
- Describe three ways of keeping oil out of an evaporator.
- Explain why the circulation of air or water through an evaporator coil improves evaporator performance.

Lesson 4: Defrosting, Maintaining, and Troubleshooting Evaporators

Topics

Manual, ambient air, heated air, water, brine, hot-gas, reverse-cycle, and electric defrost methods; Cleaning coils; Frost problems; Troubleshooting

Objectives

- Explain why periodic defrosting of evaporator coils is necessary.
- List and describe at least five different methods of defrosting an evaporator.
- Explain the differences between the hot-gas and reverse-cycle defrost methods.
- Explain how to clean an evaporator coil, drain pan, and drain line.
- Describe how to remove rust, scale, and sludge from shell-and-tube evaporators.
- List two ways evaporator coils can be winterized.
- Tell how low airflow and excessive moisture increase frost buildup on coil surfaces.
- Explain how dirty coils and damaged fins reduce an evaporator's cooling capacity.

Lesson 5: Metering Device Types, Maintenance, and Troubleshooting

Topics

Hand-operated, automatic, thermostatic, and thermal-electric expansion valves; Capillary tubes; Float valves; Maintenance and troubleshooting

Objectives

- Explain the primary function of a metering device.
- Name the five main types of expansion valve, and describe the operation of each.
- Contrast the operation of an internally equalized and an externally equalized TXV.
- Explain how to adjust the superheat on a TXV.
- Describe the structure, operation, and application of high- and low-side float valves.
- Identify three causes of floodback and describe the corrective action for each.
- List the common problems of TXVs along with their solutions.

Condensers and Cooling Towers

Course 435: Condensers and Cooling Towers
Covers the function, construction, and operation of both air- and water-cooled condensers and related devices. Discusses cooling towers and spray ponds, including maintenance and troubleshooting. Includes a lesson on evaporative condensers. Concludes with a discussion of water-related problems and how to solve them.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Air-Cooled Condensers

Topics

Condenser capacity, construction, and types; Pumpdown circuit; Low-ambient controls; Receivers; Pressure-relief devices; Maintenance

Objectives

- Contrast the two types of air-cooled condensers—natural draft and forced air.
- Describe the construction of an air-cooled condenser, including the tubes, fins, headers, and subcooling circuit.
- Name the factors that affect condenser capacity.
- Explain the effects of ambient temperature on the capacity of an air-cooled condenser.
- Describe various types of low-ambient controls for air-cooled condensers.
- Explain how spring-loaded pressure-relief valves and fusible plugs protect against possible explosions caused by high pressure.
- List the periodic maintenance procedures common to most air-cooled condensers.

Lesson 2: Water-Cooled Condensers

Topics

Condenser types; Pressure-relief devices; Water-regulating valves; Strainers; Maintenance; Cleaning; Inspection; Troubleshooting

Objectives

- Name and describe the basic types of water systems used by water-cooled condensers.
- Define the terms makeup water and fouling factor.
- Describe the construction of the various kinds of water-cooled condensers.
- Explain the purpose of the accessories used with water-cooled condensers—pressure-relief devices, water-regulating valves, and strainers.
- Explain water-cooled condenser maintenance procedures, including inspection for leaks, and chemical and mechanical

Lesson 3: Cooling Towers and Spray Ponds

Topics

Cooling tower and spray pond function capacity, types, controls, maintenance, and troubleshooting

Objectives

- Explain the function of cooling towers and spray ponds and the factors that affect their capacities.
- Identify the basic types and construction of cooling towers and spray ponds.
- Describe the components required in a cooling-tower or spray-pond water-circulating system and explain the purpose of each.
- Describe the various devices used to control cooling-tower capacity.
- Explain cooling-tower and spray-pond maintenance procedures.

Lesson 4: Evaporative Condensers

Topics

Refrigerant, air-circulation, and water-circulation systems; Capacity control; Freezing condition operation; Maintenance; Troubleshooting

Objectives

- Identify the basic types of evaporative condensers.
- Describe the components that make up the three circulation systems in an evaporative condenser—refrigerant, air, and water—and explain the operation of each.
- List the kinds of capacity controls used on evaporative condensers and explain the operation of each.
- Explain how to provide freeze protection for an evaporative condenser.
- Outline evaporative-condenser maintenance procedures.

Lesson 5: Controlling Water-Related Problems

Topics

Chemical water treatment; Water-related problems; Causes and control of corrosion, scale, biological fouling, and wood deterioration

Objectives

- Describe the three categories of water problems encountered in the water systems of water-cooled equipment.
- Name the five causes of corrosion and explain how to control them.
- Describe the three most common types of scale, their causes, and how to control them.
- List the three types of organisms that grow in water systems and explain how to control them.
- Describe the three types of wood deterioration and explain how to control them.
- Explain the operation of three chemical-feeding devices used in water systems.

Piping

Course 436: Piping
Examines piping system materials and sizing. Includes coverage of codes, valves and fittings, and the cutting and joining of piping and tubing. Explains the function and unique requirements of the discharge line, liquid line, and suction line. Concludes with a lesson on piping system maintenance, including handling dirt and scale, expansion, vibration, corrosion, and leaks.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Piping Materials and Fittings

Topics

Material compatibility; Sizing; Oil migration; Pipe vs tubing; Schedules and codes; Valves; Fittings; Cutting and joining pipe; Tubing materials and sizes; Cutting, flaring, bending, and joining tubing

Objectives

- Name the three main lines of piping in a refrigeration system.
- Explain why air conditioning and refrigeration piping must be sized correctly.
- Contrast pipe and tubing and explain why tubing is often preferred over piping.
- Explain how pipe is classified according to schedule.
- Name three methods of joining steel pipe.
- Explain how tubing is cut, flared, bent, and joined.
- Describe the step-by-step procedure for making a brazed joint.

Lesson 2: Discharge Line

Topics

Refrigerant condition; Pressure drop; Oil circulation; Piping layout, sizing; Refrigerant migration; Accessories

Objectives

- List the four functions of the discharge line in a refrigeration piping system.
- Explain the importance of pressure drop in piping and its effects on system operation.
- Define the term entrainment and explain why entrainment of oil is important.
- State the flow velocity needed for refrigerant vapor to entrain oil in horizontal piping and in vertical risers.
- Name some practical steps you can take to assure a good flow of refrigerant in horizontal piping.
- Describe ways of preventing refrigerant and oil migration to the compressor.
- Name and explain the purposes of three discharge-line accessories.

Lesson 3: Liquid Line

Topics

Refrigerant condition; Pressure drop; Oil circulation; Piping layout and sizing; Liquid receiver; Components, accessories, and insulation

Objectives

- Name the functions of the liquid line.
- Explain why it is desirable to have subcooling in the liquid line.
- Describe the effects of pressure drop in the liquid line on the operation of a refrigerant system.
- Describe the effects of flash gas formation on the performance of the system.
- Explain the purpose of a liquid receiver.
- Explain why each of the following devices is used in the liquid line: sight glass, solenoid valve, check valve.

Lesson 4: Suction Line

Topics

Lubricating oil; Pressure drop; Accumulators; Heat exchangers; Controls; Valves; Filters; Vibration eliminators; Insulation

Objectives

- Describe the functions of the suction line, its structural demands, and special design features.
- Explain why suction lines are pitched down toward the compressor.
- Explain how a double suction riser moves oil along with the refrigerant.
- Explain the function of an accumulator and a heat exchanger in a suction line.
- Describe the basic differences between evaporator pressure regulators and crankcase pressure regulators.
- Explain why it is necessary to insulate the suction line.
- Explain how a suction line for multiple compressors differs from a suction line for a single compressor.

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Lesson 5: Piping Systems Maintenance

Topics

Dirt and scale; Piping expansion; Supports; Vibration; Corrosion; Leaks; Liquid hammer; Thermal insulation; Troubleshooting

Objectives

- Name at least four factors that cause piping problems and can lead to operating problems.
- Explain why cleanliness is essential when assembling refrigeration piping.
- Name at least three ways to allow for the expansion of piping.
- Describe the various ways of supporting horizontal and vertical pipe runs.
- Describe the damage that can be caused by vibration and tell how to protect piping from it.
- Define corrosion and explain how it can be prevented in refrigerant and water piping.
- Explain the importance of thermal insulation for refrigeration system piping.

Control Systems

Course 437: Control Systems
Introduces the need for control, control methods, and system basics. Includes information on self-powered, pneumatic, hydraulic, electric, and electronic systems. Covers various sensors and controlled devices. Covers basics of two-position, floating, and proportional control systems and their maintenance and troubleshooting. Discusses processes requiring control in a refrigeration or air-conditioning system.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Introduction to Control Systems

Topics

Automatic control; Control system basics; Two-position, floating, and proportional control; Open- and closed-loop control; Operating power

Objectives

- Explain why control systems are needed and name devices used to control environmental conditions.
- Define the terms used to describe control systems—controlled variable, controller, controlled device, setpoint, control point, and controlled medium—and name the basic elements of a control system.
- Describe the action of two-position, floating, and proportional control.
- Explain how anticipators work.
- Compare open-loop and closed-loop control.
- Compare the basic requirements of pneumatic/hydraulic control systems to those of electric/electronic control systems.

Lesson 2: Sensors and Controlled Devices

Topics

Temperature, humidity, and pressure sensors; Dampers; Valves; Variable-speed drives

Objectives

- Explain the need for a sensor in a control system.
- Name and explain the operation of three kinds of temperature sensors.
- Define relative humidity, state the range required for human comfort, and describe common humidity sensors.
- Name three common pressure sensors and explain their operation.
- Explain the operation of two-position dampers and valves in shutoff and throttling applications.
- List the advantages of variable-speed drives over older methods of speed control.

Lesson 3: Automatic Control Systems

Topics

Two-position, floating, and proportional electric control; Pneumatic systems, controllers, actuators, relays, and switches; Electronic systems; Proportional band, gain, and PID control

Objectives

- Describe the operation of two-position, floating, and proportional electric controllers.
- List the equipment needed for a pneumatic control system.
- Name several pneumatic relays and switches, and explain why each is used.
- Discuss the advantages and basic operation of electronic controls.
- Define resolution, sensitivity, proportional band, and gain, and explain how they are related.
- Distinguish between integral and derivative action, and explain how each can improve system performance.

Lesson 4: Control of Refrigeration and Air-Conditioning Processes

Topics

Primary control; Low-pressure, high-pressure, and high-temperature controls; Anti-recycle timers; Pressure regulators; Oil-level controls; Overload protection; Capacity control

Objectives

- Explain how pumpdown control operates and why pumpdown is often preferred over other methods of primary control.
- Describe the location, function, and operation of a high-pressure control.
- Name three ways to control condenser pressure and at least three ways to control system capacity.
- Explain how a differential oil pressure safety control works.
- Compare the two methods of modulating the flow of water to hydronic terminals.

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Lesson 5: Maintaining and Troubleshooting Controls

Topics

Maintaining pressure controls, thermostats, switches, valves, timers, controllers, relays, and power supplies; Troubleshooting the system

Objectives

- List the four basic steps involved in setting up a PM program.
- Explain the importance of high-pressure controls as safety devices and explain their testing procedures.
- Explain how oil pressure is maintained in various kinds of compressors.
- Describe the testing and maintenance required for condenser water regulating valves and compressor capacity controls.
- Explain how to check for oil and water contamination in control air and what measures to take to minimize them.
- Explain the major maintenance requirements of a pneumatic control system.
- Describe the maintenance required by electric and electronic controllers.
- Explain how to use a troubleshooting chart.

Air-Handling Systems

Course 438: Air-Handling Systems
Covers airflow basics, including how air moves, types of airflow, and pressure relationships. Compares and contrasts various fans and fan motors. Examines types of ducts, fittings, connections, insulation, and terminal devices. Covers methods of cleaning and filtering air, as well as balancing and troubleshooting the air-handling system. Concludes with a lesson on indoor air quality and sick building syndrome.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Air Movement and Distribution

Topics

Air handling system; Comfort, process air conditioning; Heat and moisture transport; How air moves; Types of airflow; Pressure relationships; Controlled ventilation and pressurization; Dual-duct systems; System velocity

Objectives

- List the variables controlled by an air-handling system.
- Define comfort and explain how to predict whether or not people in a space will be comfortable.
- Define the following terms: laminar flow, turbulent flow, streamlining, and eddy currents.
- Differentiate between static pressure, velocity pressure, and total pressure in an air-distribution system.
- Compare a dual-duct system to a single-duct system in both structure and operation.

Lesson 2: Fans and Fan Motors

Topics

Fan construction; Centrifugal and axial-flow fans; Fan performance curves; System characteristics; Preventive maintenance for fans; Impeller maintenance; Belt, drive-train, and bearing maintenance

Objectives

- Describe the two basic types of fans used in air-conditioning systems.
- Define the terms system characteristic and point of operation.
- Explain why a knowledge of fan laws and performance curves is necessary when altering an air-handling system.
- Describe preventive-maintenance procedures for typical fans.
- Explain how to replace the bearings in a centrifugal fan.

Lesson 3: Ductwork Types, Fabrication, and Repair

Topics

Types of ducts; Duct designations, fittings, and connections; Insulation; Terminal devices; Fabricating sheet metal ducts; Duct reinforcement; Duct maintenance

Objectives

- Define the term aspect ratio.
- Compare and contrast a radial duct system and an extended plenum system.
- Describe the structure and purpose of dampers and turning vanes.
- Identify a variety of fittings and connections used in a sheet metal ductwork system.
- Explain how and why ducts are insulated and reinforced.
- Identify common types of sheet metal seams and describe how each is fashioned.
- Explain the basic servicing and inspection procedures for ductwork systems.

Lesson 4: Air Filtration

Topics

Mechanical air filters; Service schedules; Servicing impingement filters; Replacing dry media filters; Installing HEPA filters; Electronic air cleaners

Objectives

- Explain the function of an air filter.
- Describe the two main types of mechanical air filters.
- Explain how to establish a service schedule for air filters.
- Explain how to clean and/or replace the filters in your HVAC system.
- Explain the operation of electronic air cleaners and tell how they are serviced.

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Lesson 5: Air System Balancing and Troubleshooting

Topics

Measuring instruments; Pretest data collection; Preparing the system; Measuring and adjusting the main airflow, branch ducts, registers, and diffusers; Troubleshooting

Objectives

- Explain why air-handling systems need to be balanced.
- Describe the instruments used to test and balance an air-handling system.
- Demonstrate how to measure velocity pressure and show how airflow rates are calculated from these pressure readings.
- Describe a pitot-tube traverse.
- Explain in step-by-step fashion how to test and balance an air-handling system.
- Name common complaints related to air-handling systems and give common causes.

Lesson 6: Indoor Air Quality and Sick Building Syndrome

Topics

Sick building syndrome (SBS) characteristics, contributors; HVAC systems as contaminant sources; Pollutant pathways; Odors and contamination, Building-related illness

Objectives

- Discuss the characteristics of sick building syndrome (SBS).
- Describe the process for investigating an SBS complaint and explain how to conduct a facility site review.
- Discuss ways a facility can minimize the probability of perceived SBS problems.
- Discuss internal and external SBS contributors, including HVAC systems, and discuss ways to eliminate or reduce the problems.
- Describe specific ways to control particulates, odors, and other contaminants.
- Define the abbreviations SBS, IAQ, BRI, VOC, and MCS.

System Troubleshooting

Course 439: System Troubleshooting
Discusses the keys to effective troubleshooting and emphasizes the importance of safety. Details a step-by-step procedure to use when troubleshooting. Covers the use of a troubleshooting flowchart. Examines three sample problems, leading the trainee through the steps necessary to locate the problem in each example.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Preparation for Troubleshooting

Topics

Mechanical refrigeration systems; Keys to effective troubleshooting; Safety in troubleshooting; Tools and equipment; Supplies; Human relations skills

Objectives

- Give an example of each of the following applications: process refrigeration, commercial refrigeration, process air conditioning, comfort air conditioning.
- Tell what knowledge is essential for an effective troubleshooter to have.
- Tell what safety precautions must be followed when dealing with the mechanical, electrical, chemical, and environmental hazards involved in troubleshooting.
- List the necessary tools, equipment, and supplies needed to perform troubleshooting procedures.
- Explain why human relations skills are important to the refrigeration system troubleshooter.

Lesson 2: Troubleshooting Procedures

Topics

Six steps of troubleshooting; Avoiding a recurrence of the problem

Objectives

- Name the six basic steps in the troubleshooting procedure.
- Explain why it is important to collect information from the equipment operator when a system is malfunctioning.
- Explain what type of information is contained on a nameplate and in the operations log of a system.
- Explain the structure and use of troubleshooting charts.
- Explain how to set up a preliminary checklist and how to select the most likely components and subsystems for further examination.
- List items to check out after making repairs to a refrigeration system.

Lesson 3: Troubleshooting Electric Controls

Topics

Troubleshooting flowchart; Checking the contactor; Faulty coils; Relays and switches; The power side

Objectives

- Explain how to use a troubleshooting chart.
- Explain how to isolate a control circuit failure from a motor circuit failure.
- List the causes of abnormally high control circuit resistance.
- Explain the difference between using an ohmmeter and using a voltmeter to check for a closed electric switch.
- Describe how to check contactor coils and motors for shorts and opens.

Lesson 4: Troubleshooting Pneumatic Controls

Topics

Equipment and tools; Checking the control air supply; Output pressure test; Checking for air leaks; Checking other controllers; Actuator problems; Thermostat adjustments

Objectives

- Describe the symptoms of control air contamination and explain how to remedy it.
- Explain how to check thermostat output pressure.
- List at least three kinds of actuator problems and explain how to solve them.
- Describe the calibration procedure and explain its purpose.
- Explain how to calibrate a pneumatic controller.

Lesson 5: Troubleshooting the Refrigerant Circuit

Topics

Preliminary checks; Analyzing the complaint; Checking refrigerant pressures; Checking refrigerant charge; Checking for refrigerant leaks; Compressor cycling; Checking high-side components; Low-side problems, Distribution problems

Objectives

- Distinguish between a refrigerant circuit problem and a conditioned-medium problem.
- Explain the procedure for checking refrigerant charge.
- Name major causes of variance in head and suction pressures.
- Explain how to isolate the cause of compressor short cycling.
- Explain how to use head-pressure readings and suction-pressure readings in diagnosing refrigeration problems.

Absorption Chillers

Course 440: Absorption Chillers
Covers the basic principles of absorption refrigeration as compared to mechanical refrigeration. Introduces absorption terminology and common absorption fluid pairs. Examines water/lithium bromide systems, ammonia/water systems, and evolving systems. Concludes with a discussion of chiller selection factors, cost of operation, and absorption system applications.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Principles of Absorption Chiller Systems

Topics

Mechanical vs. absorption refrigeration systems; Absorption terminology; Single-effect absorption cooling; Common absorption fluid pairs

Objectives

- Explain the differences between a mechanical refrigeration system and an absorption system.
- Describe the basic components in a simple absorption system and their functions in the refrigeration cycle.
- Distinguish between the characteristics of a weak solution and a strong solution and explain the function of each in the absorption cycle.
- Define the terminology associated with absorption systems.
- Describe the steps in a simple single-effect absorption cooling cycle.

Lesson 2: Water/Lithium Bromide Absorption Systems

Topics

Water/lithium bromide systems; Double-effect direct-fired system; Solution flow cycles; Operating characteristics; Crystallization

Objectives

- Discuss basic characteristics of water/lithium bromide absorption systems and name common industrial uses.
- Describe the differences between single-effect and double-effect absorption systems.
- Discuss the action of the solution and the refrigerant throughout a solution cycle within absorption systems used for heating only, cooling only, and simultaneous heating and cooling.
- Compare reverse, series, and parallel solution flow cycles.
- Discuss operating characteristics of various absorption machines and explain how the coefficient of performance (COP) is used in equipment selection.
- Describe the cause of crystallization and its effect on an absorption system.

Lesson 3: Lithium Bromide Absorption

Topics

Controls and maintenance — limitations; Control scheme; Start, run, and shut down sequence; Operating limits; Safety controls; Maintenance; Insulation; Noncondensables gases

Objectives

- Discuss the general operating limits of absorption units, including ASHRAE 15 machine room safety requirements.
- Describe the basics and benefits of today's microprocessor-based operation and capacity control.
- Describe the normal absorption unit start, run, and shutdown sequences.
- Name various kinds of system operating controls and safety controls and explain their functions.
- Describe general setup and maintenance requirements and the procedures that keep the absorption chiller operating efficiently.
- Discuss the necessity for insulation and control of noncondensable gases, including air.

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Lesson 4: Ammonia/Water Absorption Systems

Topics

Ammonia systems background and characteristics; Basic, industrial, and domestic ammonia/water absorption systems; Ammonia system advantages

Objectives

- Discuss the solubility of ammonia in water and other characteristics, including hazards, that affect ammonia absorption systems.
- Explain the function of the analyzer and rectifier in an ammonia absorption system.
- Define the terms strong aqua and weak aqua as related to the ammonia water solution and compare them with the terms strong solution and weak solution as related to a lithium bromide system.
- Describe typical applications for industrial ammonia absorption systems and small residential and commercial ammonia absorption systems.
- Explain the operation of the Platen-Munters ammonia/water/hydrogen system.
- Name reasons why ammonia absorption systems are likely to be used increasingly in the future.

Lesson 5: Evolving Absorption Systems

Topics

Improving COPs; GAX heat pump cycles; Triple-effect cycles; Single-effect system with heat recovery; Double-effect system with solar heating; Power plant heat recovery; Hybrid high-lift pump with mechanical compression

Objectives

- Discuss reasons for continuing testing and development of advanced absorption systems.
- Describe current developments in the GAX ammonia/water residential heat pump systems.
- Describe triple-effect systems and compare absorption and adsorption cycles.
- Explain how special-application absorption systems use recovered heat, waste heat, or a solar array to provide the energy for operation.
- Describe the properties of non-standard solution pairs.
- Explain how two kinds of hybrid arrangements incorporate the absorption system.

Lesson 6: Absorption Systems vs. Mechanical Compression Systems

Topics

Water/lithium bromide, ammonia/water absorption units; Mechanical compression systems; Chiller selection factors; Economic perspectives; Absorption system application

Objectives

- Describe important characteristics of both single-effect and double-effect water/lithium bromide absorption chillers and ammonia/water absorption units.
- Briefly describe the operation and characteristics of centrifugal chillers.
- Briefly describe the operation and characteristics of reciprocating and screw positive-displacement chillers.
- Name factors that must be considered in selecting air-conditioning equipment for specific applications and compare COPs for the various kinds of equipment.
- Discuss general cost criteria for the various types of energy used to drive the equipment and describe an appropriate absorption system application.

Heat Pumps

Course 441: Heat Pumps
Introduces the heat pump concept and related terminology. Covers water-to-water, water-to-air, ground-to-air, air-to-air, solar-assisted, geothermal, dual-fuel, and split systems, as well as packaged units. Defines balance points, coefficient of performance, energy efficiency ratio, and degree days. Covers components, controls, installation, checkout, and startup.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Introduction to Heat Pumps

Topics

Heat pump operation and advantages; Cooling, heating, and defrost cycles; Balance points; Degree-days; Unit sizing; Operating costs

Objectives

- Explain how a heat pump differs from standard air-conditioning equipment.
- List the benefits of heat pump systems.
- Describe the heating, cooling, and defrost heat pump cycles.
- Define degree-day.
- List considerations in sizing heat pumps.

Lesson 2: Heat Pump Systems

Topics

Water-to-water, water-to-air, ground-to-air, air-to-air, solar-assisted, geothermal, dual-fuel, and split systems; Packaged units

Objectives

- Compare the operation of water-to-water and water-to-air heat pump systems.
- Compare the operation of ground-to-air and air-to-air heat pump systems.
- Describe the operation of solar-assisted heat pump systems.
- Describe the operation of geothermal heat pump systems.
- Describe the operation of dual-fuel heat pump systems.
- Discuss the differences in configuration and installation of split and packaged heat pump units.

Lesson 3: Balance Points and Cost of Operation

Topics

Determining balance points; Supplemental heating; Performance ratings; Efficiency ratings; Operating costs; Cost estimation

Objectives

- Determine heat pump system balance points and explain their relationship to system capacity.
- Discuss the use and control of supplemental heat.
- Discuss ARI single-point and seasonal heating and cooling ratings for heat pump equipment.
- Explain how several common variables affect heat pump operating costs.
- Describe how to use the heating degree-day, cooling degree-day, and bin methods of estimating heat pump system energy use.
- Describe common problems of heat pump systems in the heating mode.

Lesson 4: Heat Pump Components

Topics

Accumulators; Indoor and outdoor coils; Compressors; Reversing and check valves; Heat exchangers; Filter-driers, Thermostats

Objectives

- Explain why heat pump systems include an accumulator.
- Describe the indoor and outdoor coils, indoor air handling components, and various metering (flow-control) devices.
- Briefly discuss the requirements of reciprocating and scroll compressor operation as used in heat pump systems.
- Discuss the use and operation of the reversing valve and check valves in heat pump systems.
- Explain the functions of the equalizer tank, heat exchanger, and filter-driers in heat pump systems.
- Briefly describe indoor and outdoor controls and popular defrost control systems.

Lesson 5: Heat Pump Controls

Topics

Defrost and pressure controls; Heat sequencers; Emergency heat relay; Starting components; Lockout relays; Overload protectors

Objectives

- Describe the operation of the pressure differential and temperature differential defrost methods.
- Compare the advantages and disadvantages of the timed defrost and time-and-temperature defrost methods.
- Compare the construction and operation of electromechanical and solid-state defrost controls.
- Explain the functions of pressure controls, heat sequencers, and the emergency heat relay in heat pump systems.
- Describe typical starting and lockout devices used on heat pumps and explain why systems include transformers, contactors, and overload protectors.

Lesson 6: Heat Pump Installation

Topics

Outdoor and indoor units; Air distribution system; Refrigerant lines; Condensate drain; Electrical system; Packaged heat pumps

Objectives

- Discuss considerations in selecting the best location for outdoor unit installation.
- Discuss considerations in selecting the best location for indoor unit installation.
- Describe installation practices that help the air distribution system fulfill its purpose.
- Discuss procedures for installing refrigerant lines and primary and auxiliary drain lines.
- Discuss the requirements for installing electrical wiring.
- Describe additional requirements for installing a packaged heat pump unit.

Lesson 7: Heat Pump Checkout and Startup

Topics

Leak testing; Charging; Insulation; Electrical system, connections; Miscellaneous checks

Objectives

- Describe basic checkout procedures for the compressor crankcase heater, air distribution system, and all heat pump mountings.
- Describe basic steps in leak testing and charging a heat pump unit and discuss basic requirements for post-installation checkout of heat pump insulation and piping.
- Describe both the general post-installation checkout of the electrical system and tests to check specific electrical connections.
- Explain how to check the operation of the system thermostat, outdoor thermostats, and defrost controls.
- Name ways to increase blower output and explain why operator instructions are important.

Heating System Basics

Course 442: Heating System Basics
Covers fundamental information on all types of heating systems. Begins with the concept of heat energy, heat transfer, and temperature scales. Examines factors affecting human comfort. Introduces all types of heating equipment and its operation. Includes a Lesson on combustion and thermal efficiency. Concludes with a lesson on duct systems.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Heat Energy

Topics

Heating system requirements; Heat and energy; Temperature; Sensible heat and latent heat; Heat transfer; Energy conversions; Electric motors

Objectives

- Name the three main requirements of heating systems and various kinds of energy related to heating systems.
- Define terms related to the basic concepts of heating systems.
- Describe differences between standard temperature scales and explain how to convert between Fahrenheit and Celsius scales.
- State the two basic laws of heat transfer and describe the three ways heat is transferred from one location to another.
- Explain how to convert between kilowatts (kW) and brake horsepower (bhp).
- Briefly describe various kinds of single-phase motors used in heating systems.

Lesson 2: Personal Comfort and Heat Distribution Systems

Topics

Personal comfort; Humidity; Humidifiers; Heat delivery systems; Forced-air furnaces; Heat pumps; Hot water heating systems; Room heating panels

Objectives

- Discuss the effects of temperature, humidity, and air velocity on personal comfort.
- Describe various kinds of humidifiers used in furnaces.
- Describe the basic operation of a forced-air furnace.
- Discuss the use of heat pumps.
- Explain the main difference between forced-air and hot water (hydronic) heating units.
- Describe the basic operation of floor, wall, and ceiling heating panels.

Lesson 3: Combustion

Topics

Combustion facts; Combustion reactions; Heating value; Compensation for altitude; Fuel classification; Solid, liquid, gaseous fuels; Thermal efficiency; Combustion products as pollutants

Objectives

- Define combustion and describe what happens to the fuel and oxygen supplied during the process.
- Describe characteristics of stoichiometric combustion and discuss problems associated with incomplete combustion.
- Define the terms ignition temperature, upper and lower flammability or explosive limits, higher and lower heating values, and flash point.
- Discuss the general differences between solid, liquid, and gaseous fuels and describe their characteristics.
- Explain how thermal efficiency applies to heating systems.

Lesson 4: Chimneys and Venting

Topics

Chimney and gas venting terminology; Need for combustion air; Draft control methods; Basic chimney requirements, operation factors; Gas, oil-fired furnace venting; Fireplace chimneys; Vent and chimney accessories

Objectives

- Define terms related to chimneys and venting.
- Describe several methods of draft control used on chimneys.
- Discuss factors that affect chimney operation.
- Discuss the relationship between chimney height and draft and explain why correction factors may be needed.
- Discuss the basics of gas furnace venting and oil furnace venting.
- Discuss the general principles affecting the operation of fireplaces and their chimneys.

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Lesson 5: Forced-Air Duct Systems

Topics

Duct system basics; Forced-air system components; Supply outlets; Duct dampers; Damper motors and actuators; Blowers (fans); Duct system pressure, integrity, design

Objectives

- Explain how the duct system delivers warm air throughout the building and describe two common ductwork layouts.
- Describe the various components of the duct system and explain why centrifugal blowers are preferred within the system.
- Discuss pressure variations within the duct system and explain how manometers and pitot tubes are used to measure pressure.
- Discuss the importance of duct system integrity as it relates to system efficiency and name factors that contribute to this integrity.
- Describe typical duct system designs and explain how the equal friction method is used.

Heating System Equipment

Course 443: Heating System Equipment
Covers the hardware associated with heating systems, including gas and oil furnaces, electric systems, solid-fuel and hydronic systems, and finally some alternative systems—solar heating, heat pumps, and fuel cells. Includes a discussion of furnace performance criteria, return air systems, and the importance of filters.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Gas Heating Equipment

Topics

Gas heating basics; Gaseous fuels; Combustion air; Furnace categories; Furnace components for heat production, ignition, venting; Conditioned air system; Heating system controls; Service procedures

Objectives

- Describe the main parts of the furnace system, both those that produce the heat and those that distribute the heated air, and describe the four basic furnace configurations.
- Discuss the differences between natural gas and liquefied petroleum gas (LPG), the hazards associated with each fuel, and the heating rates of each fuel.
- Discuss the purposes of the primary and secondary air supplies to the combustion chamber and compare the characteristics of category I, III, and IV gas furnaces.
- Describe how the gas is introduced, mixed with the air, and burned in the heat-producing components of the furnace.
- Describe several burner ignition methods and safety shutdown measures in case of flame failure.
- Discuss the basic sequence of furnace operation and the controls required.
- Describe common service procedures for gas heating systems and discuss safety.

Lesson 2: Oil Heating Equipment

Topics

Oil heating basics; Fuel oils; Burner components; Pumps; Nozzles; Blowers; Electrodes; Transformer and controls; Fuel supply; Heat exchangers and combustion chamber; Combustion efficiency; Service procedures

Objectives

- Discuss the similarities and differences between oil furnaces and gas furnaces.
- Name two common fuel oils and discuss the relationships between grades of fuel, viscosity, and temperature.
- Compare the requirements and operation of oil burner systems having the storage tank above the furnace to those having the tank below the furnace.
- Explain the reason for atomizing fuel oil and describe nozzle action and spray patterns.
- Describe the function of blower components that provide combustion air.
- Explain the purpose of the electrodes, transformer, and controls in an oil burner system.
- Discuss various ways of testing for combustion efficiency and describe common servicing procedures for oil burner systems.

Lesson 3: Electric Heating Systems

Topics

Electric heating basics; Advantages and disadvantages of electric heating; Electric heating applications; Electric baseboard heating; Radiant ceiling heating panels; Electrically heated walls, floors; Forced-air electric furnaces; Forced-air control system; service tips

Objectives

- Describe the characteristics of the electric wire used for resistance heating elements.
- Discuss the advantages and disadvantages of electric heating systems.
- Explain how electric baseboard heating is applied to smaller facilities.
- Describe basic designs for radiant systems and discuss heating element safety.
- Describe the function of each main component in an electric forced-air furnace.
- Follow a wiring diagram to discuss the operation of an electric furnace including startup, shutdown, and safety features.

Lesson 4: Solid-Fuel Furnaces and Furnace Performance Criteria

Topics

Coal furnaces; Stoker classifications; Coal furnace control systems; Wood furnaces; Dual-fuel furnaces; Furnace performance criteria

Objectives

- Explain why coal is in decline as a heating fuel and describe the layout of a coal furnace.
- Compare various kinds of mechanical stokers and explain why each kind is used.
- Describe the functions of furnace safety and operating controls.
- Discuss the basic requirements of wood-burning furnaces.
- Discuss the benefits and function of dual-fuel furnaces.
- Explain how to use furnace efficiency formulas, including the AFUE system.

Lesson 5: Hydronic Systems

Topics

Hydronic basics; Thermal, hydraulic, distribution systems; Additional system components; Radiant panel systems; Heating/cooling systems; Control methods; Domestic water heating; MTW and HTW systems; Freeze protection; Altitude considerations; Air elimination

Objectives

- Discuss how water can be used in residential and light commercial buildings to provide heating and cooling.
- Discuss the relationships between the five basic components of hydronic systems and describe the functions of the expansion tank and centrifugal pump.
- Compare the layouts and uses of series (one-pipe) and parallel (two-pipe and four-pipe) distribution systems.
- Discuss the use of radiant panels, heating/cooling systems, and domestic water heating.
- Name characteristics that make MTW and HTW systems economical for large commercial and industrial systems and explain why the simpler LTW systems are used for residences and small commercial buildings.
- Explain how to provide freeze protection, how to adjust for high altitude, and how to eliminate air from the system.

Lesson 6: Other Heating System Equipment

Topics

Fireplaces; Other in-space heaters; Solar heating; Heat pump systems; Fuel cells; Return air systems; Filters

Objectives

- Describe various kinds of fireplaces and the resulting level of efficiency.
- Discuss the three flue-venting arrangements in newer fireplaces.
- Discuss various kinds of in-space heaters and their use in residences and commercial and industrial facilities.
- Discuss the basics of solar heating and describe various kinds of solar heaters used for building cooling and heating.
- Discuss the emerging technology of fuel cells for heating and electric power generation.
- Explain why certain locations are preferred for supply and return vents in forced-air heating systems.
- Discuss today's filtration systems and IAQ concerns.

Ammonia Refrigeration Basics

Course 461: Ammonia Refrigeration Basics
Covers all aspects of using ammonia as a refrigerant. Describes both single-stage and two-stage ammonia systems. Explains the importance of accumulators and intercoolers in ammonia refrigeration. Concludes with coverage of liquid recirculation system operation.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Ammonia Characteristics

Topics

Ammonia sources, uses, and chemical characteristics; Environmental, hazardous material concerns; Temperature-pressure relationships; Materials compatibility; MSDS criteria; Safety

Objectives

- Name common uses of ammonia and describe benefits of ammonia refrigerant in terms of ozone depletion and global warming potentials (ODP and GWP).
- Describe the properties of ammonia and explain how they affect the use of ammonia as a refrigerant.
- Discuss the toxicity and flammability of ammonia and its classification as a hazardous material.
- Discuss important features of ammonia saturation curves, reactions with metals, and MSDS criteria.
- Name two standards governing ammonia refrigeration systems and describe the four main ammonia safety concerns, steps for their prevention, and first aid treatment in the event of exposure.

Lesson 2: Single-Stage Ammonia Systems

Topics

Positive-displacement systems; Refrigeration loads; Primary, secondary refrigeration system components; Components in parallel; Superheat; Single-stage pressure-enthalpy diagram

Objectives

- Briefly compare absorption and mechanical compression systems, compare dynamic and positive-displacement compressors, and name those generally used in industrial ammonia refrigeration systems.
- Explain how a positive-displacement compressor increases the ammonia vapor pressure.
- Define British thermal unit (Btu), specific heat, sensible heat, latent heat, and tons of refrigeration.
- Name four primary components in single-stage ammonia refrigeration systems and describe their functions.
- Describe the functions of the oil separator, high-pressure liquid receiver, king valve, and suction accumulator in single-stage ammonia refrigeration systems.
- Define superheat, enthalpy, and entropy and explain how they are used on the pressure-enthalpy (P-H) diagram.

Lesson 3: Two-Stage Ammonia Systems

Topics

Compression ratio; Compressor capacity; Two-stage system division, Booster desuperheater, intercooler; Two-stage system components, performance; Complex two-stage systems

Objectives

- Define compression ratio and explain its importance in single-stage and two-stage industrial ammonia refrigeration systems.
- Explain why flash gas removal, booster discharge-vapor desuperheating, and interstage liquid cooling are desirable in the two-stage system.
- Plot a two-stage refrigeration system on an ammonia pressure-enthalpy (P-H) diagram.
- Name the primary and secondary components of a two-stage refrigeration system and describe component functions.
- Explain why a two-stage system requires less overall power than a single-stage system.

Lesson 4: Suction Accumulators and Intercoolers

Topics

Need for suction accumulators; Accumulator design features; Liquid/vapor separation; Intercoolers; Shell-and-coil vs flash intercoolers; Alternate intercoolers

Objectives

- Explain why suction accumulators are needed and describe the damage that can result from liquid entering the compressor.
- Discuss the purposes and reasoning behind the design features, including the boil-out coil, of suction accumulators.
- Describe the various ammonia refrigerant liquid/vapor separation criteria.
- Explain how the intercooler deals with flash gas and desuperheats the booster discharge.
- Describe basic differences between a flash intercooler and a shell-and-coil intercooler.
- Describe typical configurations for alternate intercoolers provided with internally compounded compressors.

Lesson 5: Liquid Overfeed (Recirculation) Systems

Topics

Liquid overfeed, recirculation systems; Recirculation system advantages and disadvantages; Recirculation vessel design; Pumper drum system; Controlled pressure receiver system

Objectives

- Describe the various functions performed within the recirculation vessel.
- Discuss the advantages and disadvantages of recirculation systems.
- Describe design features of horizontal and vertical recirculation vessels.
- Discuss the surge-volume requirements of a recirculation system and reasons for high-level alarm/cutout controls on the recirculation vessel.
- Describe the features and drawbacks of various kinds of liquid-refrigerant pumps.
- Describe the operation of pumper drum (gas-pressure) recirculation systems and controlled pressure receiver (CPR) recirculation systems.

Positive-Displacement Compressors





Course 462: Positive-Displacement Compressors
Begins with coverage of reciprocating compressors—their design, lubrication, efficiency, and application. Covers rotary vane compressor operation and limitations. Details screw compressors and the operation of related drive, lubrication, capacity control, and safety systems. Discusses oils and the importance of system lubrication.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Reciprocating Compressors

Topics

Features of industrial ammonia reciprocating compressors; Capacity control; Lubrication; Efficiency; Application data; Compound compressors

Objectives

- Briefly describe the evolution of ammonia reciprocating compressors.
- Describe typical design features of today's reciprocating compressors.
- Explain how capacity control and proper lubrication are achieved in ammonia reciprocating compressors.
- Explain how to use volumetric and adiabatic efficiency data and the performance factor in sizing or selecting compressors for an application.
- Describe the function and basic design requirements of internally compounded reciprocating compressors.

Lesson 2: Sliding-Vane Rotary Booster Compressors

Topics

Rotary vane compressor design and operation; Fixed volume ratio; Applicability; Limitations; Capacity control

Objectives

- Describe the basic operation of sliding-vane rotary booster compressors.
- Explain the principle of fixed volume ratio compressors.
- Describe typical rotary compressor design features.
- Explain why sliding-vane rotary compressors have been replaced by screw compressors.
- Discuss the reasons for rotary vane compressor speed limitations and the causes and effects of blade wear.
- Describe how capacity control is achieved in rotary compressors.

Lesson 3: Oil-Flooded Screw Compressors

Topics

Oil-flooded screw compressor operation; Fixed volume ratio; Capacity control in fixed, variable compressors; Efficiency; Compound compressors; Application criteria

Objectives

- Discuss the developments that led to the use and acceptance of the oil-flooded screw compressor in industrial refrigeration.
- Describe typical design features of single-screw and twin helical screw compressors.
- Explain how the compression system works within screw compressors.
- Compare fixed and variable volume machines and their applications.
- Explain how the capacity-control slide valve and variable Vi slide stop function.
- Describe the general range of application for screw compressors.

Lesson 4: Screw Compressor Units

Topics

Screw compressor systems; Drive systems; Lubrication, refrigerant/oil separation, oil cooling, economizer/side load, capacity control, microprocessor control, and safety systems

Objectives

- Explain why screw compressors are provided as units and describe the main systems that make up the screw compressor unit.
- Explain why a vertical or horizontal oil separator may be preferred and explain why check valves are used on the unit inlet and outlet connections.
- Discuss drive methods and oil distribution methods used on screw compressors and describe tasks provided by the lubricant within the compressor.
- Explain how the refrigerant vapor/oil separation system operates and list the methods and benefits of oil cooling in screw compressor units.
- Discuss the beneficial uses of the side port and the operation of the screw compressor capacity reduction slide valve control system.
- Name the codes and other criteria with which ammonia refrigeration systems must comply to establish and maintain a safe work environment.

Lesson 5: Ammonia Systems Lubrication/Oil Management

Topics

Need for lubrication; Miscibility; Viscosity; Lubricants and oils; Lubricant selection, handling and management; Separators; Low-side oil recovery

Objectives

- Discuss the purposes of lubricants in ammonia systems.
- Define the terms used to describe and specify lubricants and oils and discuss the importance of the miscibility and viscosity relationships between lubricants and ammonia.
- Describe the proper methods for handling lubricants.
- Explain how oil is separated from the refrigerant vapor within the screw compressor system.
- Describe the IIAR-approved method for removing oil from the system low-side oil pots.
- Name lubricants recommended for use with ammonia systems and explain the importance of using only specified lubrication products.

Evaporators, Condensers, and Controls

Course 463: Evaporators, Condensers, and Controls
Covers gravity feed, overfeed, dump trap, CPR, and DX supply systems. Describes evaporator and evaporative condenser design, selection, and operation. Discusses various defrost systems—hot gas, electric, water, and glycol spray. Examines stop, shutoff, relief, check, solenoid, expansion, pressure-regulating, and float valves.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Liquid Ammonia Evaporator Supply Methods

Topics

Gravity feed, liquid overfeed, pumped overfeed, dump trap, controlled pressure receiver, direct expansion, and flooded liquid chiller systems

Objectives

- Explain how refrigerant flows in a thermosyphon system and describe the requirements for a surge drum in a gravity feed system.
- List the benefits of a machine room liquid recirculation unit and benefits compared to direct expansion systems.
- Describe the various level controls used in a recirculation unit and explain how the liquid refrigerant is pumped from the recirculation unit through the evaporator coils.
- Describe how a dump trap functions and how it differs from a pumped overfeed system.
- Discuss the differences between a recirculation unit and a CPR system.
- Explain how a thermal expansion valve works and why a DX coil must have more heat transfer surface than an overfeed coil.
- Describe the liquid feed and operation of flooded ammonia shell-and-tube fluid coolers.

Lesson 2: Evaporators

Topics

Evaporator operation and heat transfer principles; Tube design; Chillers; Air coils; Freezers; Ice makers; Specialty evaporators

Objectives

- Discuss basic details of evaporator operation, including the use of secondary coolant.
- List basic principles affecting evaporator heat transfer ability in DX and liquid overfeed systems.
- Discuss the reasons for coil fins and enhanced tube designs.
- Describe common DX and flooded liquid chillers.
- Discuss the construction and operation of evaporators used as air coils (coolers), including the benefits of penthouse installation.
- Describe the operation of various common kinds of freezers and ice makers.
- Explain how subcoolers, intercoolers, and thermosyphon oil coolers function as evaporators.

Lesson 3: Air Unit Defrost Systems

Topics

Reasons for defrost; Hot gas, soft hot gas, electric, water, continuous glycol spray, and room air defrost; Defrost cycle initiation and termination

Objectives

- Explain why ice and frost form on a coil and discuss the problems resulting from this formation.
- Describe the basic process of defrosting by means of hot gas from the compressor discharge.
- Explain how the soft hot gas defrost system protects large industrial coils.
- Describe common defrost methods that do not use hot gas—electric, water, continuous glycol spray, and room air.
- Describe preset timer defrost methods.

Lesson 4: Evaporative Condensers

Topics

Evaporative condenser basics and design features; Condenser selection; Condenser location; Refrigerant piping; Winter operation and capacity control; Water treatment

Objectives

- Describe the basic differences between air-cooled, water-cooled, and evaporative condensers and discuss the main operating features of each.
- Discuss the benefits of the evaporative condenser and explain why it has the lowest condensing temperature.
- Describe the design components of an evaporative condenser and explain how they work together to provide cooling.
- Discuss both the process of condenser selection and good and bad practices in locating condensers.
- Describe proper piping and equalization practices for both single and multiple condenser installations.
- Explain the need for condenser winterization and capacity control and discuss proper water treatment to control mineral and bacterial content.

Lesson 5: Control Valves and Switches

Topics

Safety relief, stop and shutoff, check, solenoid, hand expansion, pressure regulating, and float valves; Float valve switches and controllers

Objectives

- Discuss the relief valve safety requirements as specified by the ASHRAE 15 code.
- Explain why dual relief valves are used, describe proper positioning of the three-way diverting valve, and explain how to calculate relief valve flow capacity.
- Describe the functioning of the various stop valves used on ammonia systems and explain why angle valves are preferred.
- Describe the various kinds of check valves and solenoid valve uses in automatic control on ammonia refrigeration systems.
- Describe the operation and functions of the hand expansion valve and describe typical pressure regulating valve applications and methods by which the valve is controlled.
- Discuss system high-side and low-side float valve uses and describe the operation of mechanical float switches.
- Discuss the benefits of the newer electronic level controllers in the automatic control of liquid levels, safety alarms, and system shutdown procedures.

Purging, Piping, and Safety

Course 464: Purging, Piping, and Safety
Explains the effects of noncondensables on an ammonia system and the importance of their removal. Covers a wide range of piping considerations—sizing, flow rate, pressure drop, and others. Concludes with a thorough coverage of safety codes and programs, including ANSI/ASHRAE, IIAR, OSHA, and EPA information.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Purging Air and Noncondensables

Topics

Materials to be purged; Effects of noncondensables; Power penalty; Purge point locations; Automatic purging; Economics of purging

Objectives

- List common noncondensable vapors and discuss their effects in a refrigeration system.
- Discuss the power penalty resulting from noncondensable gases in terms of compression and loss of refrigeration capacity.
- Explain how to determine the presence of concondensables.
- Explain how to minimize the entrance of noncondensables and describe common entry points.
- Compare the features and operation of manual and automatic purging equipment and name the best connection points for the purge unit.
- Discuss the economic benefits of the purge unit in terms of typical payback times.

Lesson 2: Ammonia System Piping

Topics

Pressure drop in pipes; Laminar and turbulent flow; Line sizing, flow rate, suction line pressure drop, discharge line pressure charts; Special piping situations

Objectives

- Discuss the relationship between pressure drop requirements and pipe sizing.
- Discuss the factors that affect the pressure drop in a pipe.
- Explain the significance of the Reynolds number and the distinction between laminar and turbulent flow.
- Discuss the use of various kinds of line sizing charts including flow rate tables, equivalence tables for fittings and valves, and pressure drop charts.
- Explain how to select the proper suction line, discharge line, and liquid line sizing for an ammonia system.
- Discuss special piping situations that require alternative sizing or installation.

Lesson 3: Ammonia System Safety Codes and Guidelines

Topics

Codes for ammonia refrigeration systems; ANSI/ASHRAE 15-1994; ASMEB 31.5; IIAR2; IIAR bulletin 111; IIAR bulletin 112

Objectives

- Describe the basic differences between ASHRAE and ASME codes and IIAR standards and guidelines.
- Discuss several main points in the ASHRAE 15-1994 safety code for mechanical refrigeration.
- Describe code requirements based on the occupancy classifications, leak probability classifications, and refrigerant characteristic classifications.
- Describe several requirements in the ASME B 31.5 refrigeration piping code concerning the materials and fabrication of refrigeration piping systems.
- Name several safety requirements specified by IIAR 2 for ammonia refrigeration equipment.
- Describe the kinds of information provided by IIAR bulletins.

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Lesson 4: OSHA Process Safety Management

Topics

OSHA regulations; PSM requirements; Estimation of ammonia inventory; PSM plan development; Process safety information, hazard analysis; Standard operating procedures; Contractor procedures

Objectives

- Discuss the purposes of Process Safety Management and describe the thirteen elements that make up PSM.
- Describe the process for estimating a plant's ammonia inventory and establishing a plant ammonia library and explain why each is needed.
- Discuss the personnel and steps involved in developing a PSM plan for a specific refrigeration plant.
- Describe the process hazard analysis (PHA) and explain how it can reduce the likelihood of ammonia accidents and spills.
- Describe the requirements for preparing standard operating procedures (SOPs) for all normal plant service, repair, and maintenance.
- Discuss contractor responsibilities for PSM.
- Discuss the importance of management-of-change procedures in keeping paperwork up to date.

Lesson 5: EPA Regulations and Ammonia Safety

Topics

40 CFR 68; Worst case/alternate ammonia release scenario; Elements in common with OSHA PSM; Penalties for nonconformance

Objectives

- Describe the purposes of the EPA Risk Management Plan and compare it to the OSHA Process Safety Management program.
- Explain the reasoning behind the dual hazard assessment requirements of a worst-case ammonia release and the more practical alternative ammonia release.
- Discuss the toxic end point criteria for an ammonia release and distinguish between rural and urban end points and differences in requirements.
- Discuss the importance and difficulties of presenting the required release data and plan to the community.
- Discuss the hazards of working with ammonia and the importance of using personal protective equipment to avoid or minimize the effects of an ammonia release.
- Describe correct first aid procedures pertaining to contact with ammonia vapor and liquid.

Introduction to Carpentry

Course 361: Introduction to Carpentry
Gives the new trainee a grasp of the basics of carpentry. Aims to familiarize persons who have had no carpentry experience with the tools and materials of the trade. Covers specifications, estimating procedures, codes, and how to read prints and plans.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Layout and Hand Tools

Topics

Safety clothing, accessories, and equipment; Layout tools; Framing square; Chalk box and line; Vises and clamps; Hand tools

Objectives

- Identify the safety equipment that a carpenter should wear to protect his eyes, hands, and feet.
- List the twelve common layout tools mentioned in this lesson.
- Describe how to check the accuracy of a framing square.
- Tell how you would acquire the hand tools you need as a carpenter trainee.
- Point out the features that you'd look for when buying your own toolbox.

Lesson 2: Carpenter's Power Tools

Topics

Power tool safety; Circular, saber, and reciprocating saw; Power drill and plane; Routers; Sanders; Nailers and tackers; Powder-actuated tools

Objectives

- List the twelve safety rules for power tools mentioned in this Lesson.
- Explain how to mount a new blade properly in a circular saw.
- Tell how to start and finish a cut with a circular saw.
- Describe how to drill wood safely with a power drill.
- Tell how to shape an edge with a router.
- Identify the three steps involved in sanding a surface with a finishing sander.

Lesson 3: Lumber, Wood Products, and Fasteners

Topics

Hardwood vs softwood; Lumber sizing, grades, and defects; Moisture content; Millwork; Plywood; Hard and particle board; Storage; Nails; Screws

Objectives

- Describe the difference between the actual and nominal dimensions of lumber.
- Tell how defects such as checks, knots, and warping limit the value and use of lumber.
- Explain how kiln drying of lumber produces different results from air drying.
- Point out the differences between solid core and veneer core plywood.
- Describe the construction and uses of particleboard.
- Compare common nails, casing nails, and finishing nails.
- List the information you must give your supplier when ordering wood screws.

Lesson 4: Estimating Carpentry Costs

Topics

Ordering materials; Reducing and using waste material; Bill of materials; Preparing a cost estimate; Tips for organizing a task

Objectives

- Explain the difference between a board foot and a linear foot of lumber.
- Describe the relationship between a bundle and a square of roofing shingles.
- List the information contained in a bill of material.
- Name the factors you need to prepare a cost estimate for labor on a job.
- Point out some of the things you must do before beginning a job, so the work goes smoothly.

Lesson 5: Plans, Specifications, and Codes

Topics

Reading drawings; Dimensions on drawings; Symbols in drawings; Equipment schedules; Building codes and permits; Zoning laws

Objectives

- Name the features of a building that you'll find in the plan and elevation views.
- Demonstrate how to use an architect's scale and a draftsman's scale.
- List at least four building features whose details are contained in the specifications.
- Explain why building codes are necessary in the construction industry.
- Describe the information you must submit to obtain a building permit.

Constructing the Building Shell

Course 362: Constructing the Building Shell
Covers basic building techniques common to most structures, including methods of laying foundations, framing, covering walls, and roofs.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Footings, Foundations, and Forms

Topics

Laying out building lines; Levels; Batterboards; Grading; Excavating; Footings; Concrete; Foundation walls; Waterproofing concrete

Objectives

- Demonstrate how to lay out a right angle without using instruments.
- Explain how to set up batterboards and building lines for an excavation.
- Tell what you can do to assure your own safety when working around an excavation.
- Describe how to erect a form for a concrete footing.
- Show how to mix a small batch of concrete using the "bottomless box."
- Describe how to prevent concrete slabs from cracking.

Lesson 2: Framing the Structure

Topics

Common framing method; Mounting the sill; Floor joists; Cantilever framing; Subflooring; Framing walls; Cross bracing; Wall sheathing

Objectives

- Demonstrates how to lay out anchor bolt holes in sills.
- Describe the two methods of framing a cantilever.
- Compare cross bridging and solid bridging between floor joists.
- Explain how to construct and erect an inner stud wall.
- Tell why carpenters prefer to use plywood for sheathing walls.

Lesson 3: Framing the Roof with a Framing Square

Topics

Roof designs; Rafter layout; Pitch and slope; Framing square; Estimating, laying out rafters; Setting frame in place; Roof trusses; sheathing

Objectives

- Point out differences in heel, plumb, and seat cuts in a rafter.
- Identify the information printed on the face and back of a framing square.
- Explain how to use a framing square to determine the line length of a rafter.
- Describe how to lay out studs for a gable end.
- Tell how to determine the length of hip rafters.

Lesson 4: Installing Windows and Exterior Doors

Topics

Types of windows and sashes; Glazing; Heat gain/loss; Window unit and glass installation; Door jamb construction; Hinges; Hanging a door

Objectives

- Explain how awning-type and hopper-type casement windows differ in operation.
- Name three or four of the common glazings and tell the advantages of each.
- List the critical dimensions for preparing and installing window units.
- Describe how to install a window unit.
- Tell how to mount a fixed glass in a picture window.
- Explain how to install mortise hinges on a door, and hang the door in the jamb.

Lesson 5: Installing Roofing and Siding

Topics

Roofing materials; Built-up roofing; Shingles; Flashing; Valleys; Capping a roof; Cornices; Wood, other-than-wood, shingled, and vertical siding

Objectives

- Explain how a built-up roof is constructed.
- Give some of the safety precautions to follow when working with hot tar.
- Describe how to apply asphalt shingles to a roof.
- Tell how to estimate the amount of roofing required for a building.
- Tell how to estimate the amount of roofing required for a building.
- Describe how to use a story pole in the application of wood siding to a building.
- Explain how to install cornerboards for exterior trimming.

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Finishing the Building Interior

Course 363: Finishing the Building Interior
Covers constructing stairways, installing doors, and finishing procedures. Emphasizes interior walls, ceilings, and floors.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Interior Walls and Ceilings

Topics

Plasterboard construction and application; Fastening and cutting plasterboard; Corners and edges; Drywall construction and taping; Paneling; Plaster and masonry walls; Suspended tile ceilings

Objectives

- Explain how to fasten single-ply plasterboard panels to the stud framing for interior walls.
- Describe the three-step procedure for cementing and taping drywall construction.
- Name the advantages of a drywall system that uses metal studs.
- Explain how to install interior plywood paneling.
- Differentiate between the three coats of plaster required for plaster wall construction.
- Identify the main parts of the framing system for suspended tile ceilings.

Lesson 2: Laying Flooring

Topics

Concrete and wood floors; Finishing and prefinished wood floors; Underlayment; Resilient floor coverings; Ceramic tile; Wood decking

Objectives

- Tell the differences between strip, block, and plank flooring.
- Explain how to lay flooring strips, keep them straight, and make adjustments when they are not straight.
- Tell how to plan and make a careful layout for installing a wood block floor.
- Give the sequence of sanding operations for a newly installed wood strip floor.
- Name the materials you can use for underlaying a resilient or ceramic floor.
- Explain how to lay a tile floor with the tile veneer method.

Lesson 3: Stair Construction

Topics

Prefab stairs; Stairway parts, framing; Determining the height of risers, width of treads, run of stairway, and length of stringers; Railings

Objectives

- Describe some of the common stairway configurations: open, closed, L-shaped, U-shaped, etc.
- Starting with the stringers, name all the parts in a stair assembly.
- Explain how to use a story pole to check stair calculations.
- Tell how to anchor a flight of stairs.
- Name the guidelines for constructing handrails or railings in stairways.

Lesson 4: Interior Doors and Door Jambs

Topics

Hinge construction, operation, and installation; Constructing a door jamb; Installing doors; Locking devices for doors

Objectives

- Explain how hollow-core, fiber-core and solid-core doors differ in construction.
- Tell how to remove a door hung on hinges with fixed pins. Also with loose pins.
- Give the guidelines for placing three hinges on the edges of a door.
- Describe how to install a single-swing door.
- Differentiate between pocket-type and bypass-type sliding doors.
- Name a few of the types of locks used on interior doors.

Lesson 5: Installing Interior Trim

Topics

Types of molding; Joints; Using a miter box; Installing door trim, window trim, and baseboards

Objectives

- Differentiate between a base shoe molding and a baseboard molding.
- Give the uses of cove, crown, and half-round moldings.
- Describe how to make a scarf joint and coped joint.
- Demonstrate how to cut a 45° miter with a miter box.
- Tell how to install the casing around a door opening
- Explain how to construct the interior casing for a window.

Structural Painting

Course 364: Structural Painting
Covers the techniques of selecting and applying paints and coatings to buildings, inside and out. Describes the composition of paints and other coatings, and how to use brushes, rollers, spray guns, and other tools of application. Also describes how to prepare new and existing surfaces for coating, and explains the easiest, most successful techniques of application.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Paint Selection for Normal Conditions

Topics

Ingredients and types of paints; Coating selection; Substrate; Ferrous and nonferrous metals; Concrete; Wood; Environmental conditions

Objectives

- Explain the three basic reasons for using paint.
- Identify the ingredients of paint and explain the importance of each.
- Name several generic paint types and describe their uses in normal industrial applications.
- Compare the characteristics of ferrous and nonferrous metals, concrete, and wood as substrates.
- Discuss environmental factors that influence paint choices.

Lesson 2: Coatings for Extreme Conditions

Topics

Corrosion; Galvanic coupling; Storage tanks; Waste-treatment, chemical, food, and beverage plants; Safety markings; Pipe identification

Objectives

- Give at least four examples of extreme workplace conditions.
- Explain the electrochemical process of corrosion and its effect in a galvanic coupling.
- Identify some paint types used for storage tanks and in waste-treatment plants.
- Discuss coatings appropriate for chemical plants and various areas of food and beverage plants.
- Explain the meaning of the colors used in the standard safety and piping codes.

Lesson 3: Painting Tools

Topics

Brushes; Rollers; Spray application; Air spray guns; Airless sprayers; Blasting equipment; Abrasives; Testing; Inspection

Objectives

- Describe the different types of paint brushes.
- Explain the uses of different roller constructions and different lengths of roller nap.
- Discuss the various types of spray equipment.
- Compare the different types of blasting equipment and the abrasives used with them.
- Explain how film gauges, holiday detectors, and surface profile devices work.

Lesson 4: Surface Preparation

Topics

SSPC and NACE standards; Chemical cleaning; Cleaning with hand, power tools; Abrasive blasting; Concrete prep; Special surfaces

Objectives

- Discuss the importance of correct surface preparation and compare SSPC and NACE standards.
- Compare the various methods of chemical cleaning.
- Name the hand tools and power tools used for cleaning.
- Explain the characteristics and applications of the different grades of abrasive blasting.
- Describe surface preparation techniques for concrete, galvanized metal, wood, mildewed surfaces, and chain-link fencing.

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Lesson 5: Painting Techniques

Topics

Mixing and thinning; Brush, roller, and spray application; Blasting; Coating failure; Calculating coverage; Follow up; Records

Objectives

- Describe correct mixing and thinning methods.
- Point out the dos and don'ts of brush and roller usage.
- Explain how to use and troubleshoot spray equipment correctly and how to set up blasting equipment.
- Discuss the causes of common coating failures and explain how to prevent them.
- Calculate estimated coverage and keep satisfactory records.

Lesson 6: Ground and Aerial Supports

Topics

Safety rules; Using ladders; Scaffold planking, Ropes and cables; Stationary and portable scaffolds; Rigging safely; Lifelines

Objectives

- Explain the importance of attitude in preventing injury, and how heat, cold, wind, and heights can be dangerous.
- Compare different types of ladders and tell how to use them safely.
- Discuss stationary scaffolding and accessories.
- Describe boom and scissors lifts and tell how to use them safely.
- Compare bosun's chairs, work cages, and swinging scaffolds and platforms.
- Point out safety measures necessary when using cable-supported or suspended units.

Lesson 7: Handling Hazardous Materials Safely

Topics

Fire hazards; Explosives; Fire prevention; Health hazards; Toxic, dermatic materials; Respiratory protection; Protective clothing; MSDS

Objectives

- Explain how painting materials cause fire or explosions and tell how to reduce these hazards.
- Define six categories of health hazards and name ways to avoid them.
- Give examples of toxic and dermatitic painting materials and explain the purpose of threshold limit values.
- Compare types of respirators and their uses, and list the rules for working safely in confined spaces.
- Describe appropriate uses for safety clothing and tell how to use an MSDS.

Flat Roof Maintenance

Course 366: Flat Roof Maintenance
Introduces roofing, including flat roof systems and various types of decks. Examines insulating and water-proofing materials, and techniques of application. Discusses roofing damage, how to repair roofs, and how to make a proper roof inspection. Explains types of preventive maintenance, how to plan preventive maintenance, and how to select the proper materials to use.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Introduction to Flat Roof Systems

Topics

Structural deck; Wood, concrete, and steel decks; Vapor barrier; Thermal insulation; Waterproofing materials; Aggregate; Flood coats; Walkways

Objectives

- Name and define the four basic components that make up a flat roof system.
- Explain the differences among a pre-stressed concrete deck, a pre-cast deck, and a reinforced deck.
- Explain the functions of a vapor barrier.
- Tell why thermal insulation is applied above deck in some applications, and below deck in others.
- List three benefits of coating a flat roof with aggregate or crushed slag.

Lesson 2: Roof-Related Components

Topics

Base and counter flashings; Flashings for vents; Irregular roof penetrations; Expansion joints; Drainage systems; Parapet walls; Scuppers

Objectives

- Explain how a base flashing and a counter flashing work together to protect a roof.
- Tell how and why a hot vent is usually flashed differently from a cold vent.
- Name three roof conditions that make it necessary to install expansion joints.
- Describe how the components of a flat roof drainage system work together
- Tell how to keep moisture out of parapet walls.

Lesson 3: Causes of Common Roof Problems

Topics

Roofing membrane failure; Bare spots; Blisters; Punctures; Splits; Dirt and debris; Alligatoring; Installation problems; Ponding; Damp insulation

Objectives

- Describe the causes of blisters, bare spots, and punctures.
- Explain how dirt and debris create maintenance problems on flat roofs.
- Name the most common reasons for vent flashing failure.
- List the steps to take to prevent water from ponding on a flat roof.
- Tell how to set heavy equipment on a flat roof without damaging the membrane.

Lesson 4: Roof Inspection

Topics

Selecting an inspector; Making the inspection; Hidden trouble; Moisture in the roof

Objectives

- Tell what a roofing bond or guarantee usually covers and doesn't cover.
- List the materials and information that a roof inspector should have for his guidance.
- Describe two ways of telling whether the roofing bitumen is asphalt or coal tar.
- Explain how water can seep through roof penetrations, pitch pockets, and parapet walls.
- Describe a simple means for measuring the moisture content in a roof system.

Lesson 5: Preventive Maintenance and Repair

Topics

Maintaining the roofing membrane; Flashings, pitch pockets, drains, gutters, and parapet walls; Emergency repairs; Snow and ice; Safety

Objectives

- Name the basic materials that should be stocked for making roof repairs.
- Tell how to repair a split membrane if sealing tape isn't available.
- Describe how to repair a hole in a base flashing.
- Explain how moisture can cause a parapet wall to crack and crumble.
- Explain how to channel a roof leak to a floor drain.
- Describe how to use tools, ladders, and hoists safely when repairing roofs.

Lesson 6: Single-Ply Roofing

Topics

Thermoplastic polymers; Elastomers; Modified bitumen; Roof-laying methods; Installation and maintenance; Inspection checklist

Objectives

- Name and describe the three types of single-ply roofing materials.
- Detail the roof-laying methods used with each of these types.
- Identify actions that would void a typical roof warranty and explain why it is important to keep the warranty in effect.
- Explain the six key points that should be checked in the inspection of a single-ply roof.

Plumbing Systems Maintenance

Course 367: Plumbing Systems Maintenance
Covers maintaining plumbing systems in a factory, plant, or other industrial or commercial site. Describes the structure and function of on-site plumbing systems (water supply, sanitary waste, and storm water), and explains how the major fixtures in these systems work. Tells how to take care of common plumbing problems.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Introduction to Plumbing

Topics

Codes and standards; Stacks; Traps; Connection methods; Sewer system; Venting system; Plumbing fixtures; Water supply and distribution

Objectives

- Describe a basic plumbing system.
- Name the parts of a DWV system and explain their functions.
- Explain the purpose of the different elements in an industrial cold water supply and distribution system.
- Describe a basic system for industrial hot water supply and distribution.
- Describe three basic systems for boosting in coming water pressure.

Lesson 2: Plumbing Fixtures

Topics

Water closets; Leaks and stoppages; Urinals; Lavatories; Trim and faucets; Sinks; Showers; Drinking fountains

Objectives

- Describe six lavatory categories and compare the different flushing systems used in water closets and urinals.
- Explain the operation of different types of faucets.
- Give examples of industrial showers, sinks, and drinking fountains.

Lesson 3: Sanitary Drainage Systems

Topics

Materials used; Fittings and joints; Piping; Subdrains; Floor drains; Leaks; Stoppages; Indirect wastes; Cleanouts

Objectives

- State the function of sanitary drainage systems and describe the materials, fittings, and joints used in them.
- Discuss the installation and connection of the piping components of a sanitary drainage system.
- Explain the purpose of floor drains and cleanouts, and where they are needed.
- Tell how to repair leaks and clear stoppages in sanitary piping.

Lesson 4: Vent Systems

Topics

Pipe materials, fittings, and joints; Piping; Fixture trap vents; Types of vents; Vent terminals

Objectives

- List the components of a vent system and explain their functions.
- Discuss the materials used for vent pipes, fittings, and joints.
- Explain the importance of air pressure and water flow in DWV systems.
- Discuss the requirements for the installation of piping in a vent system.
- Describe several types of vent system and their applications.

Lesson 5: Storm Water Drainage

Topics

Materials; Fittings and joints; Piping; Subdrain system; Site drainage system; Roof drains; Expansion and contraction; Subsoil drainage

Objectives

- Explain the function and installation of the elements in storm water and site drainage systems.
- Name the materials, fittings, and joints used in storm water and site drainage systems.
- Describe how the piping components of storm water and site drainage systems should be installed.
- Compare six different roof drains and give details of their installation.

Lesson 6: Potable Water Distribution

Topics

Materials, fittings, and joints; Pressure and velocity; Hydraulic shock; Limiting flow and pressure; Pressure-boosting systems; Contamination

Objectives

- Tell how the separate components of a potable water distribution system work together in its operation.
- List the materials suitable for use in a potable water system, the fittings used with them, and the factors to be considered in selecting them.
- Discuss the effects of water pressure and flow in a potable system.
- Give installation details for piping and valves in a potable eater system.
- Explain how a potable water system can be contaminated and how contamination can be prevented.

Lesson 7: Hot Water Distribution

Topics

Materials, fittings, and joints; Water heaters; Safety requirements; Circulation; Temperature; Expansion and contraction

Objectives

- Explain the selection of materials and the installation of components for a hot water system.
- Describe the operation and application of different water heaters.
- Explain the safety requirements for hot water tanks and heaters.
- Describe a hot water circulation system, tell when it must be installed, and explain the advantages of strip heaters.
- Tell how water temperature affects the equipment and layout of a hot water distribution system.

Lesson 8: Valves

Topics

Gate, globe, check, quarter-turn, plug, ball, and butterfly valves; Materials; Applications

Objectives

- Compare the function and applications of plumbing system valves.
- Tell how the main types of valves end connections.
- Compare the different types of valve end connections.
- Name the factors to be considered in the selection of materials for valves.

Lesson 9: Piping Assembly Procedures

Topics

Cast iron soil piping; Brass, steel piping; Wrenches; Copper tubing; Plastic piping

Objectives

- List three joints used in iron piping and tell how to make them.
- Explain how to assemble screwed and flanged joints in brass and steel piping.
- Give example of the proper use of different pipe wrenches and vises.
- Tell how to assemble copper tubing with soldered, compression, and flared joints.
- Review the procedures for making joints in PVC and CPVC piping.

Lesson 10: Maintaining Plumbing Systems

Topics

Maintaining fixtures, water heaters, and waste systems; Opening clogged drains; Maintaining valves; Insulation; Leak repair

Objectives

- Name the chief points involved in the care and correct use of hand tools.
- Describe how to open the clogs and repair leaks in plumbing fixtures.
- Compare maintenance procedures for different types of valves.
- Tell how to clear stoppages and repair leaks in the drainage system.
- Explain the maintenance of water heaters, pumps, and pipe installation.

Locks and Key Systems

Course 374: Locks and Key Systems
Covers basic lock types: mortise, auxiliary or rim, tubular bolt, key-in-know, narrow stile, and unit lock. Explains how they operate, how to install, maintain, and adjust them. Also describes key control, master key systems, panic bars, and other accessories for building security.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Commonly Used Doors and Locks

Topics

Terminology of locks and doors; Levels of building security; Mortise, auxiliary, tubular bolt, key-in-knob, unit, and narrow-stile locks

Objectives

- Use standard lock and door terminology.
- Differentiate between right-hand and left-hand doors, and between hollow-core and solid-core doors.
- List four different types of hinges.
- Explain installation procedures for full-mortise, half-mortise, full-surface , and half-surface hinges.
- Identify the mortise lock, auxiliary lock, tubular bolt lock, key-in-knob lock, unit lock, and narrow-stile lock.

Lesson 2: How Locks Operate

Topics

Mortise lock mechanisms and installation; Rim spring-bolt locks; Jimmy-resistant locks; Tubular-bolt and key-in-knob lock installation

Objectives

- Describe how a mortise lock mechanism works.
- Tell what operations are involved in installing a mortise lock.
- Compare the functions of rim spring-bolt locks, rim bolt locks, and jimmy-resistant locks.
- Diagram the construction of a tubular bolt lock.
- Explain how key-in-knob locks, unit locks, and narrow-stile locks operate.

Lesson 3: Installing Locks

Topics

Installing the mortise, auxiliary, tubular bolt, key-in-knob, unit, and narrow-stile lock; Lock tools

Objectives

- Explain how to position a mortise lock with the proper setback for installation.
- Describe installation procedures for an auxiliary lock, tubular bolt lock, key-in-knob lock, unit lock, and narrow-stile.
- List the tools needed to install locks.

Lesson 4: Maintaining and Adjusting Locks

Topics

Lock problems, disassembly; Opening a cylinder with and without a key; Cleaning lock mechanisms; Lubrication; Misalignment; Settling

Objectives

- Describe how lock problems can develop.
- List preventive maintenance practices that promote good lock function.
- Describe the process of opening a cylinder both with and without a key.
- Tell how to clean and lubricate lock mechanisms.
- List common problems with bolts and latches and their remedies.

Lesson 5: Key Control and Master Key Systems

Topics

Advantages and disadvantages of master keying; Alternatives; Key control; Record keeping; Key storage and tagging; Other access control systems

Objectives

- Describe how a master key system operates.
- List the advantages and disadvantages of master keying.
- Differentiate between the maison system, keyed-alike system, and sectional system.
- List the information that must be included in the security survey plan, key progression chart, and key issuance files.
- Identify other access control systems, such as card-key systems, electronic systems, and push-button locks.

Landscaping Maintenance

Course 375: Landscaping Maintenance
Covers the major features of landscaping maintenance, from the basics of how plants develop to recognizing diseases and parasites. Details the selection and care of trees, ground covers, flowers, and grasses.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Basic Plant Care

Topics

Plant structure; Organic matter in soils; Acidity, alkalinity of soils; Macronutrients; Micronutrients; Soil temperatures

Objectives

- Explain the importance of understanding and using a uniform plant identification system, and name the classifications into which plants are grouped.
- List six essentials of plant life.
- Describe the pH scale and tell how the acidity or alkalinity of a soil affects plant growth.
- Tell how to recognize the symptoms of overwatering and underwatering.
- Name at least four nutrients plants need, explain why is needed, and tell how to recognize a lack of overabundance of each.

Lesson 2: Shade Trees

Topics

Tree shapes, sizes, textures, and colors; Hardiness; Growth rate; Handling and transporting nursery stock; Storing, planting, watering, and pruning trees

Objectives

- Give examples of the following: course-textured, medium-textured, and fine-textured trees.
- Describe the three ways in which nursery stock is normally offered for sale.
- List and explain the five steps involved in planting a landscape tree.
- Tell why trees may require pruning and describe the two basic pruning cuts.
- Summarize the safety rules that apply when doing tree maintenance work.

Lesson 3: Turf Management

Topics

Cool and warm season grasses; Mowing, fertilizing, and watering; Light and shade; Seeding, sodding, plugging, sprigging, and stolonizing; Pests and weeds

Objectives

- Tell how lawns and grass plants differ from other types of landscape plants.
- Define and give examples of cool season grasses and warm season grasses.
- Discuss the importance of proper mowing.
- List three things to keep in mind when watering turf.
- Describe how to establish turf by plugging and discuss the advantages and disadvantages of this method.

Lesson 4: Shrub and Flower Care

Topics

Characteristics and types of shrubs; Hedges; Planting, care of shrubs; Ground cover; Vines; Flowers; Annuals; Biennials; Perennials; Bulbs

Objectives

- List several things to consider when selecting shrubs.
- Explain the different kinds of pruning required by different kinds of shrubs—for example, spring-flowering shrubs, roses, narrow-leafed evergreens, and hedges.
- Explain how to plant and care for vines.
- Name and define the three classes into which flowers fall.
- Give several examples of hardy bulbs and tender bulbs and compare and contrast the methods of care each requires.

Lesson 5: Pest and Disease Control

Topics

Viruses, bacteria, fungi, insects, galls, and weeds; Pesticides; Spraying equipment; Other equipment for pest and weed control; Safety

Objectives

- Recognize fungi and the symptoms of bacteria disease and tell how to control them.
- Identify several living things that help control insects.
- Name several different kinds of pesticides and the ways in which they work.
- Explain the different kinds of pesticides and the ways in which they work.
- List several things to consider when choosing where each is used.
- Describe some of the many forms in which pesticides come and ways in which they are applied.

Cleaning Chemicals

Course 451: Cleaning Chemicals
Covers the safe use of cleaning chemicals, including the OSHA Hazard Communication standard. Covers the basic chemistry of cleaning chemicals, then explains the correct use of detergents, soaps, solvents, disinfectants, and other cleaning chemicals. Explains how chemicals are packaged, labeled, mixed, and applied in order to make working with chemicals safer and the trainee more efficient.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Using Chemicals Safely

Topics

OSHA Haz Com standard; MSDSs; Chemical hazards; Exposure routes; Controlling chemical hazards; Detecting exposure

Objectives

- Identify the goals of the Hazard Communication Standard and the agency responsible for writing and enforcing the standard.
- Explain the purpose and basic content of an MSDS.
- Give examples of the health hazard information contained in MSDSs and how it is used.
- Give examples of the physical hazard information contained in MSDSs and how it is used.
- Describe typical MSDS instructions on special precautions and procedures.
- Define chemical hazard and name the two categories into which they are divided.
- Name and describe the six kinds of health hazards.
- Name the three basic routes of health hazard exposure.
- Discuss common methods of controlling chemical hazards.
- Explain how to detect exposure hazards and symptoms.

Lesson 2: Introduction to Cleaning Chemicals

Topics

Cleaning chemicals, agents; Disinfectants; Selecting a product; Correct product use

Objectives

- List the three kinds of cleaning chemicals.
- Explain the advantages and disadvantages of soaps.
- Compare and contrast soaps and detergents.
- Tell what protective equipment is required when working with solvents.
- Explain how solvent and abrasive cleaners work.
- Describe the purpose of a disinfectant.
- List the important factors to consider when selecting a cleaning product.
- Tell where to find information about correct product usage.

Lesson 3: Cleaning Agents

Topics

Physical and chemical characteristics of cleaning agents; General-purpose cleaners; Strippers; Degreasers; Shampoos; Product selection

Objectives

- Name the chemicals in cleaning agents that dissolve grease and oil.
- Name and describe the four most important detergency processes.
- Define penetration, suspension, and viscosity as characteristics of cleaning agents.
- Tell how cationic soaps and detergents differ from anionic soaps and detergents.
- Name an advantage and a disadvantage of a multi-duty cleaners.
- Tell why wetting agents are used in degreasers.

Lesson 4: Disinfectants

Topics

Microorganisms; Controlling germs; Disinfectants; Product information; Preparing products for use; Cleaning and disinfecting

Objectives

- Define the term pathogenic.
- List four kinds of microorganisms capable of causing disease.
- Explain the difference between cleaning and disinfecting.
- List three factors that make killing germs a difficult task.
- Define the terms sanitization, disinfection, and sterilization.
- State an advantage and a disadvantage for each of the main kinds of disinfectant.
- Explain why it is important to follow product dilution information carefully.

Lesson 5: Special-Purpose Cleaning Chemicals

Topics

Bowl cleaner; Glass cleaner; Absorbents; Dust control chemicals; Furniture and metal polish; Hand soaps; Drain cleaners; Deodorants

Objectives

- Explain why it is necessary to use an acid bowl cleaner on toilets and urinals.
- List the characteristics of a good glass cleaner.
- Explain the purpose of absorbents.
- Explain where and why dust control chemicals are used.
- Give three reasons for using furniture polish on unsealed wood.
- List the properties of a good hand cleaner.
- Describe the necessary precautions to take when using drain cleaners.
- Name the three common forms of room deodorant.

Floors and Floor Care Equipment

Course 452: Floors and Floor Care Equipment
Covers many different kinds of floors and flooring materials in use in many locations. Covers a variety of powered floor care equipment, explaining how to operate each device safely and efficiently. Explains how and why to use floor machines and vacuum cleaners and their various attachments. Also covers the use and maintenance of autoscrubbers, powered sweepers, pressure washers, and sanders.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Kinds of Flooring

Topics

Resilient, natural hard, synthetic hard, and wood flooring; Special floorings

Objectives

- Tell how to identify the common resilient floorings, and explain the characteristics of each.
- Name the common natural hard floorings, and explain the characteristics of each.
- Explain how synthetic hard flooring is formed and installed.
- Explain why wood floors must be cleaned with care.
- List the main features of cork flooring.
- Explain where and why iron and steel, conductive, and pedestal floors are used.

Lesson 2: Floor Machines

Topics

Machine size and speed; Distribution of machine weight; Machine parts and attachments; Operation and care

Objectives

- Identify which size floor machine to use for various floor areas.
- Tell which speed range is best for scrubbing, stripping, buffing, and shampooing.
- Explain the relationship between electric motor horsepower ratings and machine size.
- Describe the function and operation of the transmission in a floor machine.
- Explain how to install pads, pad holders, and brushes on a floor machine.
- List the step-by-step operation and maintenance procedures for floor machines.

Lesson 3: Vacuum Cleaners

Topics

Dry-tank, wet/dry, upright, and backpack vacuum cleaners; Vacuum cleaner operation and care

Objectives

- Explain the basic operating principle of a vacuum cleaner.
- Describe the four most widely used types of vacuum cleaners and their main parts.
- Identify which machine to use for a particular vacuuming task on a particular surface.
- List common vacuum attachments, and tell when each is used.
- Explain the step-by-step operation and maintenance procedures for the four types of vacuum cleaners.

Lesson 4: Automatic Scrubbers

Topics

Autoscrubber types, drives, power sources, and controls; Preparing for use; Operating, cleaning, and maintaining autoscrubbers

Objectives

- Name the three pieces of equipment contained in a single autoscrubber unit.
- Name the different types of drives, power sources, and controls that a typical autoscrubber has, and explain how each functions.
- Explain when and where not to use an autoscrubber.
- List the step-by-step procedures for preparing an autoscrubber to dry vacuum, dry buff, dry buff and dry vacuum, wet vacuum, wet scrub, wet scrub and wet vacuum, and strip.
- Tell how to clean and maintain an autoscrubber.

Lesson 5: Other Powered Equipment

Topics

Powered sweepers; Vacuum sweepers; Pressure washers; Floor sanders

Objectives

- Describe the three different types of powered sweepers and tell where to use each one.
- Name the three sources of power for powered sweepers, and describe the advantages and disadvantages of each.
- Identify which powered sweeper is best to use in a particular size area, surface, and type of soil.
- Explain the uses and advantages of pressure washers, and explain how they work.
- Describe the different kinds of floor sanders, and explain how to operate a floor sander.
- Tell why you need an edger when sanding wood floors.

Maintaining Floors and Other Surfaces

Course 453: Maintaining Floors and Other Surfaces
Covers the tasks involved in the daily, routine maintenance of floors. Lists floor coatings and uses. Explains periodic floor care tasks step-by-step, telling which particular methods to use on the various floors and floor coverings within buildings. Covers floor care problems trainees are likely to encounter. Concludes with a lesson on the cleaning of walls, windows, furniture, and other above-the-floor surfaces.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Routine Floor Care Tasks

Topics

Removing dry dirt; Wet cleaning; Disinfecting; Buffing

Objectives

- Calculate the area of a floor.
- Explain why it is important to remove dry dirt before wet cleaning.
- Name the four methods for removing dry dirt and tell when each is used.
- Name the three kinds of mopping (wet cleaning) and tell when each is used.
- Explain how to clean a floor using an autoscrubber.
- Explain why pressure washing sometimes does a better job of cleaning floors than scrubbing does.
- Describe the process of disinfecting a floor.
- Explain how to dry buff and spray buff a floor using a floor machine.

Lesson 2: Floor Coatings

Topics

Strippers; Floor finishes; One-step floor care; Testing a floor finish

Objectives

- List four reasons floors need coatings.
- Name the two kinds of floor strippers and tell when each is used.
- Describe the precautions that you must take when using solvent-base strippers.
- Explain the purposes of floor sealers.
- Tell why it is important that a sealer and finish have the same kind of base.
- List the properties of a good floor finish.
- Explain how to test and evaluate a floor finish.

Lesson 3: Periodic Floor Care Tasks

Topics

Scrubbing; Stripping; Etching; Screening; Sanding; Sealing; Refinishing; Safety

Objectives

- List the equipment needed and describe the procedures used for scrubbing.
- List the equipment needed and describe the procedures used for stripping various floor coatings from different kinds of floors.
- Describe the processes of etching, screening, and sanding, and explain why each is used.
- Tell when to use water-base sealers and when to use solvent-base sealers, and explain how each is applied.
- Name the three basic types of floor finishes and tell how each is applied.
- Explain at least three safety points to remember when refinishing floors.

Lesson 4: Choosing a Floor Care Method

Topics

Resilient, natural hard, synthetic hard, wood, cork, iron, and steel flooring; Conductive floors; Pedestal floors; Production floors

Objectives

- Describe the procedures and name the chemicals used for routine and periodic maintenance of resilient flooring.
- Describe the procedures and name the chemicals used for routine and periodic maintenance of concrete, terrazzo, marble, and other natural hard flooring.
- Describe the procedures and name the chemicals used for routine and periodic maintenance of synthetic hard flooring.
- Describe the procedures and name the chemicals used for routine and periodic maintenance of wood and cork flooring.
- Describe the procedures and name the chemicals used for routine and periodic maintenance of iron and steel flooring.
- Describe the procedures and name the chemicals used for routine and periodic maintenance of conductive and pedestal floors.

Lesson 5: Floor Care Problems

Topics

Problems with resilient flooring, hard flooring, and wood flooring; Adjusting conductive floors; Stains

Objectives

- Identify resilient flooring problems and explain how to avoid and correct them.
- Describe problems encountered in the refinishing of resilient flooring and tell how to avoid and correct them.
- Identify hard flooring problems and explain how to avoid or correct them.
- Define warping and tell how to avoid it.
- Explain how to adjust the conductivity of conductive floors.

Lesson 6: Other Cleaning Tasks

Topics

Emptying trash; Dusting; Cleaning lights; Washing walls; Caring for wood furniture; Washing windows, mirrors; Cleaning drinking fountains; Maintaining kitchens

Objectives

- Explain the procedures for emptying trash cans and ashtrays, and tell why it is important to empty them daily.
- Describe the tools you need for dusting, and list the reasons why dusting is important.
- Discuss the cleaning procedures for lamps and lighting fixtures, drinking fountains, and wooden furniture.
- Describe the two methods for washing walls, and tell when to use each method.
- Explain how to keep a chalkboard clean.
- List the steps in cleaning a kitchen.

Rest Room Care

Course 454: Rest Room Care
Covers the fundamentals of rest room design and construction and the elements of routine rest room cleaning. Covers the specifics of cleaning rest room plumbing fixtures. Describes the periodic tasks required to keep rest rooms in good condition. Finally introduces the trainee to the topic of disinfection, its important in rest rooms, and methods of performing this task safely.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Rest Room Basics

Topics

Rest room floors, walls, and ceilings; Plumbing fixtures; Sinks; Toilets; Showers and tubs; Hospital, food service rest rooms

Objectives

- List the three kinds of rest room surfaces that you must clean, and tell how to clean each type.
- Describe the different rest room flooring materials, and tell how to recognize and clean each one.
- Describe the common types of walls and ceilings in rest rooms, and tell how to care for each one.
- Name the common types of rest room plumbing fixtures, and describe the features of each.
- Describe the differences among rest rooms in different kinds of buildings.

Lesson 2: Routine Rest Room Cleaning

Topics

Cleaning supplies; Clearing and blocking a rest room; Removing trash; Restocking; Cleaning plumbing fixtures and floors; Equipment care

Objectives

- Explain how to gather and prepare supplies needed for routine cleaning tasks.
- Explain how to clear and block a rest room for daily cleaning.
- Explain how to remove trash from a rest room's trash cans, sanitary napkin disposals, and ashtrays.
- Explain how to restock paper products and hand soap.
- List the correct sequence of steps for cleaning the surfaces of a rest room.
- Explain daily dry cleaning and wet cleaning procedures for above-floor surfaces of a rest room.
- Explain procedures for daily cleaning of a rest room floor.

Lesson 3: Cleaning Plumbing Fixtures

Topics

Equipment and chemicals for cleaning sinks, toilets, showers, and tubs; How to clean

Objectives

- Explain safety precautions that you must take to protect yourself when cleaning plumbing fixtures.
- List the equipment and chemicals needed for cleaning sinks.
- Explain the proper procedure for cleaning sinks.
- List the equipment and chemicals needed for cleaning toilets and urinals.
- Explain the proper procedure for cleaning toilets and urinals.
- List the equipment and chemicals needed for cleaning showers and tubs.
- Explain the proper procedure for cleaning showers and tubs.

Lesson 4: Periodic Rest Room Cleaning

Topics

Rest room ceilings, walls, and partitions; Graffiti removal; Pressure washing; Stripping and refinishing

Objectives

- Tell how often to clean rest room ceilings, walls, and partitions.
- Explain how to wash rest room ceilings by hand and with a machine.
- Tell which ceilings must be vacuumed and explain how to vacuum ceilings.
- Explain how to remove graffiti from rest room walls, and how to wash rest room walls and partitions.
- Tell how to scrub, pressure wash, strip, and refinish a rest room floor.
- Explain the difference between scrubbing and/or pressure washing a rest room floor that has a drain and one that does not.

Lesson 5: Rest Room Disinfection

Topics

Germ size, growth, movement, and transfer; Chemicals that kill germs; Kinds of cleaner/disinfectants; Aseptic cleaning

Objectives

- Describe germs in terms of size and reproduction.
- Tell what conditions germs need to live, grow, and multiply, and relate these conditions to rest rooms.
- Explain how germs move from one place to another in a rest room.
- List the kinds of disinfectants that kill germs, or stop them from growing.
- Contrast resident and transient odors in a rest room, and explain how to prevent resident odors.
- Explain how, why, and when to use deodorants in a rest room.
- Tell why disinfection must be done, how often it should be done, and how to do it correctly.

Carpet and Upholstery Care

Course 455: Carpet and Upholstery Care
Covers the many kinds of carpet in use today. Explains the importance of preventive maintenance. Gives step-by-step explanations of the various carpet-cleaning methods available, explaining which is best to use on different types of carpet. Covers stretching, bleeding, insect attack, and many other carpet problems, and suggests remedies. Concludes with a lesson on upholstery fabrics and their care.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Carpet Materials and Construction

Topics

Carpet construction; Types of carpets; Carpet padding and installation; Carpet color

Objectives

- Name the different parts of a carpet and explain the function of each.
- Compare the natural and synthetic fibers used in carpet yarns, and list the advantages and disadvantages of each.
- Describe the construction of the major types of carpet.
- Explain why padding or cushioning is used under carpet, and describe the different padding materials, both natural and synthetic.
- Explain how problems can develop in a carpet that is not installed correctly.

Lesson 2: Preventive Maintenance and Routine Carpet Cleaning

Topics

Dirt-catching devices; Routine vacuuming; Vacuum cleaners; Static electricity treatment; Protecting carpet yarn from crushing

Objectives

- Name the sources of soil that make a carpet dirty.
- Name the common types of dirt-catching devices, and explain how each works and where it is used.
- List the steps that you should take to police an area for preventive carpet maintenance.
- Explain how weekly vacuuming differs from daily vacuuming, and tell what kind of equipment is used for each.
- Name the parts of a vacuum cleaner, and explain how the vacuum works.
- Explain how to care for carpet in germ-sensitive areas.
- List conditions that lead to static buildup, and explain how carpets can be treated to prevent it.
- Describe the devices that prevent furniture and chair legs from crushing carpet yarn.

Lesson 3: Periodic Carpet Cleaning

Topics

Shampooing frequency, methods; Water extraction; Dry powder, foam shampooing; Wet foam shampooing; Sanitizing; Soil retardants

Objectives

- List the factors that help to determine how often you should shampoo a carpet.
- Name the four most common carpet shampooing methods.
- Explain how to make an area ready for shampooing.
- Describe each of the following shampooing methods: water extraction, dry powder, dry foam, and wet foam.
- List advantages and disadvantages of each of the above shampooing methods.
- Explain how to “set the pile” of a carpet after shampooing and tell why it is important.

Lesson 4: Carpet Care Problems

Topics

Uneven wear; Rippling; Seam problems; Shedding and pilling; Bleeding; Fading; Rapid soiling; Crushing; Mildew; Electric shocks; Insect attack; Stains; Burns; Spot repairs

Objectives

- Describe several ways of dealing with uneven carpet wear.
- Define the terms stretching, buckling, and rippling.
- Describe the problems that can occur in carpet seams.
- List the carpet problems commonly handled by a custodian as well as those that require the services of an expert.
- Explain how the problems of shedding, sprouting, and pilling differ.
- Name the five most common causes of rapid carpet soiling.
- Explain how to repair crushed pile yarns, cigarette burns, and mildew in carpet.
- Explain the step-by-step procedure for removing an unknown stain from a carpet.

Lesson 5: Upholstery Care

Topics

Upholstery fabric types; Weave and texture; Nonwoven fabric; Padding and filling materials; Routine care; Shampooing; Special problems

Objectives

- List the natural and synthetic fibers most frequently used in upholstery fabrics.
- Name the tasks that you should perform as part of daily and weekly upholstery care.
- List the procedures and materials that you should use to remove stains from upholstery.
- Explain why it is important to know what padding or filling materials are underneath upholstery before you shampoo it.
- Describe the step-by-step procedure for preparing to shampoo upholstery.
- Describe wet foam, dry foam, water extraction, and liquid dry cleaning shampooing methods.
- Explain how to solve common upholstery problems, and recognize when to call an expert.

Semiconductors

Course: 251: Semiconductors
Describes semiconductor operation, various diodes, and transistors. Stresses proper environmental conditions, minimizing electrostatic discharge (ESD) and radio frequency interference (RFI). Discusses printed circuit board (PCB) and integrated circuit (IC) technology. Identifies semiconductor packages. Explains how to interpret manufacturers' spec sheets and analyze circuit performance by Q points and characteristics.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Introduction to Semiconductors

Topics

Electron flow; Semiconductor materials, structure, and doping; Junction diodes; Diode characteristic curves and specifications; LEDs; Photoelectric devices

Objectives

- Discuss the basic structure of a semiconductor atom and the movement of free electrons and holes.
- Discuss the purification and doping of semi-conductors.
- Describe the p-type region, n-type region, and junction of a pn junction diode.
- Discuss the characteristic curves and specification ratings of a diode.
- Describe the operation of a light-emitting diode, a photoconductive device, and a photovoltaic device.

Lesson 2: Environmental Conditions

Topics

Temperature protection; Static electricity; Wrist straps; Line power conditioning; Radio frequency and electromagnetic interference

Objectives

- Discuss the importance of various environmental conditions to semiconductor operation.
- Discuss the effect of ESD on semiconductor devices and list several ways of preventing ESD in any work area.
- Discuss the requirements of a static-free workstation, and the proper techniques for using tools at the workstation.
- Describe ways to minimize ESD problems during packing and shipping.
- Explain how power conditioning prevents line power problems.
- Describe ways of preventing damage from radio frequency interference (RFI) and electromagnetic interference (EMI).

Lesson 3: Printed Circuit Boards

Topics

Materials for boards and conductors; Single-, double-sided, and multilayer PCBs; Mounting components; Soldering; PCB connectors

Objectives

- Discuss the advantages of PCBs over direct wiring.
- Explain why both flexible boards and rigid boards are used for printed circuits, and discuss the advantages and disadvantages of each.
- Explain how single-sided, double-sided, and multilayer boards are made.
- Describe the three classes of surface mount assemblies.
- Compare various soldering methods and discuss the advantages and disadvantages of each.
- Describe PCB connectors and mountings.
- Discuss PCB repair techniques and limitations.

Lesson 4: Transistors and Integrated Circuits

Topics

Transistor purpose and structure; Symbols; Performance curves; Transistor connections, characteristics, and specifications; ICs

Objectives

- Describe the differences between an npn transistor and a pnp transistor and identify the schematic symbol for each.
- Discuss transistor performance in the active region, saturation region, and cutoff region.
- Explain how the three kinds of transistor connections affect circuit values.
- Discuss four common transistor characteristics.
- Discuss various ways of classifying integrated circuits.

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Lesson 5: Packages and Performance Analysis

Topics

Lead identification; Mounting components; Replacement methods; Maximum ratings; Transistor operating points; characteristics

Objectives

- Describe several kinds of semiconductor packages.
- Explain how to identify leads.
- Describe methods for mounting components on PCBs and chassis.
- Explain how to use manufacturers' data sheets.
- Discuss the analysis of circuits by Q points and by characteristics.

Power Supplies

Course 252: Power Supplies
Covers the four basic kinds of power supply conversions. Explains how to work with nonchemical cells as well as primary and secondary cells of various materials. Describes in detail the functions and operation of several kinds of rectifiers, filters, and voltage regulators and explains how they work together as power conditioners. Discusses basic tools, test devices, and procedures for troubleshooting.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Power Supplies and Power Conditioners

Topics

Power supply and power conditioner functions; DC-to-DC, AC-to-AC, AC-to-DC, and DC-to-AC power supplies; Inverter feedback circuits; Power conditioners; Safety precautions

Objectives

- Discuss the basic functions of power supplies and power conditioners.
- Describe dc-to-dc, ac-to-ac, ac-to-dc, and dc-to-ac power supplies.
- Compare the operation of transformer-driven and oscillator-driven inverters.
- Discuss the functions of filters, voltage regulators, voltage dividers, switching power supplies, zand ferroresonant power supplies.
- Explain why low voltages can be dangerous.

Lesson 2: Cells and Batteries

Topics

Electrochemical cells; Primary, secondary, lead-acid, nickel-cadmium, nickel-metal-hydride, and nickel iron cells; Maintenance, hazards, and precautions; Nonchemical cells

Objectives

- Explain the difference between a battery and a cell and identify symbols for each.
- Describe the parts of an electrochemical cell.
- Compare the characteristics and uses of Leclanché, high-energy, and alkaline carbon-zinc cells.
- Discuss battery-recharging problems and explain how to check for overcharging.
- Discuss ways to maintain and dispose of chemical cells and batteries safely.
- Discuss the use of five kinds of nonchemical energy sources and recent developments in cells and batteries.

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Lesson 3: Rectifiers

Topics

Diode rectifiers and ratings; Parallel and series diodes; Half-, full-wave, bridge, and three-phase rectifiers; Voltage multipliers

Objectives

- Define the term rectifier.
- Explain how to interpret diode ratings on a manufacturer's specification sheet.
- Compare the effects of connecting diodes in parallel and in series.
- Describe the operation of a silicon-controlled rectifier.
- Compare the operation of half-wave and full-wave rectifiers.
- Discuss the operation of bridge and three-phase rectifiers and explain how voltage multipliers work.

Lesson 4: Filters

Topics

Kinds of filters; Ripple; Circuit components; Bleeder resistors; Bypass filters; Input filters

Objectives

- Name several kinds of filters used in power supplies.
- Discuss the effects of ripple and describe ways ripple is measured.
- Discuss the use of capacitors, inductors, and resistors in filter circuits.
- Compare the advantages and disadvantages of capacitance, inductance, RC, and LC power supply filters.
- Explain why capacitor power supplies should include bleeder resistors.
- Discuss the uses of bypass filters and input filters.

Lesson 5: Voltage Regulators

Topics

Voltage regulators; Shunt, series, integrated circuit (IC), switching, and primary circuit regulators

Objectives

- Discuss the purposes of voltage regulators in power supplies.
- Explain the function of the control circuit and the current limiting circuit in series voltage regulators.
- Discuss the advantages of IC voltage regulators.
- Describe the operation of switching regulators and explain how it differs from that of other kinds of regulators.
- Discuss the use of SCRs and triacs in primary circuit regulators.

Lesson 6: Troubleshooting Power Supplies

Topics

General approach; Preliminary checks; Power-off, power-on tests; Output tests; Section tests; Part tests

Objectives

- Discuss at least five kinds of test equipment and tools used to troubleshoot power supplies.
- Describe the three main steps in troubleshooting a power supply.
- Describe the basic procedures for preliminary checks and power-off visual inspection and fuse tests.
- Describe the basic procedures for power-on tests and output tests.
- Explain how to perform section tests and part tests.

Amplifiers

Course 253: Amplifiers
Covers the effects of gain, bandwidth, and distortion on performance. Compares linear and nonlinear amplifiers. Explains using transistor curves to analyze amplifier operation by region, load line, operating (Q) points, and biasing. Discusses impedance matching, comparing capacitive, transformer, and direct-coupled amplifiers. Provides methods for troubleshooting common amplifier problems.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Introduction to Amplifiers

Topics

Amplifying circuits; Amplifier characteristics; Transistor amplifiers; Characteristic curves; Effects of temperature

Objectives

- Explain how gain, bandwidth, and distortion relate to amplifier operation.
- Compare bipolar transistor amplifiers and FET amplifiers.
- Explain how to use characteristic curves to predict transistor performance.
- Explain how to use an input/output curve to determine transistor gain.
- Discuss the effect of ambient temperature on amplifier performance.
- Discuss the uses of operational amplifiers and switching amplifiers.

Lesson 2: Single-Stage Amplifiers

Topics

Biasing circuits; Operating points and load lines; Biasing common-emitter, -collector, and -base circuits; Biasing FET amplifiers; Amplifier classifications; Push-pull amplifiers

Objectives

- Discuss the transistor characteristics that define operating region limits.
- Explain how to draw an amplifier load line.
- Explain how to find the operating point of an amplifier.
- Discuss biasing as a means of establishing a stable operating point in an amplifier circuit.
- Discuss five ways that amplifiers can be classified and compare Class A, AB, B, and C amplifiers.

Lesson 3: Amplifier Performance and Multistage Amplifiers

Topics

Power, current, and voltage gain; Distortion; Impedance matching; Multistage amplifiers; Amplifier, capacitive, and transformer coupling; Direct-coupled amplifiers

Objectives

- Explain how to calculate amplifier power gain, efficiency, current gain, and voltage gain.
- Explain how nonlinearity and clipping cause amplifier distortion.
- Discuss the importance of impedance matching in interconnecting circuits.
- Explain how to calculate multistage amplifier gain and bandwidth.
- Compare the advantages and disadvantages of capacitive-coupled, transformer-coupled, and direct-coupled amplifiers.

Lesson 4: Op Amps

Topics

Differential amplifiers; Typical op amp; Inverting, summing, and noninverting amplifiers; Nonlinear op amp circuits; Integrators; Comparators; Squaring circuits

Objectives

- Describe the operation of differential amplifiers.
- Compare the properties of an ideal op amp and a typical actual op amp.
- Describe the operation of inverting amplifiers in terms of virtual ground.
- Compare the advantages of inverting amplifiers and noninverting amplifiers.
- Explain how integrators and comparators work.
- Explain how zener diodes are used in squaring circuits.

Lesson 5: Troubleshooting Amplifiers

Topics

Troubleshooting single- and three-stage amplifiers; Troubleshooting by DC and AC analysis; Measuring gain and power supply performance; Troubleshooting components, op amps

Objectives

- Describe basic procedures for troubleshooting single-stage and multistage amplifiers.
- Explain how dc analysis, ac analysis, and troubleshooting trees are used in amplifier maintenance.
- Explain how to measure amplifier gain and power supply performance.
- Describe the procedures for troubleshooting resistors, capacitors, and op amps.

Oscillators

Course 254: Oscillators
Covers how oscillation is started and maintained. Compares sine-wave oscillators and square-wave switching circuits. Discusses monostable, astable, and bistable flip-flop operation;Schmitt trigger circuits, frequency dividers, ripple counters, propagation delays, and glitches. Describes operation of low-, high-, and band-pass filters; and, how to troubleshooting oscillator components and circuits.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Introduction to Oscillators

Topics

Oscillation; Oscillators and amplifiers; Classes of oscillators; Common oscillator circuits

Objectives

- Describe the conditions needed to start and to sustain oscillation.
- Explain how positive feedback affects oscillation.
- Name three kinds of feedback networks used in oscillators.
- Discuss the advantages and disadvantages of tuned circuits, phase-shift oscillators, and crystal oscillators.
- Describe several common oscillator circuits.

Lesson 2: Flip-Flops

Topics

Square waves; Switching circuits; One-shots; Astable flip-flops (multivibrators); Frequency of multivibrators; Bistable flip-flops

Objectives

- Discuss the differences between sine wave oscillators and square wave switching circuits.
- Explain how rise time and the time constant affect flip-flop circuits.
- Compare the operation of discrete transistor one-shots and IC one-shots.
- Explain how IC pairs of one-shots or IC op amps form an astable multivibrator.
- Describe the operation of bistable flip-flops.

Lesson 3: Logic Clocks

Topics

Combinational and synchronous logic; Clock conditioning; Schmitt trigger circuit; Frequency dividers; Multiphase and real world logic clocks

Objectives

- Compare combinational logic, synchronous logic, and sequential logic.
- Explain how logic clocks are generated.
- Explain how negative resistance enables the UJT relaxation oscillator to be used as a logic clock.
- Discuss the effect of hysteresis on logic clock operation and describe the operation of the Schmitt trigger circuit.
- Describe the operation of ripple counters and other frequency dividers.
- Discuss problems caused by real-world (nonideal) logic clocks.

Lesson 4: Filters and Waveforms

Topics

Wave shaping; Simple, RC low-pass, RL low-pass, high-pass, band-pass, band-reject, and active filters; Time constants; Differentiators and integrators; Function generators

Objectives

- Discuss the composition of waveforms and explain how filters change the shapes of waveforms.
- Compare the frequency characteristics of low-pass and high-pass filters and of band-pass and band-reject filters.
- Discuss the calculation of time constants in timing circuits.
- Describe methods of creating and shaping complex waveforms, including the differentiator and integrator circuits.
- Explain briefly how digital waveforms are generated with a microprocessor.

Lesson 5: Troubleshooting Oscillators

Topics

Test equipment; Tracing oscillator operation; Troubleshooting multivibrators, one-shots, flip-flops, sequential logic circuits, clocks, and filters

Objectives

- Discuss the basic requirements of four kinds of equipment used to test oscillators.
- Describe good general practices in troubleshooting oscillator components and circuits.
- Describe the steps in tracing oscillator circuit operation and selecting test points for monitoring waveforms.
- Discuss the steps in troubleshooting multivibrators, one-shots, and flip-flops.
- Discuss troubleshooting methods for sequential logic circuits, including clocks.
- Discuss troubleshooting methods for frequency dividers and filters.

Digital Logic Systems

Course 291: Digital Logic Systems
Compares analog and digital switching circuits. Explains Boolean logic functions. Describes TTL and CMOS logic, and IC logic devices. Explains how flip-flops, clock circuits, counters, multiplexers, and memory circuits work. Describes sections and interfaces in functional logic systems, including microprocessors. Describes proper methods for detection and correction of common fault potentials.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Digital Logic Fundamentals

Topics

Digital logic; Boolean algebra; Logical AND, OR, NOT function; Positive and negative logic; NAND logic; Combining logic circuits; TTL logic; IC logic devices

Objectives

- Explain the difference between digital and analog circuits.
- Describe And, Not, and Or logic functions.
- Explain how solid-state switches can perform logic functions.
- Compare equivalent nand and nor gates using positive and negative logic.
- Discuss the importance of TTL and CMOS circuits.

Lesson 2: Logic Building Blocks

Topics

Sequential logic; Flip-flops; Clock circuits; Schmitt triggers; Frequency dividers; Pulse counters

Objectives

- Describe the function of a logic clock.
- Explain the operation of a flip-flop.
- Discuss the differences among clocked R-S flip-flops, D-latches, and J-K master-slave flip-flops.
- Explain how to convert between the decimal and binary number systems.
- Discuss the use of BCD and the octal and hexadecimal number systems.

Lesson 3: Medium- and Large-Scale ICs

Topics

Counters; Serial vs. parallel data transmission; Registers; Multiplexers; Decoder/demultiplexers; Arithmetic circuits; LSI memories

Objectives

- Explain the operation of each of the following counters: ripple, BCD, synchronous, and up/down.
- Describe the operation of a shift register.
- Discuss the difference between multiplexers and decoders/demultiplexers.
- Define the terms read, write, serial access, and random access as they apply to memories.
- Discuss the purposes of RAM and ROM devices.

Lesson 4: Functional Logic Systems

Topics

Logic subsystems; Microprocessors; I/O subsystems; Noncontact switches; Multiple-bit I/O devices; Data codes, displays, and transfer

Objectives

- Describe the sections of a basic logic system.
- Compare a ROM, a PROM, and a PLA.
- Name the basic parts of a microprocessor.
- Describe common kinds of I/O interfaces and data displays.

Lesson 5: Troubleshooting Logic Systems

Topics

Gathering information; Isolating the problem; Localizing the trouble; Interpreting logic diagrams; Timing waveforms; Test equipment

Objectives

- Describe seven external faults that can affect solid-state circuits.
- List the major steps in efficient troubleshooting.
- Name information sources for identifying system malfunctions.
- Explain how to trace a faulty component by using a troubleshooting tree.
- Explain how to use various kinds of test equipment to pinpoint system faults.

Energy Conservation Basics

Course 376: Energy Conservation Basics
Covers energy sources and the history of energy usage. Examines alternative energy sources and their feasibility. Identifies current energy usage patterns and places where energy can be conserved. Explains how to recognize energy waste, and includes sample corrective actions. Explains how to conduct an energy survey.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Energy and its Sources

Topics

Energy; Fossil fuels; Nuclear power; Solar energy; Wind; Hydroelectric power; Evaluating energy sources; Measuring energy

Objectives

- Define energy and list several potential energy sources
- Explain how fossil fuels developed and how they are extracted from the earth.
- Explain, in simple terms, how uranium produces energy.
- List at least one advantage and one disadvantage of each of the following: oil, natural gas, coal, solar power, wind energy, and hydroelectric power.
- Tell how heat and temperature are measured (what units).

Lesson 2: Why the Energy Crisis?

Topics

History of energy use; Fossil fuel reserves; Alternative and, synthetic fuels; Gas and oil from coal; Nuclear fuels; Geothermal energy; Biomass

Objectives

- Define the fossil fuel age and list the energy sources that made it possible.
- Name some of the factors that contributed to the greatly increased use of fossil fuels in the past century.
- Describe the outlook for fossil fuel availability in the next century.
- Give examples of current efforts to develop alternative sources of oil and gas.
- Identify potential sources of future energy and describe their present limitations.

Lesson 3: Energy Consumption and Loss

Topics

Using fuel to generate electricity; Energy loss; Effects of climate on energy use; Degree-days; Cost of saving energy; ROI and payback period

Objectives

- Tell why generating electricity is an inefficient use of energy and what characteristics of electricity justifies this inefficiency.
- Compare energy use in the three categories of energy consumers.
- Explain degree-days and how they are used?
- State why a building's HVAC system is a good place to start looking for potential energy savings.
- Tell how to calculate the payback period of an energy conservation plan.

Lesson 4: Practical Conservation Measures

Topics

Recognizing and correcting energy waste in buildings, mechanical, and electrical systems; Energy conservation examples

Objectives

- Recognize energy waste conditions in building structures.
- Name at least three factors that affect boiler and furnace efficiency.
- Give examples of energy waste in a building's mechanical system and how it might be eliminated.
- Explain peak demand and why it is important in electricity costs.
- Tell how computer monitoring and control can be used to save energy and lower utility costs.
- Tell how computer monitoring and control can be used to save energy and lower utility costs.

Lesson 5: Conducting an Energy Audit

Topics

Audit tools; Sample energy audit; Fuel usage information; Building, equipment data; Conservation opportunities

Objectives

- Name and describe the six segments of a detailed energy audit.
- Define a mini-audit and tell when it might be used.
- List the tools required for an energy survey of any building.
- Record the data necessary to make up an energy audit.
- Explain the procedure for assigning priorities to energy-saving projects.

Energy Losses in Buildings

Course 377: Energy Losses in Buildings
Covers physical laws of heat transfer and how they apply to building heat losses. Discusses effects of sun, wind, and shade on energy consumption in buildings. Examines different types of walls, roofs, windows, and flooring. Demonstrates how different forms of insulation can improve thermal resistance. Gives sample applications of energy conservation measures, illustrating how to determine cost and payback period.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Heat Flow Principles

Topics

Detecting heat loss; Insulation; Environmental considerations; Windbreaks; Foundation plantings; Building orientation

Objectives

- Distinguish between heat transfer by conduction, convection, and radiation.
- Explain the importance of infiltration in a building's heat loss/gain.
- Define thermal conductance, overall coefficient of heat transmission, and thermal resistance and how they relate to each other.
- Explain the concept of the building envelope
- Tell how environmental factors can affect the loss of gain of heat in a building.

Lesson 2: Heat Loss/Gain Through Roofs

Topics

Roof construction and insulation; Vapor barriers; Ventilation; Types of insulation, applications; Checking heat leaks; Infrared scanner

Objectives

- Demonstrate how to arrive at the R value of a roof section.
- List the principal types of roof and ceiling insulation and the applications for which each is best suited.
- Name the two most effective precautions to take against moisture damage and give examples of their proper installation.
- Explain how and under what circumstances heat leaks can be detected in roof structures.
- Identify the facts needed for payback calculations and tell how to use them to determine payback periods.

Lesson 3: Minimizing Heat Flow Through Walls

Topics

Totaling R values; Insulating materials; Vapor barriers; Cold-side venting; Convective looping; Insulating foundations; Metal walls; U values

Objectives

- Evaluate the merits of the common forms of insulation as applied to wall construction.
- Identify at least two types of vapor barrier and tell when each would be used.
- Explain convective looping and how to prevent it.
- Tell why metal buildings have special insulation needs and describe the techniques developed for them.
- Use payback calculations to determine which of two alternatives conservation measures is the more profitable.

Lesson 4: Heat Loss/Gain Through Windows and Doors

Topics

Infiltration; Caulking; Weather-stripping; Air locks; Sealed windows; Storm windows; Draperies; Solar heat gain; Shading

Objectives

- Identify two forms of infiltration.
- Explain the valves of an air lock and describe a typical installation.
- Name at least three means of reducing conductive heat loss through windows.
- Tell why the angle of the sun is important in efforts to increase or minimize solar heat gain.
- State the reason for the lengthy payback period on most window retrofits.

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Lesson 5: Controlling Losses Through Floors

Topics

Above-, below-, and on-grade floors; Vapor barriers; Ground cover; Crawl spaces; Surface drainage; Floor coverings; Pipes; Duct work; Retrofits

Objectives

- Describe the principal methods of insulating existing above-ground floors.
- Tell how to test for capillary rise in a crawl space.
- Point out the value of a ground-cover vapor barrier.
- List two ways to insulate on-grade or below-grade floors.
- Explain the special problems involved in calculating heat losses and payback periods for on-grade and below-grade floors.

Heating/Cooling System Efficiency

Course 378: Heating/Cooling System Efficiency
Covers the measurement of various environmental factors and their effect on human comfort. Introduces the concept of zones. Covers ventilation requirements and savings possible by reducing airflow. Examines energy waste vs. conservation measures relating to furnaces, boilers, air conditioners, and refrigeration equipment.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Conditioning the Air

Topics

Human comfort; Heat generation in buildings; Thermal zones; Types of HVAC systems; Guidelines for HVAC

Objectives

- Explain the various environmental factors affecting human comfort.
- Interpret the ASHRAE comfort chart.
- Differentiate between sensible and latent heat.
- Explain the operation of the components in a basic al-air HVAC system.
- Name the different kinds of single-path and multiple-path HVAC systems, tell how each operates, and list ways to conserve energy in each type.

Lesson 2: Managing Airflow in HVAC Systems

Topics

Air pressure within a duct; Airflow measuring devices; Building ventilation requirements; Heat recovery systems; Component maintenance

Objectives

- Compare and contrast static pressure, velocity pressure, and total pressure.
- Define ventilation air and tell how to determine ventilation air requirements.
- Calculate the amount of energy needed to heat or cool outside air.
- Name four types of heat recovery systems and explain how each works.
- Explain where and why exhaust systems are used and how they may be installed.

Lesson 3: Conserving Energy in Heating Systems

Topics

Warm air furnaces; Boilers; Furnace and boiler maintenance; Stack gas analysis; Purchased steam, hot water; Metering steam

Objectives

- Explain why good furnaces and boiler maintenance is an important part of an energy conservation program.
- Detail the types of maintenance required on various types of furnaces.
- Tell how to locate and correct energy waste in steam and hot water distribution systems.
- Explain the importance of steam traps and describe their operation and maintenance.
- List ways energy may be saved in humidification systems.

Lesson 4: Conserving Energy in Cooling Systems

Topics

Mechanical compression and absorption systems; External and internal controls; Evaporator and condenser temperatures; Self-contained units; Heat pumps; Refrigerators/freezers

Objectives

- Compare and contrast the operation of a mechanical compression system and an absorption system.
- Define external and internal controls for refrigeration and give examples of each.
- Explain how evaporator and condenser temperatures influence energy consumption.
- Name several different methods for cooling condensers.
- Describe the basic operation of a heat pump and tell how it differs from other air conditioning systems.

Lesson 5: Reducing Losses in Distribution Systems

Topics

Fans; Air duct insulation; Hydronic system balancing; Piping system insulation; Maintaining pumps; Strainers; Control valves

Objectives

- Define the term fluid and discuss the importance of reducing a fluid's resistance to flow.
- List several ways to reduce flow resistance in air distribution systems.
- Discuss the purpose of insulating air ducting and tell how insulation is applied.
- Explain how flow resistance can be reduced in piping systems.
- Name several types of control valves, tell where each is used, and explain the importance of good valve maintenance.

Mechanical Energy Conservation

Course 379: Mechanical Energy Conservation
Covers causes and effects of friction and the importance of lubrication. Includes a discussion of efficient operation of materials handling systems, elevators, and escalators. Examines ways to conserve energy by reducing vibration. Explains importance of good maintenance of pumps, blowers, and compressors. Discusses vehicle efficiency, emphasizing tuneups, lubrication, and other energy-saving practices.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Reducing Friction

Topics

Power transmission efficiency; Reducing friction; Lubrication; Seals; Lubricating devices and systems

Objectives

- Name the three basic parts of a mechanical system
- Explain the concept of mechanical efficiency.
- Give examples of the three basic kinds of friction encountered in mechanical systems.
- List at least four purposes of lubrication.
- Define viscosity, viscosity index, and pour point.
- Tell why oil and grease seals are used.

Lesson 2: Cutting Transmission Losses

Topics

Belt, chain, and gear drives; Bearings; Clutches and brakes; Drive couplings; Vibration; Balancing machinery

Objectives

- Explain why proper bearing lubrication is important.
- Name the drive component responsible for the most power loss.
- List three functions of couplings.
- Show how to check coupling alignment.
- Define vibration and explain why vibration control is important.
- Compare and contrast static unbalance and dynamic unbalance.

Lesson 3: Pumps, Fans, and Compressors

Topics

Pump installation, piping, and priming; Bearing lubrication; Improving fan performance; Compressor operation and maintenance

Objectives

- Tell why proper pump installation is important to energy conservation.
- Describe the problems that can occur if pump bearing lubrication is neglected.
- Demonstrate the proper method of replacing pump packing.
- List the three major maintenance items related to centrifugal pumps.
- Identify several places where energy losses can occur in a fan system.
- Explain how to determine whether a fan is suited to the system in which it is operating.
- Name several maintenance procedures important to efficient compressor operation.

Lesson 4: Elevators and Conveyor Systems

Topics

Drive packages; Conveyor operation; Escalators; Elevators; Maintenance; Safety; Loading docks

Objectives

- List at least two energy-saving tips to keep in mind when dealing with conveyor operation.
- Explain the purpose of a take-up in a conveyor system.
- Differentiate between unit-handling belt conveyors and bulk-handling belt conveyors.
- Tell how lagging can reduce energy waste.
- Name one type of conveyor that is not capable of wasting energy and explain some of its uses and limitations.
- List the three basic methods used to drive elevators.
- Identify common causes of energy waste at loading docks.

Lesson 5: Improving Vehicle Efficiency

Topics

Vehicle selection; Tires; Vehicle operation; Maintenance and repairs; The PM program

Objectives

- Name the three basic areas offering energy conservation opportunities in vehicles.
- Explain why it is important to use the correct conservation opportunities in vehicles.
- Compare and contrast the applications of IC engine and electric vehicles.
- List as least ten tips for fuel-conscious vehicle operations.
- Describe what a PM program involves and tell why it is important.
- Tell why air cleaner care is important to an energy conservation program.
- Explain the importance of battery maintenance in an electric vehicle.

Electrical Energy Conservation

Course 380: Electrical Energy Conservation
Covers electrical energy consumers in typical commercial and industrial facilities. Investigates utility rate structures and relates cost to load management. Examines power factors, including how they are calculated and how they affect energy usage. Shows methods of conducting lighting surveys and how lighting fixture and lamp selection can impact electricity costs.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Surveying Electrical Consumption

Topics

Identifying electricity consumers; Determining system efficiency, consumption; Meter selection

Objectives

- Conduct an electrical energy audit.
- Determine the efficiency of an electrical system.
- Give three reasons for metering electric energy use.
- Name the three basic types of meters used in energy conservation work and explain how each is used.
- Differentiate between indicating and recording meters.

Lesson 2: Using Load Management Techniques

Topics

Load factor; Equipment audits; Target demand; Methods of control; Demand controllers

Objectives

- Name the two metered quantities that determine the major part of an electric bill.
- Define power factor and load factor and explain why each is important.
- Show how to use meters to identify usage patterns ad peak usage periods.
- Compare and contrast manual and automatic demand control and give an example of each.
- Name several types of demand controllers and tell how each operates.
- Describe the way in which electric bills are calculated.

Lesson 3: Improving Electrical Equipment Efficiency

Topics

Electrical quantities; Capacitors; Induction motors; Motor efficiency; Variable speed drives; Transformers; Energy saving devices

Objectives

- Name the two familiar forms energy may take.
- List three elements of impedance in an ac system.
- Explain how power factor is calculated in a single-phase and a three-phase circuit.
- Tell why capacitors are important from an energy conservation standpoint and name three sources of capacitance in an electrical system.
- Explain the information found on a motor nameplate and tell how it relates to energy on a electrical system.
- Calculate load losses and no-load losses of motors, speed controls, and transformers.
- Evaluate the value of energy-saving devices.

Lesson 4: Conducting a Lighting Survey

Topics

Lighting levels; Lighting survey; Improved switching; Reducing lamp size; Improved lighting controls; Task lighting; Using natural light

Objectives

- Explain the importance of a good lighting system.
- Define uniform lighting and selective task lighting and tell how they affect energy consumption.
- Determine recommended and actual lighting levels
- Distinguish between lumens and footcandles as measures of light.
- Give examples of ways in which switching modifications can be used to reduce energy consumption.
- Describe several ways to use natural lighting more efficiently.

Lesson 5: Evaluating Lamps and Fixtures

Topics

Incandescent and fluorescent lamps; Scheduling lamp replacement; HID, mercury, metal halide, high-, and low-pressure sodium lamps; Maintenance

Objectives

- Tell why cleaning lamps and fixtures is important.
- Compare and contrast incandescent and fluorescent lamps.
- Differentiate between R lamps and ER lamps.
- Name six types of lighting in order of efficacy.
- List advantages and disadvantages of each of the following types of high intensity discharge lighting: mercury, metal halide, HPS, and LPS.

Force and Motion

Course 391: Force and Motion
Covers fundamentals of force and motion, showing how an engineer thinks about these concepts. Demonstrates how mathematical and graphical representations can help clarify our thinking about mechanical force and motion.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Scalars and Vectors

Topics

Physical quantities; Properties and components of vectors; Adding, subtracting, multiplying, and dividing vectors

Objectives

- Explain the difference between scalars and vectors, and list examples of each.
- Draw a vector, given a verbal description.
- Describe a vector verbally, given its graphic symbol, a frame of reference, and an appropriate scale.
- Define resolution, resultant, and commutative.
- Demonstrate how to resolve a vector into its rectangular components.
- Demonstrate how to add and subtract vector quantities in one-dimensional and two-dimensional frames of reference.
- Multiply and divide a vector by a scalar.

Lesson 2: Motion Along a Straight Line

Topics

Speed; Velocity; Slope; Changing and instantaneous velocity; Velocity-vs-time graph; Finding displacement; Using a curved graph

Objectives

- Explain the difference between speed and velocity.
- Define the terms instantaneous velocity, average velocity, and slope.
- Identify the delta notation, and explain how to use it in a calculation.
- Demonstrate how to determine displacement and velocity from a position-versus-time graph.
- Demonstrate how to determine displacement by calculating the area under a velocity-versus-time graph.

Lesson 3: Acceleration

Topics

Directional acceleration; Equations of motion; Acceleration due to gravity; Upward and lateral motion during free fall

Objectives

- Define acceleration.
- Demonstrate how to determine the magnitude of an acceleration from a velocity-verses-time graph.
- Demonstrate the difference between average acceleration and instantaneous acceleration.
- Solve simple problems for average acceleration, displacement, and final velocity.
- Explain why the velocity-verses-time graph for all objects in free fall are parallel (when drawn on the same coordinate system).

Lesson 4: How to Describe Force

Topics

Motion; Basic forces of nature; Action/reaction pairs; Newton's Third Law of Motion; Unbalanced forces; Resolution of forces

Objectives

- Define force.
- Name the four basic types of forces in nature.
- State Newton's Universal Law of Gravitation.
- Explain how and why vectors are used to represent forces.
- Explain Newton's Third Law of Motion.
- Give examples which demonstrate that forces always occur in action-reaction pairs.
- Demonstrate how to add force vectors.
- Describe how to resolve a force vector into its components.

Lesson 5: Force and Acceleration

Topics

Friction; Newton's First and Second Laws of Motion; "Resistance" to acceleration; Units of force; Conservation of momentum

Objectives

- State Newton's First Law of Motion.
- Define inertia, and describe how it is measured.
- Explain why a force must be applied continuously to objects on earth in order to maintain their motion.
- Explain what happens when a net applied force is greater than the friction force.
- State Newton's Second Law of Motion.
- Solve problems using the equation F=ma.

Lesson 6: Equilibrium

Topics

Forces on bodies; Particles in static equilibrium; Equilibrium of a rigid body; Center of mass

Objectives

- State the two conditions of equilibrium, and distinguish between static and dynamic equilibrium.
- Explain the difference between particles and rigid bodies.
- Define torque.
- Solve problems involving torque and rotational equilibrium.

Lesson 7: Rotational and Circular Motion

Topics

Centripetal and centrifugal force; Rotational motion; Angular displacement; Velocity; Acceleration; Tangential acceleration; Moments of inertia

Objectives

- Describe centripetal force.
- Differentiate between centripetal acceleration, angular acceleration, and tangential acceleration, and state the formula for each.
- Demonstrate how to convert degree measurements to radian measurements.
- Define the terms uniform circular motion, period angular velocity, angular impulse, angular momentum, and moment of inertia.
- Explain why moment of inertia is calculated differently for different objects.
- State Newton's Second Law in terms of rotational motion.
- Identify examples of the Law of Conservation of Angular Momentum.

Lesson 8: Simple Harmonic Motion

Topics

Periodic motion; Simple harmonic motion; Hooke's Law; Equations of harmony; Resonance

Objectives

- Describe the relationship between simple harmonic motion and uniform circular motion.
- Define the terms cycle, amplitude, frequency, period, and Hertz.
- State Hooke's Law.
- Describe how acceleration and restoring force vectors change as an object moves in simple harmonic motion.
- Use equations to determine the period and frequency of both a mass-spring system and a pendulum.
- Give examples of resonance.

Chemical Hazards

Course 151: Chemical Hazards—OSHA's Hazard Communication Standard
Covers OSHA'S Hazard Communication Standard. Discusses the physical and health hazards presented by dangerous chemicals. Explains the information contained in a Material Safety Data Sheet (MSDS).

The lessons, topics, and objectives for this course are listed below.

Lesson 1: What the Standard Requires

Topics

Identifying and evaluating chemical hazards; Providing an MSDS; Labeling and listing chemical hazards; Training employees; Writing a hazard communication program

Objectives

- Identify the goals of the Hazard Communication standard and the agency responsible for writing and enforcing the standard.
- Lost the eight fundamental actions required by the OSHA Hazard Communication standard and state the purpose of each.
- Explain the key requirements for carrying out each fundamental action.

Lesson 2: Types of Chemical Hazards

Topics

Physical and health hazards; Exposure routes; Factors that affect the degree of hazard; Controlling chemical hazards; Detecting exposure hazards

Objectives

- Define chemical hazards covered by the Hazard Communication standard and the two categories into which they are divided.
- Identify the common physical forms of chemical hazards and the industrial operations that produce or release vapors, mists, dusts, and fumes.
- Name the three basic routes of exposure to health hazards.
- Explain the key factors that affect the degree of hazard.
- Discuss common methods of controlling chemical hazards.
- Explain how to detect exposure hazards and symptoms.

Lesson 3: Material Safety Data Sheets

Topics

Chemical identification; Physical and chemical data; Health and physical hazard information; Fire, explosion, and reactive hazards; Special protection

Objectives

- Explain the purpose, availability, preparation, and basic content of MSDSs.
- Give examples of the health hazard information contained in MSDSs and how it is used.
- Give examples of the physical hazard information contained in the MSDSs and how it is used.
- Describe typical MSDS instructions on special precautions and procedures.

Machine Shop Practice

Course 315: Machine Shop Practice
Covers the principles of machining, measurement, tool grinding, and machine shop safety. Discusses the properties of metals, how to lay out and set up a job, how to use measuring devices such as the micrometer and vernier caliper, and how to read working drawings. Explains how to grind single-and multi-point tools.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Principles of Machining

Topics

Machine tools; Metal cutting tools; Properties of metals; Case hardening; Cutting metals; Cutting fluids; Speeds and feeds; Chip shape and disposal

Objectives

- Name the two main classes of machine tools.
- Tell how to identify ferrous and nonferrous metals.
- Explain methods of identifying steels.
- Define the following terms: tensile strength, compressive strength, ductility; and malleability.
- Explain various heat treating processes used with metals.
- List the functions of a cutting fluid.
- Explain how to change sfpm to rpm.
- Describe the information you can gather from chip color and shape.

Lesson 2: Layout Work and Shop Safety

Topics

Shop drawings; Scribing lines; Calipers; Measuring angles; Surface plates, gauge; Making a layout; Shop safety

Objectives

- Describe the tools commonly used for layout work in the machine shop.
- Explain the function of a surface plate.
- Define the terms bolt circle, pitch chord, and centerline.
- List the steps involved in laying out flange holes.
- Explain shop safety practices relating to eye protection, chip removal, and tool handling.

Lesson 3: Setup Tools

Topics

Holding devices; Supporting the workpiece; Rests; Step blocks; V-blocks; C-clamps; Angle plates; Hold-downs; Magnetic chucks; Safety

Objectives

- Explain how to hold and drive work held between centers on a lathe.
- Explain how to hold lathe work in a chuck, and how to mount and remove a chuck from a lathe.
- Define the term swing as it relates to a lathe.
- Tell how to hold oddly shaped workpieces on a lathe
- Explain when each of the following is used: collet chuck, steady rest, and follower rest.
- Explain how each of the following is used to hold work on a machine table: T-slot bolts and clamps, step blocks, V-blocks, C-clamps, angle plates, and planer jacks.
- Tell when and how to use a vise to hold a workpiece.
- List safety precautions for setup tools.

Lesson 4: Setup Measurement

Topics

Working drawings; Dimensions; Precision; Tolerance; Using a steel rule, micrometer, vernier caliper, sine-bar, and gauge blocks

Objectives

- Explain the importance of having a working drawing when machining a part.
- Define the terms section and sectional view.
- Name the three systems of dimensioning.
- Define the terms precision and tolerance.
- Define the term fit, and compare actual fit, clearance fit, interference fit, and transition fit.
- Name the simplest measuring tool in the shop.
- Explain how to hold and read a micrometer.
- Tell how to use a vernier caliper, sine-bar, and gauge blocks.

MPACT® INSTITUTE Certified Training Program

Lesson 5: How to Grind Single-Point Tools

Topics

Tool materials; Relief angles; Grinders and grinding wheels; Finishing, grooving, and threading tools; Carbide-tipped tools

Objectives

- Describe the various materials used for tools.
- Identify the parts of a single-point tool.
- List important specifications for single-point cutting tools.
- Name the two basic types of grinders and explain how they are used to sharpen single-point tools.
- Explain the standard marking system for grinding wheels.
- Describe the best way to grind carbide-tipped tools.

Lesson 6: How to Grind Multi-Point Tools

Topics

Grinding a drill; Checking lips and relief angles; Thinning the drill web; Milling cutters; Cutter relief, clearance, end mills, and counterbores

Objectives

- Describe the construction of a twist drill, including identification of its parts.
- Explain how to perform the following operations when grinding: check the drill lips, check the relief angles, and thin the drill web.
- List the three categories of milling cutters based on the way they are mounted on a milling machine.
- Name the most common type of milling cutter for maintenance work.
- Explain how to grind end mills, counterbores, and reamers.

Machine Shop Turning Operations

Course 316: Machine Shop Turning Operations
Covers the major types of lathes and their attachments, safety, maintenance, job preparation, and basic lathe operations. Discusses all facets of drilling and boring, types of drills and drill presses, milling machines, and job bores. Explains reaming and reamer terms. Covers threads and threading.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Lathes and Attachments

Topics

Engine lathes; Lathe size, capacity, and parts; Holding work; Steady and follower rest; Preparing for lathe operation; Safety

Objectives

- Explain the function of each of the following lathe parts: lathe bed, ways, headstock, tailstock, carriage, compound rest, and spindle.
- Name the two dimensions usually used to describe lathe capacity.
- List and describe several methods of holding work in a lathe.
- Explain the function of a steady rest and follower rest.

Lesson 2: Basic Lathe Operations

Topics

Preparing and centering the stock; Aligning and using rests; Cutting speed and feed; Turning operations; Cutting fluids and coolants

Objectives

- Describe the factors to consider when selecting and preparing a piece of stock for a lathe job.
- Explain how to mount eccentric or irregularly shaped workpieces.
- Define the terms cutting speed and feed rate and list factors that affect each.
- Name two factors that affect the smoothness of a finishing operation.
- Explain the function of cutting fluid in lathe work.

Lesson 3: Drilling and Boring

Topics

Drills and drill presses; Drill numbering and sizing; Setting up work; Speed and feed; Drilling compounds; Boring; Safety

Objectives

- Identify the main parts of a twist drill.
- Explain the step-by-step procedure for drilling a hole.
- Demonstrate how to convert speed in surface feet per minute to inches per minute.
- Describe safety precautions to observe when working with a drill press.
- Describe the boring procedure and tell when it is used.

Lesson 4: Reaming

Topics

Carbide-tipped reamers; Selection; Reaming speeds and feeds; Cutting fluids; Chatter; Troubleshooting; Counterboring; Spotfacing

Objectives

- Identify the main parts of a reamer.
- Tell what reaming method is best to use when a very accurate hole is required.
- Describe the benefits and uses of the following reamers: shell, hand, adjustable, expansion, taper, high speed steel, and carbide tipped.
- Explain how to remove burrs from the cutting edges or teeth of a reamer.
- Define counterboring, countersinking, and spotfacing.

Lesson 5: Threads and Threading

Topics

Common thread series; Thread ID; Tapping; Tap sets; Drilling a hole to be tapped; Tapping pipe threads; Threading with dies; Measuring threads

Objectives

- Describe and state the uses of the following threads: National, square, Acme, and Buttress.
- Explain how the sizing of pipe threads differs from the sizing of other threads.
- Explain when to use each of the following taps: plug, taper, bottoming, spiral-pointed, spiral-fluted, and fluteless.
- Tell why cutting fields are used in tapping operations.
- Explain how to deal with long chips when tapping.

MPACT® INSTITUTE Certified Training Program

Machine Shop Shaping Operations

Course 317: Machine Shop Shaping Operations
Covers types of milling machines and milling operations. Covers spindles, arbors, feed rates, and safety precautions. Discusses shaper and planer operations—setup, maintenance, and safety procedures. Also introduces grinding, power sawing, and gear cutting operations.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Milling Operations

Topics

Milling machines; Spindles; Arbors; End mill holders and collets; Locating the cutter; Spindle speed, feed, and direction; Indexing; Safety

Objectives

- Explain the difference between peripheral milling and face milling.
- List the four types of knee-and-column milling machines.
- Explain how each of the knee-and-column machines works.
- Explain how a workpiece is held on a milling machine.
- Name and describe the three basic styles of arbor.
- Explain how the speed of a milling cutter is measured.
- Define indexing.

Lesson 2: Shaping and Planing

Topics

Shaper tooling; Cutting fluids; Cutting speeds; Setup procedures; Angular, internal shaping; Planer construction and tools; Safety

Objectives

- Compare and contrast shapers and planers.
- Explain the processes of shaping and planing.
- Explain how to select a shaper cutting fluid.
- Explain how shaper cutting speed is expressed.
- Explain how to check alignment of the shaper vise and ram.
- Explain how cutting fluids are applied to planer work.

Lesson 3: Grinding Operations

Topics

Grinding machines; Manual grinding; Grinding wheels; Mounting, dressing, and truing a grinding wheel; Cutting fluids; Grinding faults; Safety

Objectives

- Define grinding.
- Name the five categories of grinding.
- Explain how to read the marking code on a grinding wheel.
- Explain how to mount a grinding wheel.
- Define the terms dressing and truing as related to grinding wheels.
- Explain how cutting fluids id grinding operations.
- List the steps involved in surface grinding.

Lesson 4: Gear Cutting

Topics

Gear types, terms, and definitions; Diametral pitch; Tooth calculations; Cutting spur, bevel gear teeth; Repairing a gear; Cutting other gears

Objectives

- Name the most common and easiest-to-make gear.
- Name the most widely used types of gears in plant machinery.
- Define the following terms: pitch diameter, circular pitch, diametrial pitch, working depth, and face width.
- Explain how to check the first full tooth of a spur gear after cutting.
- Describe the pitch line of an involute rack.
- Explain how the teeth of straight bevel gears are cut.

Lesson 5: Power Sawing

Topics

Power hacksaws; Blade selection, inspection, and installation; Band saws and blades; Cutting fluids; Straight, contour, and friction sawing; Safety

Objectives

- Explain when and why cutting fluid is required when using a power hacksaw.
- Explain how to select a power hacksaw blade.
- List at least three rules for good hacksawing.
- Contrast the operation of a hacksaw and a band saw.
- List the three factors involved in selecting the right band saw blade.
- Explain the important points of power sawing safety.

MPACT® INSTITUTE Certified Training Program

Machine Shop Job Analysis

Course 323: Machine Shop Job Analysis
Covers types of jobs likely to be encountered by the maintenance machinist, and describes how the machinist decides which machine(s) to use for particular operations. Shows how to analyze the entire job before selecting the most efficient sequence of machining operations. Builds on Courses 315, 316, 317, and is a prerequisite for the "hands-on" projects in the courses that follow.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Machining Cylindrical Shapes

Topics

Turning; Shoulder facing; Machining fillets; Turning profiles; Knurling; Filing; Facing; Boring; Counterboring; Thread cutting

Objectives

- Explain the procedures for turning single and multiple diameters, including shoulders, fillets, and relief notches.
- Compute tapers, including the use of the setover method, compound rest method, and taper attachment method.
- Show how to use the cutting tools and machines for knurling, filing, and polishing.
- List the procedures for facing chucked work and work mounted between centers on the lathe.
- Describe the procedures for boring and counterboring in a lathe and boring mill.

Lesson 2: Drilling, Reaming, and Honing

Topics

Workpiece stationary, drill rotating; Workpiece rotating, drill stationary; Drill press jobs; Radial drill presses; Spot facing tools; Boring bars; Drill bushings and jigs; Reaming; Honing

Objectives

- Describe the basic drilling process.
- List drilling procedures for work mounted in a lathe.
- List drilling procedures for work mounted in a drill press.
- Explain the use of reaming in a lathe and a drill press.
- Explain the use of honing and the type of equipment used.

Lesson 3: Machining Flat Surfaces

Topics

Plain, side, straddle, profile, and face milling; Irregular shapes; Slotting; Shaping; Broaching; Surface grinding

Objectives

- Describe the basic milling process, cutter types, and their application.
- List slotting procedures in a milling machine.
- Define shaping, its tooling, and its relationship to planing and milling.
- Define broaching, its application, and the machines used.
- Define surface grinding, its application, and the machines used.

Lesson 4: Determining Tolerances and Finishes

Topics

Linear dimensions; Tolerances; Limits; Tolerance stackup; Rough cuts; Allowances for finishing; Finish cuts; Surface texture and finish

Objectives

- Define dimensional factors, including linear and angular dimensions.
- Compute tolerances and tolerance stackup.
- Describe allowance for finishing, including procedures for finish cuts.
- Compute surface texture in terms of an average used for final machining.
- Analyze surface finish requirements as specified for the job.

Lesson 5: Variables Affecting Job Efficiency

Topics

Machinability; Chip formation; Selection and application of cutting fluids; Solid lubricants; Machining efficiency; Selecting tooling/fixtures

Objectives

- Define machinability of workpiece stock, including machining variables, and workpiece variables.
- Explain machinability ratings.
- Select cutting fluids, cutting lubricants, and solid lubricants.
- Describe machining efficiency, including minimal workpiece setups and standard versus special tooling and fixtures.
- Identify the correct machine and cutting tool for a given job.

MPACT® INSTITUTE Certified Training Program

Lathe—Turning Work Between Centers

Course 324: Lathe—Turning Work Between Centers
Takes the trainee through a series of operations on the lathe to make a student project (a plug gauge). Covers lathe setup, rough turning procedures, finish turning, and chamfering. Next covers shouldering, knurling, and notching operations. Finishes with external thread cutting and maker tapers.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Lathe Setup and Workpiece Preparation

Topics

Setting up the lathe; Installing the faceplate and lathe dog; Live and dead centers; Facing ends; Test running; Tool selection and mounting; Speed and feed

Objectives

- Describe how to select a work mounting method.
- Install a faceplate and lathe dog in a lathe.
- Select and mount a cutting tool for facing the ends of a workpiece.
- Explain how the optimum speed and feed are selected.
- Face the ends of the workpiece.

Lesson 2: Rough and Finish Turning

Topics

Selecting and aligning the cutting tool; Speed and feed selection; Trial cuts; Rough and finish turning; Setting controls; Chamfering

Objectives

- Align the cutting tool with the workpiece.
- Take a trial cut on the workpiece.
- Rough turn the workpiece.
- Finish turn the workpiece.
- Chamfer edges of the workpiece.

Lesson 3: Shouldering, Knurling, and Notching

Topics

Laying off shoulders; Caliper; Scriber; Turning filleted shoulders, large fillets, and square shoulders; Round-nose cutter; Notching; Knurling; Polishing

Objectives

- Describe how to lay off shoulders using the caliper, scriber, and parting tool methods.
- Turn a filleted shoulder on the workpiece.
- Explain how to notch a workpiece with a parting tool.
- Knurl the workpiece.
- Perform a polishing and filing operation between centers.

Lesson 4: Cutting External Threads

Topics

Lathe thread-cutting parts; Lead screw; Split nuts; Screw thread features; Thread-cutting tools; Dial indicator; Setting speed and depth of cut

Objectives

- Prepare and mount the workpiece.
- Describe screw thread features.
- Explain in detail how threads are cut on a lathe.
- Set the thread cutting speed and use the thread dial indicator.
- Determine the total depth of cut and take a trial and finish cut on the workpiece.

Lesson 5: Turning Tapers Between Centers

Topics

Taper calculation; Laying off; Tailstock setover; Taper attachment; Taper turning; Machining the taper; Using the dial indicator and bevel protractor

Objectives

- Designate standard types of tapers as well as calculate special tapers.
- Explain how to turn a taper using the tailstock setover method.
- Describe how to turn a taper using a taper attachment.
- Turn a taper using the compound rest method.
- Tell how to use the dial test indicator and vernier bevel protractor for close tolerances.

MPACT® INSTITUTE Certified Training Program

Lathe—Machining Work in a Chuck

Course 325: Lathe—Machining Work in a Chuck
A sequential follow-up to Course 324 on lathe operation, covers chuck installation, boring and counterboring operations, thread cutting, and taper boring. Continues into special lathe operations that use faceplates, angle plates, and boring bars. Provides several real "hands-on" projects.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Lathe Setup and Workpiece Preparation

Topics

Chuck size selection; Installing a chuck and work in a chuck; Correcting misalignment; Using 3-jaw, 4-jaw, collets chuck, and mandrels; Removing chuck

Objectives

- Select and install a chuck.
- Install and center work in a chuck.
- Use a 3-jaw and 4-jaw chuck.
- Use a collet chuck.
- Use a mandrel.

Lesson 2: Rough Turning and Finish Turning

Topics

Tool selection, installation, and alignment; Setting speed and feed; Rough turning; Cutting fluids; Longitudinal feed; Rough and finish turning; Facing

Objectives

- Select, install, and align both a facing tool and a turning tool.
- Set the correct speed and feed for facing and turning.
- Rough turn a workpiece.
- Finish turn a workpiece.
- Face a shoulder

Lesson 3: Boring and Counterboring

Topics

Boring tool design; Installing a boring bar and bit; Adjusting cross feed; Rough boring; Coolants; Finish boring; Counterboring

Objectives

- Select and install a boring bar and bit.
- Select the speed and feed for boring and counterboring.
- Make a trial cut.
- Rough bore and finish bore a workpiece.
- Counterbore a workpiece.

Lesson 4: Cutting Internal Threads and Boring Tapers

Topics

Tool selection; Installing, aligning, and threading the workpiece; Checking finished threads; Boring tapers

Objectives

- Select, install, and align a thread-cutting tool.
- Machine internal threads in a workpiece.
- Check finished threads.
- Bore a taper using the compound-rest method.
- Bore a taper using the taper-attachment method.

Lesson 5: Holding Irregular and Oversize Workpieces

Topics

Mounting workpiece on a faceplate; Using faceplate jaws, clamps, and angle plates; Facing large diameters; Specialized mandrel; Boring

Objectives

- Mount and true a faceplate.
- Use faceplate clamps and jaws.
- Hold work on an angle plate.
- Mount work on the lathe carriage for boring.

MPACT® INSTITUTE Certified Training Program

Basic Milling Procedures

Course 326: Basic Milling Procedures
Covers the setup and use of the horizontal milling machine, and describes the functions of basic cutters and attachments. Uses "hands-on" projects so trainees actually gain experience on the milling machine. Includes a work-holding fixture project that can have practical value in the shop when finished.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Using the Horizontal Milling Machine

Topics

Milling machine parts and functions; Vertical milling attachments; Speed and feed; Depth of cut; Lubricants; coolants

Objectives

- Identify the major parts of a universal horizontal milling machine and their functions.
- Define the use of a vertical milling attachment.
- Compute the milling spindle speed and the machine table feed rate.
- Install and align a workpiece in a V-block.
- Install and align a workpiece in a milling machine vise.

Lesson 2: Slab Milling Procedures

Topics

Slab milling cutters; Installing the arbor and cutter; Speed and feed selection; Depth of cut; Alignment; Trial cut; Rough milling; Finish milling cut

Topics

- Select and install a slab milling cutter on a Style B arbor.
- Install a Style B arbor with cutter, spacers, key, and bearing sleeve into a horizontal milling machine.
- Complete a rough slab milling cut on a workpiece.
- Complete a finish slab milling cut on a workpiece.

Lesson 3: Milling Slots and Angles

Topics

Aligning cutter and workpiece; Milling a slot; Angle milling; Angular milling with a vertical milling attachment; Milling a dovetail

Topics

- Mill a slot with the cutter in a horizontal and a vertical spindle position.
- Use a T-slot cutter in both a horizontal and vertical spindle position.
- Angle mill a bevel from both a horizontal and vertical spindle position.
- Use adapters for shank-type cutters.
- Cut a female dovetail in a workpiece using a dovetail cutter.

Lesson 4: Straddle, Side, and Face Milling

Topics

Selecting, mounting, and aligning the cutters; Machine setup; Making the first cut; Using trig functions for the final cut; Face milling

Topics

- Select, set up, and align straddle milling cutters on a Style B arbor.
- Straddle mill a workpiece.
- Cut an angular step using a side milling cutter.
- Face the side of a workpiece with a shell end mill.
- Face a broad workpiece surface using a face mill.

Lesson 5: Milling Keyseats, Squares, and Flats

Topics

Keyseats for square and woodruff keys; Selecting and installing the cutter; Depth of cut; Speeds and feeds; Using automatic feed controls; Milling squares on round work; Milling tangs and flats

Topics

- Select and install a standard Woodruff keyseat cutter.
- Mill a keyseat with rounded ends (for a square key) and a Woodruff keyseat (for a Woodruff key) in a workpiece.
- Make a plunge cut with a two-fluted end mill.
- Mill a square on the end of a shaft.
- Mill a tang and a flat on a cylindrical workpiece.

MPACT® INSTITUTE Certified Training Program

Indexed Milling Procedures

Course 327: Indexed Milling Procedures
Covers the use of the dividing head. Covers plain, differential, and angular indexing. Explains the use of the dividing head for milling hexagons. Proceeds to the cutting of spur gears, helical gears, and cams.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Using the Dividing Head

Topics

Indexing; Dividing head; Indexing fractions of a turn and parts of a degree; Sector arms; Selecting an index plate; Angular and differential indexing

Objectives

- Describe indexing and its uses.
- Identify the parts of a dividing head.
- List the four types of indexing you can do with a dividing head.
- Explain how to use sector arms to index fractions of a turn.
- Select the right index plate for the job.

Lesson 2: Dividing Head Setup

Topics

Dividing head center, driver, and chuck; Milling hexagons; Side and straddle milling; Setting up the dividing head; Indexing the workpiece

Objectives

- Mount a dividing head on a milling machine table.
- Mount work between a dividing head and footstock.
- Mount work in a dividing head chuck.
- Index and side mill or straddle mill a hexagonal workpiece.
- Use the dividing head to index a series of holes in a circle.

Lesson 3: Milling Spur Gears

Topics

Milling spur gear teeth; Concentricity; Aligning the workpiece; Setting up the dividing head; Indexing with a rotary table; Gear tooth calipers; Helical milling; Helix angle and pitch

Objectives

- Index spur gear teeth on a gear blank.
- Use formulas to compute gear tooth dimensions.
- Select the correct cutter for specific spur gear tooth dimensions.
- Explain how to use a rotary table.
- Use the measuring over pins technique to check the dimensions of gears.
- Define the terms helix, helix lead, helix angle, and helix pitch.

Lesson 4: Helical Milling

Topics

Using idler gears; Milling helical flutes; Indexing; Selecting and aligning the cutter; Setting depth of cut; Milling a helical gear

Objectives

- Use change gears to vary the lead of the milling machine.
- Describe the purpose of idler gears.
- Compute the lead of a helix.
- Index and mill helical teeth on a cutter.
- Index and mill helical gears

Lesson 5: Milling Cams

Topics

Cam functions; Nonpositive and positive cam systems; Uniform motion, harmonic cam systems; Incremental-cut method

Objectives

- Describe positive and nonpositive cam systems.
- Define radial cam terms such as cam lobe, uniform rise, cam rise, and cam lead.
- Mill a uniform-rise cam.
- Mill a short-lead cam.
- Mill a multilobe cam.
- Explain how to use the incremental-cut method to mill a nonuniform rise cam.

MPACT® INSTITUTE Certified Training Program

Multiple-Machine Procedures

Course 328: Multpile-Machine Procedures
Previous courses have dealt largely with the operation of two major machine tools, the lathe and the milling machine. This course picks up some of the other machines found in a machine shop, some of which may be used infrequently, but which nevertheless require specific skills to operate. In most cases, simple projects are described to give trainees experience working with these machines.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Power Sawing

Topics

Power hacksaw; Vertical and horizontal bandsaw; Band installation; Setup; Making the cut; Safety; Filing; Internal cutting; Welding the band

Objectives

- List the three main types of power saws commonly used in maintenance machine shops and describe their appropriate uses.
- Explain the primary difference between a hacksaw and a bandsaw.
- Demonstrate how to install the band on a horizontal bandsaw.
- Demonstrate how to set up a workpiece and make a cut on a horizontal bandsaw.
- Describe the safety precautions to be taken when working with a vertical bandsaw.
- Explain how to make an internal cut using the vertical bandsaw.
- Demonstrate how to reweld the band of a vertical bandsaw.

Lesson 2: Drilling Operations

Topics

Drill press types and components; Sample drill press project—preparation, drilling corner, mounting, dowel holes, sawing out the center

Objectives

- Name three types of drilling machines in common machine shop use.
- List the main features of a sensitive drill press.
- Describe the factors used to select the best drill for a given job.
- Describe correct, safe practices for changing drill bits.
- Explain how to achieve the most efficient order of drill press operations.
- Demonstrate how to set a workpiece perfectly level on a drill press table.
- Demonstrate how to select the correct speeds and feed rates for a drill press.

Lesson 3: Operating a Horizontal Shaper

Topics

Shaping machines; Shaper tables; Tool head and clapper box; Cutting tools; Work-holding devices; Sample project; Shaping slants and slots

Objectives

- List four specific uses for a horizontal shaper.
- Describe the safety precautions to be taken when working with or around a shaper.
- Demonstrate how to mount a block-shaped workpiece in a shaper vise.
- Explain how to calculate and set the proper stroke rate on a shaper.
- Demonstrate how to set length of stroke and correctly position the ram over the workpiece.
- Demonstrate how to indicate-in on a horizontal shaper.

Lesson 4: Grinding Operations

Topics

Surface grinder; Preparation; Grinding basic flat, parallel surfaces; Cylindrical grinder; Grinding parallel diameters and square shoulders

Objectives

- Explain the purpose of a surface grinder
- Demonstrate how to dress and true a grinding wheel.
- Demonstrate how to set up a workpiece on a surface grinder, and grind its surfaces to specified dimensions.
- Explain the purpose of a cylindrical grinder.
- Demonstrate how to set up a workpiece between centers on a cylindrical grinder.
- Describe the processes of traverse grinding, plunge grinding, and bumping the shoulder.
- Calculate the rpm settings for the wheel of a cylindrical grinder and for the workpiece, given the sfpm.
- Describe safety procedures for both types of grinders.

MPACT® INSTITUTE Certified Training Program

Lesson 5: Boring Mill Operations

Topics

Horizontal boring mill types; Boring tools and cutters; Setup and alignment; Holding the workpiece; Trial cut; Mill operations

Objectives

- Describe three different types of horizontal boring mills.
- Explain the purpose of a rotary table, a line boring bar, slot blocks, a drawbolt, and a continuous-feed (cross-slide) head.
- Explain how a boring bar is aligned on center of an existing hole in the workpiece.
- Describe how a facing operation works on a horizontal boring mill.

Bulk-Handling Conveyors

Course 331: Bulk-Handling Conveyors
Covers belt conveyors that carry coal, sand, gravel, grain and other loose materials. Acquaints the trainee with the terminology, basic structure, and operation of these systems. Includes detailed coverage of belts, belt cleaners, idlers, and feed/discharge devices, as well as an explanation of how to install, maintain, replace, and troubleshoot these components.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Conveyor Components

Topics

Conveyor profiles, pulleys, and idlers; Bulk-handling conveyor belts; Conveyor drive packages; Support components

Objectives

- Describe the basic operation of a bulk-handling belt conveyor and identify its major components.
- Name and explain the function of the different pulleys used in belt conveyors.
- Describe four popular conveyor drive-package arrangements.
- Explain the purpose and the operation of at least four of the support components of a bulk-handling belt conveyor.

Lesson 2: Bulk-Conveyor Belting

Topics

Belt plies; Storing and handling belts; Installation; Squaring ends, cutting; Belt fasteners; Vulcanized splicing; Tensioning, repairing, and replacing the belt; Troubleshooting

Objectives

- Describe the composition and structure of the three components of a bulk-handling conveyor belt.
- State correct storage and handling procedures for bulk conveyor belts.
- Detail the installation of a belt in a bulk conveyor system, including splicing and tensioning.
- Name the five points that require special attention in a preventive maintenance program for a belt conveyor system.

Lesson 3: Belt Cleaners and Idlers

Topics

Blade, brush, and plow type belt cleaners; Cleaning by rollover; Deck plates; Return idlers; Wing pulleys; PM, inspection, and troubleshooting

Objectives

- Describe the design and placement of blade, brush, and plow belt cleaners and the applications for which each one would be used.
- Name and describe the different types of blade belt cleaners.
- Describe the process of belt cleaning by rollover.
- Explain how devices such as wing pulleys, self-cleaning return idlers, and deck plates function as parts of a belt cleaning system.
- Describe the appropriate safety precautions to take when installing or maintaining belt cleaners.
- List the essential features of preventive maintenance and inspection for a belt cleaning system.

Lesson 4: Feed and Discharge Devices

Topics

Factors in loading and discharge; Skirting devices; Hoppers and accessories; Loading and discharge chutes; Spouting; Inspection; Troubleshooting

Objectives

- Explain two important factors in efficient conveyor loading and how they are affected by the two ways (directions) in which belt conveyors are loaded.
- Describe the construction and the purpose of skirtboards.
- Differentiate between a deadbed and a bed of fines and detail the use of both in chute loading of conveyors.
- Name and explain the operation of three special types of discharge spouts.

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Lesson 5: Safety and Troubleshooting

Topics

Loading and discharge points; Emergency controls; Preparing for maintenance; Common problems, possible remedies

Objectives

- Differentiate between a conveyor profile and a system profile.
- Point out the special hazards for workers at conveyor loading and discharge points.
- Explain the function and operation of the following emergency controls: electrical interlocks, backstops, level switches, pull-cords, and conveyor belt alignment switches.
- Name at least five safety measures employees should take to protect themselves when working on or near bulk-handling conveyors.
- Describe the three-step procedure for preventing accidental startup of a conveyor during maintenance work.
- Name at least one specific chore or safety caution required in maintenance work on each of the following: belts, idlers, pulleys, and drive systems.
- Identify common problems (and their probable causes) found in troubleshooting idlers, pulleys, takeup bearings, and conveyor drives.

Mechanical Drives Maintenance

Course 341: Mechanical Drives Maintenance
Covers alignment, particularly coupling alignment. Includes installation and maintenance of mechanical drives, from chain drives to enclosed gear drives.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Chain Drives

Topics

Installing and aligning shafts; Mounting the drive sprockets and chain; Test running; Lubrication; PM; Chain storage; Troubleshooting; Safety

Objectives

- List four types of chain drives.
- Describe the procedure for aligning the driving and driven shafts.
- Distinguish between bored sprockets and bushed sprockets and tell how each is mounted.
- Tell how a drive chain is mounted on the sprockets.
- List four methods of lubrication for chain drives.
- Explain both no-load and full-load test running procedures.
- Describe the causes of fatigue breaks, tensile breaks, rapid chain wear, roller wear, and side plate spreading.

Lesson 2: Belt Drives

Topics

Installing and aligning drives; Mounting sheaves and pulleys; Installing and adjusting V-belts; Idler sheaves; Flat, positive belt drives; Maintenance

Objectives

- List the three general types of belt drive and explain how they work.
- Tell how sheaves and pulleys are mounted and aligned on their shafts.
- Explain why all the belts in a multi-belt drive must be replaced at the same time.
- Describe two ways of taking up slack in a stretched V-belt.
- List three ways of splicing the ends of a flat belt together.
- Differentiate between the way positive-drive belts and other types of belt transmit power.

Lesson 3: Open Gear Devices

Topics

Aligning and preparing shafts; Handling and mounting gears; Lubricating open gearing; Preventive maintenance; Troubleshooting; Safety

Objectives

- Explain why open gearing requires special provisions for feeding lubricating oil to its parts.
- Describe how to align parallel shafts, intersecting right-angle shafts, and nonintersecting right-angle shafts.
- Describe the procedure for aligning worm gearing.
- List some of the problems a visual inspection of gearing can uncover.
- Describe the appearance and causes of wear, abrasion, corrosion, scoring, pitting, spalling, cold flowing, fatigue breaks, and cracked rims and webs.

Lesson 4: Enclosed Gear Drives

Topics

Preparing the foundation; Installation; Lubrication; Test running; PM; Troubleshooting

Objectives

- Tell how an enclosed gear drive should be mounted on the floor.
- Tell how an enclosed gear drive should be mounted on the framework of a driven machine.
- Describe the two methods of lubrication used in enclosed gear drives.
- Explain what should be done during the initial run-in, the one-week check, and the thirty-day check.
- List four steps you should take to protect an enclosed gear drive that is to be put into storage.
- Identify typical nameplate data.

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Lesson 5: Drive Couplings

Topics

Installing and aligning shaft couplings; Expansion allowance; Lubrication; No-load testing; Installing universal joints; PM

Objectives

- List three purposes of a coupling.
- List the three basic types of coupling.
- Explain how to check both the angular and the parallel alignment of shafts.
- Tell how a dial indicator is used in precision coupling alignment.
- Calculate shim thickness required to align couplings in an angular plane.
- Distinguish between couplings that need lubrication and those that do not.
- Describe how shaft couplings, spacer couplings, floating shaft couplings, and universal joints are installed.

Mechanical and Fluid Drive Systems

Course 342: Mechanical and Fluid Drive Systems
Covers further details of drive maintenance, including brakes, clutches, and adjustable-speed drives. Also covers maintenance and troubleshooting of fluid drives and package drive systems.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Mechanical Brakes and Clutches

Topics

Installing mechanical clutches and brakes; Preparing shafting; Initial lubrication; Providing the power supply; Test running; PM; Safety

Objectives

- Explain how friction-type and jaw-type clutches differ in construction.
- Name the precautions that should be taken when mounting body on a shaft.
- Explain how to test-run a mechanical clutch with no load.
- Explain how to install a mechanical brake.
- Describe the results of improper alignment between driving and driven shafts.
- Identify the problems that may be indicated by chatter and excessive noise.

Lesson 2: Electric Brakes and Clutches

Topics

Single- and multiple-disc friction clutch; Tooth-type, hysteresis, eddy-current, and magnetic particle clutch; Heat dissipation; PM; Wiring; Safety

Objectives

- Describe how single-disc and multiple-disc friction clutches operate.
- Explain how the principle of hysteresis is applied in electric clutches.
- List the three basic components of magnetic particle clutch.
- Differentiate between the static torque, pickup torque, and average torque of a clutch.
- Identify the problems that may arise in a clutch if its heat is not dissipated.
- Define decay time, pull-in time, and response time.

Lesson 3: Adjustable-Speed Drives

Topics

Storage and protection of enclosed drives; Handling and leveling enclosed drives; Repairing shafting; Vibration; Lubrication; Test running; PM; Safety

Objectives

- List the precautions necessary to provide extra protection for open-type drives.
- Describe how to install an enclosed-type drive on a concrete floor.
- Explain how to prepare the shafting when installing a new enclosed drive.
- Describe the initial lubrication of new adjustable-speed drives.
- Describe how to test-run an adjustable-speed drive under no load and full load conditions.
- Name some of the safety rules for working on an adjustable drive.

Lesson 4: Fluid Drives

Topics

Constant and variable-speed couplings; Torque converters; Coupling drive arrangements; Installing fluid couplings; PM, Safety

Objectives

- Explain how a fluid drive works.
- Describe how constant-speed couplings differ from variable-speed couplings.
- Trace the fluid path through a torque converter using either a drawing or a cutaway.
- Describe the various ways of mounting a fluid coupling.
- Explain how to cool the fluid in large couplings.
- Discuss preventive maintenance procedures for couplings.

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Lesson 5: Complete Drive Systems

Topics

Drive with coupling and roller chain, with two flexible couplings, and with right-angle shafts; Installation; PM; Troubleshooting; Safety

Objectives

- List the components used in a typical drive system.
- Name the part of a drive system in which most of the speed reduction occurs.
- Describe the construction and operation of a shaft-mounted drive.
- List the protective devices for a drive.
- Explain the proper maintenance procedures for a drive system.
- Describe the steps to be taken when troubleshooting a drive system.

Bearing and Shaft Seal Maintenance

Course 343: Bearing and Shaft Seal Maintenance
Covers plain bearings, their parts, dimensions, functions, and relining techniques. Continues with installation and replacement of antifriction bearings. Also covers linear motion bearings and shaft seals.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Plain Bearings

Topics

Lining material characteristics; Prefab and poured bearing liners; Measuring the bore; Installation; Lubrication; Removal; Troubleshooting

Objectives

- Name the important dimensions of a plain bearing.
- State the source for learning the proper running clearance in a plain-bearing installation and describe how to measure running clearance.
- State the characteristics of bearing and liner material and explain how they influence the choice of bearing for a given application.
- Discuss the steps involved in fabricating a poured babbitt bearing liner and obtaining the correct finished-bore dimensions.
- State the purpose and general principles of plain-bearing installation.
- List important factors to consider when selecting the correct lubricant for a given plain-bearing installation.
- Identify the symptoms of bearing trouble and describe how to remedy each situation.

Lesson 2: Installing Antifriction Bearings

Topics

Inspecting the bearing and bearing seat; Bearing seating methods; Cold mount techniques; Temperature mount; Lubrication; Inspection

Objectives

- Describe proper procedures in handling, storing, cleaning, and inspecting antifriction bearings.
- Explain how to measure, inspect, and condition a shaft bearing seat prior to installing a new bearing.
- Tell where pressure should be applied to force a ball bearing onto a shaft.
- Name the two dimensions that are important in mounting a tapered-bore bearing on a shaft.
- Describe the steps involved in correctly seating an antifriction bearing.
- Discuss how an adapter is used to mount a bearing on a shaft.
- Describe the steps to take when using a hot-oil bath to heat a bearing for mounting.
- Name the three major signals of bearing failure in antifriction bearings.

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Lesson 3: Removing and Replacing Antifriction Bearings

Topics

Retainers and seals; Press and impact bearing removal; Removal with mechanical pullers and heat; Cleaning, inspecting, and replacing bearings

Objectives

- Describe the correct procedures for removing bearing seals and retaining devices from a bearing assembly.
- Describe the impact bearing removal technique.
- Explain how to use an aluminum heating ring to mount and dismount the inner ring of a cylindrical roller bearing.
- Discuss the steps involved in inspecting and cleaning used bearings.
- Describe the procedures for remounting sound used bearings.
- Explain how to replace a shaft seal.
- List the safety precautions that are essential to working with bearings.

Lesson 4: Mounted Antifriction Bearings

Topics

Seals; Housings; Bearing inserts and mounting devices; Shaft misalignment; Installation; Pillow block lubrication; Maintenance

Objectives

- Name the three major types of housings or mounts for bearings.
- Name the major components of a mounted antifriction bearing.
- Describe the two basic types of bearing seal and name the advantages of each.
- List the different methods of securing insert bearings to the shaft and describe the mounting methods involved.
- Discuss shaft alignment and describe bearing design factors that compensate for misalignment.
- Explain why most bearing/shaft assemblies have one free and one fixed bearing.
- List factors to consider when selecting bearing lubricants for pillow blocks.

Lesson 5: Linear Motion Bearings and Shaft Seals

Topics

Installing and lubricating ball bearing screw; Shaft seals; Temperature effects; Shaft, housing, and seal installation and removal; Troubleshooting

Objectives

- Name the major components of a ball bearing screw.
- Describe the major differences between a ball bearing screw and an acme screw.
- Describe the main purpose of a ball bearing screw and give an example of a typical application.
- Describe the installation procedures for a ball bearing screw.
- Name the differences between contact and labyrinth seals and explain what creates the sealing action in each.
- List the factors that determine the choice of shaft seal.
- Describe how to install a lip seal on a shaft, including shaft preparation.
- Name the major problem that arises with lip seals and list at least four conditions that can cause it.

Pump Installation and Maintenance

Course 344: Pump Installation and Maintenance
Covers basic pumping concepts. Describes required maintenance of packing and seals. Covers maintenance and overhaul of centrifugal pumps. Concludes with maintenance of rotary pumps.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Basic Pumping Concepts

Topics

Available and required NPSH; Checking pump capacity; Computing pump power requirements; Operational factors; Priming a pump

Objectives

- Compute the amount of work done when given values for force and distance.
- Name the two types of energy.
- Check pump capacity by determining NPSHA of the system.
- Compute the brake horsepower required to drive a pump under given conditions.
- Explain how to prime a fluid-handling pump.

Lesson 2: Maintaining Packing and Seals

Topics

Selecting packing material; Removing old, installing new packing; Mechanical seals; Maintenance and troubleshooting

Objectives

- Identify the two major functions of packing and seals.
- Explain selection and installation of packing rings on a pump shaft.
- Identify the components of typical mechanical seals.
- Name at least three advantages of mechanical seals over packing.
- Describe how to install a mechanical seal on a pump shaft.
- Discuss the care and maintenance of packing and seals.

Lesson 3: Maintaining Centrifugal Pumps

Topics

Installing the pump; Preparing the foundation; Checking alignment; Inspection; Common problems; Cavitation; Ring seizure; Overheating

Objectives

- Explain how to align and level a pump on its base.
- Explain the needs for and uses of auxiliary pump drives.
- Identify the major symptom of faulty packing.
- Identify the major symptom of cavitation on a pump impeller.
- Describe the causes and remedies of common centrifugal pump problems.
- Tell how to conduct a periodic inspection of the major pump components.

Lesson 4: Overhauling Centrifugal Pumps

Topics

Preparation; Moving, disassembling, reassembling, and reinstalling a pump; Inspecting parts; Checking clearances

Objectives

- Describe the procedures involved in disassembling, inspecting, reassembling, and reinstalling a centrifugal pump.
- Explain how to check the runout of a pump shaft.
- Explain how to check the clearances between stationary rings and the impeller or rotating rings.
- Describe how to make a new housing gasket.

Lesson 5: Maintaining Rotary Pumps

Topics

Installing, maintaining, and troubleshooting rotary pumps; Aligning pump and piping; Direction of rotation; Startup; Scheduling inspections; PM

Objectives

- Identify the differences between the different types of rotary pumps.
- Trace the path of fluid through a rotary pump.
- Identify the major problem areas in a rotary pump.
- Explain how to troubleshoot some of the common problems of rotary pumps.
- Create a maintenance schedule for inspections and a record-keeping log.

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Maintenance Pipefitting

Course 345: Maintenance Pipefitting
Covers components and terminology used in piping systems. Also covers terminology, measurement, and maintenance of threaded, welded, and plastic piping systems. Explains the use of pipefitting accessories—supports, traps, filters and strainers, and expansion joints.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Piping Dimensions and Terminology

Topics

Piping standards, dimensions, and symbols; Pipe fittings; Flanges; Using dimensional tables; Calculating length; Straight and rolling offsets

Objectives

- State whether ID or OD identifies a given nominal pipe size.
- Given a nominal pipe size and a copy of the American Standard Code for Pressure Piping, find the wall thickness of a pipe of a given schedule number.
- Name at least four kinds of pipe fittings.
- Given a schematic drawing of a piping system, identify all fittings used in the system.
- Given a drawing showing three lengths of pipe with and without fittings installed, correctly name the application dimension for measuring the pipe length.
- Given a schematic drawing showing two parallel horizontal pipe runs with a 45° run connection, identify the travel, set, and face-to-face length.

Lesson 2: Threaded Piping Systems

Topics

Thread terminology; Measuring pipe threads; Measuring, cutting, threading, and finishing pipe; Sealants; Assembly; Emergency repair

Objectives

- Given a descriptive number, identify the pipe size, thread type, and number of threads per inch on a threaded pipe.
- Given a length of unthreaded pipe and required thread specifications, thread one end of the pipe to meet the specifications.
- Given a length of threaded pipe and two threaded fittings, prepare the parts, apply the proper compound, and assemble the components.
- State the important parts of a pipe thread.
- Given actual dimensions for travel and set of a threaded pipe and fitting assembly, use established dimensional tables to compute the total length of replacement pipe needed.

Lesson 3: Welded Piping Systems

Topics

Welded pipe fittings; Welding rings; System alignment; Preparing the work; Squaring the flange; Weld cracks; Inspection; Repair

Objectives

- Explain what steps to take to prepare lengths of pipe for butt and fillet welding.
- Name the welding ring material used with stainless steel or nickel alloy piping.
- Explain squareness and its importance in a welded piping system.
- Name the major assembly considerations when fabricating flanged connections for a rolling offset installation.
- Given a schematic drawing of this installation, compute the hole compensation angle to be used when positioning the flange for welding.
- Name at least one accessory used to help align two sections of pipe for welding.
- Given a length of pipe and a slip-on flange with a raised face, align and weld the pipe and flange.

Lesson 4: Plastic Piping Systems

Topics

Thermoplastic, thermosetting pipe, Advantages and disadvantages of plastic pipe; Installation; Troubleshooting

Objectives

- Name the materials used for plastic pipes and fittings.
- Name at least one advantage of plastic piping.
- Name the two most common materials used to make thermosetting plastic pipe.
- Given two lengths of thermosetting plastic pipe, demonstrate how to join then with a bell and spigot joint.
- Name at least one limitation of plastic piping.
- Demonstrate how to align and install fittings on a length of plastic pipe.

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Lesson 5: Pipefitting Accessories

Topics

Hangers and supports; Special mountings; Steam trap installation and cleaning; Filter, strainer, and separator installation and cleaning; Expansion joints

Objectives

- Name the three classes of piping supports and hangers.
- Explain which two types of pipe hangers are most often used to reduce line vibration and shock.
- Explain the factors to be considered when installing pipe hangers for different applications.
- Name the piping system components used to compensate for pipe length changes due to temperature changes.
- Explain the factors to be considered when locating (spacing) pipe hangers in a system.
- Name two types of steam traps and identify the major consideration in locating them.
- Explain the purpose of a line filter.

Tubing and Hose System Maintenance

Course 346: Tubing and Hose System Maintenance
Covers tubing specifications, materials, and fittings. Explains procedures used for handling, bending, cutting, and installing tubing. Gives basics of tubing in a hydraulic system. Describes hose systems and their functions. Concludes with gaskets, sealants, and adhesives.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Tubing Fundamentals

Topics

Tubing specifications and materials; Fittings; Handling, cutting, bending, sawing, filing, and deburring tubing; Calculating tubing length

Objectives

- Compare and contrast tubing and pipe.
- List factors to be considered when selecting tubing for a specific application.
- State a common application of various tubing materials.
- Describe various fittings and tell how to select the proper fitting for a given tube.
- Tell why is it sometimes necessary to anneal tubing.
- List the steps to follow when cutting, sawing, and deburring tubing.
- Explain how to calculate tubing length accurately.
- List the steps involved in bending a given length of tubing.

Lesson 2: Installing Tubing

Topics

Determining size; Soldered, brazed, flared, and flareless fittings; Flaring tubing; Installing compression fittings; Supports; Maintenance

Objectives

- Define the service conditions that must be taken into account when selecting tubing.
- List the properties and typical uses of various types of fittings.
- Explain the procedures involved in soldering and brazing.
- Name several types of flaring tools and explain how they are used.
- Explain how to install flared and flareless fittings.
- Tell how and why tubing systems should be well supported.
- List common causes of tubing system problems and their solutions.

Lesson 3: Hydraulic Tubing Systems

Topics

Hydraulic line components; Control devices; Selecting tubing and fittings; Installing, maintaining, and troubleshooting hydraulic tubing systems

Objectives

- Explain the principles of force, pressure, and area as applied to hydraulics.
- Discuss hydraulic fluids, hydraulic circuits, and hydraulic line components.
- Explain how to select the proper tubing and fittings for hydraulic systems.
- Describe maintenance and troubleshooting procedures for hydraulic tubing systems.

Lesson 4: Hose Systems

Topics

Hose construction and fitting; Measuring assembly length; Calculating hose length for bends; Installation; Testing; Inspection; Maintenance

Objectives

- Discuss the three most common applications for hoses in industry.
- Describe hose fitting classifications and installation techniques.
- Explain how to calculate hose lengths for bends.
- Describe the methods of testing, inspection, and maintaining hose.

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Lesson 5: Gaskets, Sealants, and Adhesives

Topics

Gasket materials; Critical dimensions; Making and installing a gasket; Preparing contact surfaces; Coatings and sealants; Gasket replacement

Objectives

- Identify the types and uses of gasket materials.
- Name the critical dimensions of a flanged pipe joint gasket.
- List and explain the three characteristics of contact surfaces that must be considered prior to the installation of a gasket.
- Explain the uses of gasket coatings, tapes, and strips.
- Describe the application of sealants and adhesives in gasket joints.

Valve Maintenance and Piping System Protection

Course 347: Valve Maintenance and Piping System Protection
Covers maintenance and operation of gate, globe, ball, plug, check, and special-purpose valves. Details actuators and various accessories. Explains valve selection based on application. Describes methods of protecting piping systems.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Valve Maintenance

Topics

Threaded, welded, brazed, and flanged connections; Installing and repairing gate, globe, angle, ball, plug, and check valves

Objectives

- Discuss the factors that affect the selection of valve materials.
- Describe the various methods of connecting valves to piping.
- Identify the various types of common valves and the operating characteristics of each.
- Explain general maintenance and repair procedures for different types of valves.

Lesson 2: Special Valves

Topics

Installation and repair of butterfly, diaphragm, pop safety, relief, pressure-reducing, pressure-regulating, and quick-opening valves

Objectives

- Identify several types of special valves and the operating characteristics of each.
- Discuss the installation, maintenance, and repair of special valves.

Lesson 3: Actuators and Accessories

Topics

Actuator installation, maintenance, and repair; Bourdon tube, bimetallic, and bellows gauges; Flowmeters; Rotating unions; Accumulators

Objectives

- Explain the function and operation of a valve actuator.
- Identify various types of valve actuators and describe the installation. maintenance, and repair of each.
- Discuss the operating characteristics of various accessories, including gauges, meters, accumulators, and air receivers.

Lesson 4: Valve Selection

Topics

Valve applications, materials, and identification; Soldered, threaded, and flanged valve connections; Tool selection; Valve positioning

Objectives

- Name the five major uses of valves in piping systems and identify the types of valves best suited for each.
- Identify and explain the factors that determine the selection of a valve for a given application.
- Identify various valve markings and symbols.
- Describe several types of valve-to-pipe connections.
- Discuss the selection and proper use of tools in valve installations.
- Explain the importance of the correct installation of valves in well-chosen locations.

Lesson 5: Piping System Protection

Topics

Installing and maintaining insulation; Steam tracers; Protection from freezing and corrosives; Active and passive protection; Inspection; Supports

Objectives

- Describe the methods by which heat transfer occurs.
- Discuss the methods of tracing process lines.
- Explain the various methods of protecting piping systems from heat, cold, and corrosion.
- Discuss the installation, inspection, and maintenance of insulation and other forms of piping system protection.

MPACT® INSTITUTE Certified Training Program

Introduction to Computers

Course 261: Introduction to Computers—User Level
Covers a brief history of the computer and defines fundamental computer terms. Introduces the binary and hexadecimal number systems. Explains the different levels of programming languages. Describes microprocessor characteristics and architecture in general terms. Concludes with examples of practical applications.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Computer Basics

Topics

Mainframes, minis, and micros; Hardware, software, and firmware; Bits, bytes, and nibbles; Number systems; Applications; Computer terminology

Objectives

- Explain the principal differences between mainframe computers, minicomputers, and microcomputers.
- Define the terms hardware, software, and firmware as they relate to a computer system.
- Define a bit, a byte, and a nibble.
- Explain three number systems used by computers.
- List three common computer applications.

Lesson 2: Computer Hardware

Topics

CPU operations; ROM, RAM, and I/O circuits; Peripherals; Storage devices; Monitors; Printers; Keyboards; Pointing devices; Scanners; Modems and fax machines; ADCs and DACs

Objectives

- Define peripheral equipment.
- Explain the function and operation of a central processing unit (CPU).
- Describe the different types of fast memory devices used by computers.
- Discuss the function and operation of I/O devices.
- Describe the different types of mass storage devices used by computers.
- Explain the term data interface as applied to a computer system.
- Explain the functions of an ADC and a DAC in a computer system.

Lesson 3: Computer Software

Topics

Instruction sets; Algorithms; Programs; Programming languages; Flow diagrams; Compilers; Interpreters; Operating systems

Objectives

- Explain the two essential elements of computer software—instruction sets and algorithms.
- Describe how a software flow diagram is used.
- Identify the three levels of computer programming languages.
- Explain what interpreters and compilers do.
- Describe the functions of an operating system.

Lesson 4: Computers and Microprocessors

Topics

Physical properties; Microprocessor architecture and types; Instruction sets; Co-processors and single-chip microcomputers

Objectives

- Explain the elements of microprocessor architecture.
- Discuss the different microprocessor characteristics.
- Discuss the different physical properties of a microprocessor.
- Explain the functions of the three kinds of buses used by computer systems.
- Name the elements of a single-chip microcomputer.

Lesson 5: Microprocessor Applications

Topics

Application categories; Logic system replacement; Industrial, business, and consumer applications; Future trends

Objectives

- Explain how and why microprocessors are used for logic system replacement.
- Discuss several industrial applications of microprocessors.
- Explain how microprocessors can simplify office procedures and improve business productivity.
- Give several examples of how microprocessors are used in consumer products.

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Input/Output Devices I

Course 262: Input/Output Devices I—User Level
Covers many of the input/output devices that make up a typical computer system. Explores communication—the successful transmission of information between computers—at length. Discusses both the user/machine interface and the machine/machine interface, as well as the various network configurations. Concludes with two "real-world" examples of how microprocessors are connected to I/O devices.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Introduction to I/O Devices

Topics

Digital and analog devices; Interfaces; Keyboards; Mice; Digitizers; Displays; Printers; Plotters; Storage devices; Limit switches; Shaft encoders

Objectives

- State the function of input/output (I/O) devices.
- Contrast digital and analog I/O devices.
- Describe three different types of input devices that are used by operators for entering data and commands into a computer.
- Describe three different types of output display devices.
- Compare floppy disk and hard disk mass storage.
- Explain the difference between binary and Gray code.

Lesson 2: Communication Systems

Topics

Serial/parallel communication; Frequency and phase modulation; Half- and full-duplex operation; Local data systems; LANs and configurations

Objectives

- Describe the differences between serial and parallel communication.
- Explain how microcomputer systems communicate.
- Discuss two different kinds of modulation used in data communication.
- Define the term network as it is applied to microcomputer systems.
- Describe the components that make up a network.
- Identify several different LAN configurations.

Lesson 3: User/Machine Interface

Topics

Data transmission standards; Monitors, keyboards, and encoders; USART; Character generator; CRT; Graphics; Monitor accessories

Objectives

- Discuss ASCII code and the related data transmission standards.
- Identify and describe the main components of a display monitor system.
- Explain how information is displayed on a computer screen.
- Identify several accessories that can be used with a display monitor system.

Lesson 4: Networks

Topics

Distributed processing; LAN accessing techniques and topologies; Data packets; Broadband and baseband systems; Ethernet

Objectives

- Discuss the evolution of computer networks.
- Explain the term distributed processing.
- Describe the local area network (LAN) concept.
- Explain the differences between the two LAN accessing techniques, and between the two LAN topologies, discussed in this Lesson.

Lesson 5: Specific System Applications

Topics

Application I/O; Small-scale dedicated controller example; General-purpose business system example; System requirements; Software

Objectives

- Describe two methods used by microprocessors to access I/O devices.
- Discuss the different functions of a small-scale, dedicated microcomputer.
- List some of the functions of a general-purpose business microcomputer.
- Explain how hardware is selected for a small-scale, dedicated system.
- Identify some of the tasks that the software used with a typical general-purpose business microcomputer must be able to accomplish.

MPACT® INSTITUTE Certified Training Program

How Computers Function

Course 266: How Computers Function—Technician Level
Covers the function and basic operation of each major element of a microprocessor. Explains the structure and purpose of various computer buses. Examines characteristics of different types of main memory in detail. Includes in-depth discussion of both low- and high-level computer languages.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Microprocessor Structure

Topics

CPU; Microcontrollers; Program counter; Branching; Instruction decoders; Subroutines; Stack pointer; ALU; Status bits; System clocks

Objectives

- Describe the types of microprocessor elements and their functions.
- Describe the types of registers that a microprocessor system typically has.
- Identify the different types of microprocessor clocks and their functions.
- Describe typical microprocessor bus systems.

Lesson 2: Bus Structures

Topics

Bus system block diagrams and schematics; Backplanes; Data, address, control, and serial buses; Multiplexing; Bus drivers and standards

Objectives

- Identify the different types of microprocessor buses.
- Discuss the functions of the different microprocessor system buses.
- Describe the functions of the bus drivers.
- Identify the various industry standards for microprocessor system buses.

Lesson 3: Memory Devices

Topics

Main memory; Memory-CPU communication; Expanding memories; Memory characteristics

Objectives

- Discuss the various types of memories and their characteristics.
- Describe the different ways in which the CPU and memory communicate.
- Explain how single-chip memories are organized.
- Describe different memory-expanding characteristics necessary for microprocessor systems.

Lesson 4: Low-Level Computer Languages

Topics

Data representation; Programming models; Operation codes; Addressing modes; Data-handling instructions; Interrupts; Memory-mapped I/O

Objectives

- Identify the three levels of computer programming languages.
- Define programming models and memory maps.
- Discuss the purpose and function of operation codes.
- Describe addressing modes as they relate to operation codes.
- Explain what machine language and assembly languages are and how they work.

Lesson 5: High-Level Computer Languages

Topics

Pros and cons of high-level languages; Compilers; Interpreters; Operating systems; Debuggers

Objectives

- Describe the characteristics and uses of high-level languages.
- Discuss the advantages and disadvantages of several popular high-level languages.
- Explain how compilers and interpreters work.
- Describe the functions of an operating system.

MPACT® INSTITUTE Certified Training Program

Input/Output Devices II

Course 267: Input/Output Devices II—Technician Level
Describes magnetic and optical memory devices. Explains how signals are converted from analog to digital form, and vice versa. Covers data acquisition systems and common digital transmission standards. Defines error detection techniques used to ensure the accurate transmission of digital data. Concludes with a practical application that combines all of the principles presented in previous lessons.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Magnetic and Optical Memory Devices

Topics

Data storage; Magnetic recording; Error correction; Tape cartridge devices; Helical scan tape; Rotating disk storage; Hard and floppy disks; Optical data storage

Objectives

- Discuss the characteristics and uses of the different types of data storage devices.
- Describe the different types of data storage systems and explain their advantages and disadvantages.
- Describe the functions of the controller in data storage systems.
- Identify the differences between hard disk drives and floppy disk drives.
- Explain how optical data storage devices work.

Lesson 2: Signal Converters and Processors

Topics

Weighted-resistor, binary-ladder, and typical DACs; Dual-slope, successive-approximation, and flash ADCs; Digital signal processors

Objectives

- Describe analog-to-digital and digital-to-analog conversion processes.
- Name the different types of DACs and ADCs.
- Identify the kinds of errors that might be present in an analog circuit.
- Explain digital signal processing in general terms.

Lesson 3: Data Acquisition Systems

Topics

Multiplexers; Programmable gain amplifiers; Computer output; Input signal variations; Isolation; Filtering; Sample-and-hold; Aliasing

Objectives

- List and describe the major components of a data acquisition system.
- Explain the front-end operation of a data acquisition system.
- Name the types of signal inputs used in data acquisition systems.
- Explain how aliasing occurs and how to avoid it.
- Describe different data acquisition system architectures.

Lesson 4: Digital Transmission Standards

Topics

Parallel, serial, synchronous, and asynchronous data transmission; Interface standards; UART; USRT; Fiber optics; Error detection

Objectives

- Explain the different types of digital data transmission.
- Tell why transmission standards are needed and how they apply to digital signals.
- Name some of the more important organizations that develop digital data transmission standards.
- Name two types of data transmission error detection techniques.
- Identify different types of digital transmission equipment, and explain how a modem works.

Lesson 5: Digital I/O Applications

Topics

Automotive engine control application; Single-chip microcomputers

Objectives

- Discuss the digital I/O system operation of an engine control module (ECM).
- Describe how a single-chip microcomputer is used in an ECM.
- Examine the structure of timer-based inputs and outputs.
- Identify the engine control input devices.
- Identify the engine control output devices.
- Explain the concept of real-time control.

MPACT® INSTITUTE Certified Training Program

Maintaining/Troubleshooting Computer Systems

Course 268: Maintaining/Troubleshooting Computer Systems
Covers maintenance of microprocessor-based equipment, including preventive maintenance. Describes diagnostic procedures and takes a "hands-on" look at test equipment, including oscilloscopes, logic analyzers, and in-circuit emulators. Emphasizes importance of thorough documentation in all areas. Discusses general troubleshooting guidelines, including troubleshooting aids and accessories.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Preventive Maintenance

Topics

Causes of component failure and malfunction; Noise; Hardware and software maintenance; Environmental operating conditions

Objectives

- Describe the preventive maintenance requirements of a microprocessor-based system.
- Identify potential maintenance problems of microprocessor-based equipment and propose solutions to those problems.
- Discuss ways to limit the undesirable effects that environmental operating conditions can have on a device.
- Develop an overall plan for a preventive maintenance program.

Lesson 2: Diagnostics

Topics

Hardware review; Bus timing; Logic levels; Diagnostic software; In-circuit debugging; Clock timing signals; System self test

Objectives

- Explain the best way to go about troubleshooting hardware problems in a microcomputer system.
- Explain what an in-circuit debugger does.
- Describe static stimulus testing.
- Discuss the use of diagnostic and self-test software programs.
- List at least five specialized component testers that can be used to troubleshoot microcomputer systems.

Lesson 3: Test Equipment

Topics

Logic probes and pulsers; Current probes; Oscilloscopes; Logic and signature analyzers; In-circuit emulators

Objectives

- Discuss the advantages and disadvantages of using logic probes to troubleshoot microcomputer system problems.
- Describe the major features of a modern digital oscilloscope.
- Describe differences between logic analyzers and oscilloscopes.
- Explain how a signature analyzer is used to isolate a defective part.
- Identify the purpose of an in-circuit emulator.
- List some test instruments that are available as microcomputer-based printed circuit cards.

Lesson 4: Documentation

Topics

Hardware and software documentation; Documentation problems; Operational documentation

Objectives

- Identify the different types of hardware documentation required for a microprocessor-based system, and describe their uses.
- Identify the different types of software documentation required for a microprocessor-based system, and describe their uses.
- Explain the necessity of operational documentation for a microprocessor-based system.

Lesson 5: Troubleshooting Guidelines

Topics

Flowcharts; Using test equipment; Intermittent problems; Aids for troubleshooting software; Hardware troubleshooting

Objectives

- List the basic steps to be followed when troubleshooting a microcomputer system.
- Discuss the use of flowcharts and test equipment in troubleshooting microcomputer systems.
- Identify some aids for troubleshooting software.
- Describe four hardware accessories that simplify and speed up troubleshooting.

MPACT® INSTITUTE Certified Training Program

Introduction to Packaging

Course 311: Introduction to Packaging
Covers the job of packaging mechanic. Provides detail on major types of packaging machinery. Covers various mechanical drives, couplings, motors, brakes, variable speed drives, clutches, electrical controls, motor starters, event sequencing controls, time delays, and relays. Includes packaging specifics: types of materials, methods of filling, methods of sealing, weights, and volumetric measurements.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: The Packaging Mechanic

Topics

Packaging operations; Machinery maintenance; Planned maintenance; Lubrication

Objectives

- Describe types of machines for packing and filling.
- Describe packaging machinery breakdown maintenance procedures.
- List specific requirements for planned packaging machinery maintenance.
- Explain packaging machinery lubrication selection, scheduling, and correct application.

Lesson 2: Actuating Mechanisms

Topics

Cranks; Cams; Intermittent motion mechanisms; Geneva wheels; Drives; Angle-doubling drives; Toggle links; Detents; Overload protection

Objectives

- Explain the operation of the lever and crank.
- Describe the differences among types of cams.
- Explain how ratchet wheels and Geneva wheels produce intermittent motion.
- Describe reciprocating and oscillating drive mechanisms.

Lesson 3: Problem Solving Principles

Topics

Elements and tolerances of measurement; Types of packaging machines; Troubleshooting machines; Determining causes of trouble

Objectives

- Describe the differences between intermittent-motion and continuous-motion packaging machines.
- Explain how to time a packaging machine with a timing dial.
- Define the four basic machine elements—timing, position, stroke, and alignment.
- List correct packaging machine troubleshooting steps.

Lesson 4: Mechanical Drives

Topics

Drive mechanisms; Coupling construction and installation; Belt and chain drives; Speed reducers; Gearing

Objectives

- List the functions of couplings.
- Explain the differences among the more common types of couplings.
- Describe how to check coupling alignment and how to correct a misalignment.
- Compare the different types of belt and chain drives.
- Describe the different types of speed reducers and gearing.

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Lesson 5: Motors and Brakes

Topics

Primary drive components; Motor construction classification; Mechanical/electrical speed drives; Clutches; Brakes; Maintenance

Objectives

- Describe the basic features of ac motors.
- Compare the different types of fractional-horsepower motors and three-phase motors.
- List the features of common and special types of motors.
- Explain how variable-speed units work.
- Describe the operation and use of electric, hydraulic, and mechanical clutches.

Lesson 6: Electrical Controls

Topics

Startup and running sequence; Motor starters; Machine control; Time delay relays; Product control; Adhesive application; Product sensors

Objectives

- Describe the elements of a packaging machine's start-up sequence.
- Explain how thermal overload and melting alloy starters work.
- Explain the use of detectors and time delays in packaging machine control.
- Describe how adhesive is applied.
- Explain the differences in operation among types of product detectors.

Lesson 7: Packaging Materials

Topics

Shrink and nonshrink materials; Combination and water soluble film; Plain and coated papers; Chip-board cartons; Glass and plastic bottles and jars

Objectives

- List the characteristics of film.
- Compare the different types of shrink film.
- Name the different types of combination films.
- Describe the uses of water-soluble film, kraft paper, and chipboard.
- List the advantages and disadvantages of glass and plastic bottles and jars.

Lesson 8: Methods of Filling

Topics

Flexible packaging; Vertical and horizontal filling machines; Pouch, weigh, carton, and liquid filling; Filling by count

Objectives

- Describe the operation of vertical and horizontal flexible film packaging machines.
- Explain how volumetric pouch filters work.
- Explain how carton-filling and liquid-filling machines work.
- Describe methods of filling by count.

Lesson 9: Methods of Sealing

Topics

Tube, film, and high-frequency sealing; Capping; Seaming; Tying; Sewing; Gluing; Stapling; Stitching; Strapping

Objectives

- Describe how plastic and metal tubes are sealed.
- Explain the operation of different types of film sealers.
- Describe how high-frequency sealers work.
- Explain the basics of cappers and seamers.
- Describe correct procedures for using hot and cold glues.

Lesson 10: Weighing and Measuring

Topics

Units of weight; Volume measurement; Weighing devices; Scale components; Net weighers; Controls; Checkweighers; Installation

Objectives

- Explain the uses of gross, net, and check weighers.
- Compare the mechanisms of counterbalances and force balance systems.
- List the components in a scale system.
- Explain how typical check weighers work.
- Describe proper troubleshooting, maintenance, and installation techniques for scales.

Packaging Machinery

Course 312: Packaging Machinery
Covers operating and servicing various types of packaging machinery. Describes different types of liquid filling machines. Covers positive displacement fillers, filling, and sealing machines, as well as volumetric filling machines and blister packaging machines.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Gravity and Vacuum Filling

Topics

Gravity filling; Vacuum pump construction and installation; Vacuum, gravity, balanced, and submerged filling; Fill height and container control

Objectives

- List the main advantage and disadvantages of gravity filling and vacuum filling methods.
- Tell what kinds of vacuum pumps are commonly used in filling applications.
- Describe the construction and operation of vane and piston pumps.
- Compare and contrast vacuum filling, gravity/vacuum filling, balanced vacuum filling, and submerged vacuum filling.
- Explain various methods of fill height and container control.

Lesson 2: Bottle Filling and Capping

Topics

Volumetric filling; Auger feed pumps; Volumetric-displacement, constant-level filling machines; Counter-pressure filling; Capping; Sealing

Objectives

- List some of the factors considered when selecting a bottle filling machine.
- Explain the operation of, piston-type, auger, volumetric-displacement, and constant-level filling machines.
- Describe the various kinds of bottle capping and sealing.
- List the major maintenance requirements of liquid filling machines.

Lesson 3: Pressure Liquid Filling

Topics

Indexing pressure fillers; Indexing container control; Continuous motion, rotary pressure fillers; Filling nozzles; Filling control

Objectives

- Name the most important advantage of using positive displacement pumps on pressure filling machines.
- Name the two classifications of pressure fillers.
- List possible causes of filling inaccuracies.
- Explain the importance of proper fluid velocity in filling machine operation.

Lesson 4: Aerosol Fillers

Topics

Aerosol container construction and valves; Propellants; Container, cold, and pressure filling; Safety testing; Drying; Capping; Accessories

Objectives

- Explain the concept of aerosol filling.
- Describe metal container and aerosol valve construction.
- Name and describe the two methods of aerosol container filling.
- Explain the operation of the individual stations in a filling line.
- Describe the process by which aerosol containers are safety tested.

Lesson 5: Bag Forming and Filling

Topics

Bag materials and construction; Bag forming; Film extrusion; Bag filling machines; Bag machinery maintenance

Objectives

- List commonly used bag materials and their typical applications.
- Explain the various bag constructions and related terminology.
- Describe the film extrusion method of bag forming.
- Explain the operation of bag filling machines.
- List the major maintenance requirements of bagging machinery.

Lesson 6: Pouch Filling

Topics

Pouch materials and control; Vertical filling machines; Horizontal and vertical pouch filling and modifications; Continuous motion fillers

Objectives

- Tell how pouch filling machines are classified.
- Name the three types of vertical seals made on vertical form, fill, and seal machines, and tell when each is used.
- Explain the vertical filling machine operating sequence.
- Name the two methods of classifying pouch filling machines that handle the film horizontally, and give advantages of each.

Lesson 7: Volumetric Filling Machines

Topics

Balance point measuring; Measuring by volume, weight; Intermittent motion fillers; Continuous motion, draw, and liquid volumetric filling

Objectives

- Give examples of products that can be handled by volumetric fillers.
- Explain how volumetric filling machines are identified.
- Describe the operation of volumetric filling machines.
- Describe the various methods of measuring products packaged on volumetric filling machines.
- Explain how liquid volumetric filling is controlled.

Lesson 8: Filling by Count

Topics

Filling by count; Flat plate and disk sorters; Column measuring; Electronic counting; Strip, blister packaging machines; Cottoning devices

Objectives

- Give examples of products that are commonly packaged by count.
- Describe three methods of counting product in a fill by count machine.
- Define the term strip packaging, name its two classifications.
- Give an example of a product packaged by each of the two strip packaging methods.

Lesson 9: Positive Displacement Filling

Topics

Controlling the fill; Automatic and manual filling machines; Timing control; Continuous motion filling machines; Rotary filling; Maintenance

Objectives

- Trace the positive displacement filling cycle.
- Name the kinds of pumps used to fill containers on positive displacement filling machines.
- Describe the controls associated with positive displacement filling systems.
- List important points in the maintenance of positive displacement filling machines.

Lesson 10: Blister Packing

Topics

Blister films and cards; Reducing blister failures; Test procedures; Seal examination and evaluation; Product compatibility; Blister forming and sealing

Objectives

- Define the term thermoforming.
- Describe the film and card materials commonly used in blister packing.
- Give several examples of problems that can cause blister failures.
- Describe the tests and evaluations performed on blister package seals.
- Tell what kind of film is most often used with inline blister forming machines.

Casing Machinery

Course 313: Casing Machinery
Covers operating characteristics and service techniques of accessory or auxiliary machines used with packaging lines. Describes general operating characteristics of labeling equipment, uncasing, unscrambling, and cleaning machines, gluing equipment and adhesives, wrapping machines, tying, strapping, and stitching machines, and shrink wrapping devices.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Uncasing and Unscrambling

Topics

Manual uncasing; Low-volume uncasing and unscrambling; Unscrambling with conveyors; Automatic uncasing; Conveyor chain and care

Objectives

- List the steps that must occur before an empty container can be processed.
- Tell which types of conveyors are typically used for unscrambling.
- Explain how the pickup head of an automatic uncaser grips different container shapes.
- List important steps in the periodic care and maintenance of roller chain.

Lesson 2: Cleaning and Washing

Topics

Air cleaning; Manual washing with water; Bottle washer/rinser; Metal washers; Container warming; Pasteurization; Maintenance

Objectives

- Name the two methods by which containers are usually cleaned.
- Describe the automatic air cleaning operation.
- Describe the operation of an automatic bottle washer and rinser.
- Describe the operation of a high-production bottle washer.
- Explain why pasteurization is important.

Lesson 3: Gathering Machines

Topics

Multi-packing machines; Skip-carton detector; Continuous-run accumulator; Stacking sequence; Cycling operations; Case packing, bundling machines; Maintenance

Objectives

- Name the three types of gathering machines currently in use.
- Describe the operation of a bundling machine.
- Describe the infeed supply operation and cycle of a multipacker.
- Name the two functions of a typical case packer.
- Explain your most important responsibility in gathering machine maintenance.

Lesson 4: Cartoning Machines

Topics

Carton making; Types of cartons and machines; Glue-end cartons; Carton feeding; Product infeed; Machine attachments; Closing and gluing

Objectives

- Define the following terms: reverse tuck, arthur lock, and crash fold.
- Explain why butt flaps are rarely used.
- Describe the operation of cartoning machines and related carton feeding methods.
- Explain how cartons are typically closed and glued.
- List steps involved in cartoning machine maintenance.

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Lesson 5: Casing Machines

Topics

Horizontal and vertical machines; Top, side, and bottom filling machines; Case taping machines; Heatshrink sealing; Maintenance

Objectives

- Tell how the manner in which cases are filled is determined.
- Explain the function of a compression unit.
- Contrast top filling and side filling machines.
- Explain the purpose and operation of electrical interlocks in an automatic casing machine.
- Identify the source of heat control problems in a shrink film machine.

Lesson 6: Wrapping Machines

Topics

Wrapping materials; Settings and controls; Paper feed; Paper corrugating wires, rollers, cutoff change gears, knife, feed belt, stops, and guides

Objectives

- Explain the function of registration dots on the continuous roll paper used on wrapping machines.
- Explain the functions of the paper corrugating wires in a wrapping machine.
- Trace the operation of a typical wrapping machine, including timing elements.
- Tell how to clear a jam in a wrapping machine.
- Describe various kinds of glue used in wrapping machines and their application.

Lesson 7: Strapping and Stitching

Topics

Strapping materials; Tensioners; Sealers; Combination tools; Strapping systems; Stitching machines; Stitch defects; Adjustments

Objectives

- Explain why a tensioner and sealer are sometimes combined into a single assembly.
- Describe the maintenance required by strapping heads.
- Explain the operation of a stitching machine.
- List common stitching machine problems and stitch defects and tell their probably causes.

Lesson 8: Adhesives and their Application

Topics

Properties and types of adhesives; Hot melts; Application systems; Troubleshooting, maintaining, and cleaning equipment

Objectives

- Define the terms penetration, tackiness, and viscosity as they relate to adhesives.
- Name the most likely source of trouble in hot melt application machinery.
- List steps involved in servicing a hot melt dispensing head.
- Explain common maintenance items related to application equipment.
- Describe the storing and handling requirements for liquid adhesives.

Lesson 9: Labeling and Coding

Topics

Label forms; Continuous roll, indirect label feeding; Pressure-sensitive labeling, heads; Coding attachments; Flexographic imprinting

Objectives

- Name common problems in labeling operations and give their solutions.
- Describe the process of continuous roll feeding.
- Explain the periodic maintenance required of labeling heads.
- Explain the operation of a friction-driven coder and a flexographic imprinter.

Lesson 10: Maintenance and Safety

Topics

Planned maintenance; Spare parts; Lube schedules; Mechanical and electrical maintenance; Fluid components maintenance; Guards

Objectives

- Identify the key to good planned maintenance.
- Name the two most important factors in drive belt wear on a packaging machine.
- List items to consider when replacing a motor?
- Explain the purpose of recommended color codes for plant equipment.
- Name the leading causes of industrial injuries.

How Power Plants Work

Course 111: How Power Plants Work
Covers the basic steam generation system, how thermal energy is converted into electrical energy, components of the system, and design features for gaining thermal efficiency. Includes handling of water, fuel, and wastes, and the operating features of a power plant.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Steam—The Primary Force

Topics

Energy conversions; Combustion; Ash and fuel gas removal; Heating air; Boiler design; Water level; Feedwater heaters; Economizers

Objectives

- Describe the basic concepts involved in converting energy to electricity through a steam power plant.
- Explain why air is important in combustion and describe how air is heated.
- Describe the basic design of a boiler.
- List the methods commonly used to create efficiency in a boiler.

Lesson 2: How Heat is Converted to Power

Topics

Turbines; Generators; Using exhausted steam to heat feedwater; Using condensate; Coal handling; Boiler efficiency

Objectives

- Describe the components of an elementary turbine.
- List the uses of exhaust steam.
- Explain how a vacuum is produced in a boiler system.
- Describe how condensate is formed in a boiler system and how it can be used to create a closed cycle system.
- Explain how boiler efficiency is related to steam temperature and pressure.
- Calculate absolute temperature values using Fahrenheit and Celsius readings.

Lesson 3: Power Plant Efficiency

Topics

Thermodynamic efficiency; Pumps; Feedwater and air heating; Superheaters; Circulation problems; Gaining efficiency; Condenser performance

Objectives

- List the kinds of pumps used in a boiler system and explain the function of each.
- Describe common processes by which boiler feedwater can be heated, and explain these increase boiler efficiency.
- Explain the process by which air is heated in a boiler system.
- Explain the purpose of a superheater.

Lesson 4: Handling Water, Fuel, and Wastes

Topics

Boiler water requirements; Water softening and purification; Water disposal; Fuel wastes; Flue gases; Particulate removal systems

Objectives

- List the two main uses for water in a power plant.
- Describe the physical and chemical properties of water.
- Explain the past and present methods used to purify water for use in a power plant.
- Explain the common handling procedures for flue gases and solid wastes, and describe the problems involved in disposing of these wastes.
- List some of the ways in which power plant waste problems might be resolved in the future.

Lesson 5: Power Plant Operation and Control

Topics

Power plant operating features and controls; Temperature, pressure, and special measurements; Other power sources; Nuclear power

Objectives

- Give a detailed description of the arrangement of a modern steam generating plant and explain the progression of the steam cycle from one end to the other.
- Compare and contrast the common instruments for measuring temperature.
- Compare and contrast the common instruments for measuring pressure.
- List some of the special measurement devices that are important in a steam generating plant.
- List the alternate power sources described in the lesson.
- Explain the concept of nuclear power and describe the operation of a nuclear power plant.

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Generating Steam in the Power Plant

Course 112: Generating Steam in the Power Plant
Covers energy principles and boiler maintenance. Explains coal, oil, and natural gas combustion, and how to conserve energy through improved combustion control.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Transforming Energy into Work

Topics

Energy and matter; Fuels; Combustion; Temperature and pressure; Heat transfer; Sensible and latent heat; Enthalpy

Objectives

- Define energy and describe the main forms of energy encountered in a power plant.
- Explain the process of combustion and list the three elements necessary for combustion to occur.
- Explain the principles of temperature and pressure measurement and describe the four scales on which temperature is measured.
- Describe the methods of heat transfer and the types of effects heat transfer can have on a material.
- Summarize the interrelationship of temperature, volume, and pressure in a gas.

Lesson 2: Boiler Operation

Topics

Types and characteristic of boilers; Water treatment; Boiler and cooling tower blowdown; Wastewater disposal; Thermodynamic efficiency

Objectives

- Compare the two basic types of boilers.
- Describe the characteristics by which boilers are classified.
- Explain the different processes by which water is treated for use in a boiler.
- Define blowdown and explain its importance in boiler operation.
- List the problems associated with wastewater disposal and describe how these problems are overcome.
- Describe the factors that affect boiler efficiency, as well as auxiliary equipment efficiency.
- Calculate thermodynamic efficiency.
- List practices that aid in energy conservation in all areas of the power plant.

Lesson 3: Boiler Maintenance

Topics

Soot and scale removal; Corrosion; Calibration; Cleaning; Maintaining auxiliaries; Valves; Piping; Pumps; Fans; Controls; Stacks and cyclones

Objectives

- Explain how the two types of sootblowers remove soot and slag from heat exchange surfaces.
- Describe how scale forms on boiler surfaces and list the three common removal methods.
- Explain why both hot-end and cold-end corrosion occur in a boiler, and tell what practices help prevent corrosion.
- Describe how refractory should be maintained and list the problems that can occur if it is not properly maintained.
- List the primary functions of boiler control systems and describe the three common types.
- Explain how to calibrate and clean boiler control systems and maintain compressed air systems.
- Summarize maintenance procedures for boiler auxiliaries such as pumps, valves, motors and electric circuits.

Lesson 4: Combustion and How It Works

Topics

Coal, oil and natural gas; Chemistry and efficiency of combustion; Burners; Flame color and adjustment; Coal firing; Ash analysis

Objectives

- Identify the different ranks of coal and describe how the makeup of coal affects its heating value.
- List the properties that are tested in a coal analysis.
- Summarize the properties of oil and natural gas fuels.
- Explain the combustion process in detail.
- Describe how to interpret and adjust a flame's characteristics in coal, oil, and gas burners.
- Describe the three types of coal firing systems.
- List the ways in which combustion efficiency is measured.

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Lesson 5: Steam Generation

Topics

Temperature/pressure/volume relationships; Superheating; Boiler water circulation; Conserving energy; Blowdown; Makeup water

Objectives

- Trace the flow of water and steam through the boiler system.
- Explain the relationship between temperature and pressure and explain why superheated steam has a higher quality than saturated steam.
- Read a steam table properly and apply its information to a boiler system.
- Compare natural circulation boilers with forced circulation boilers, and explain how pressure and temperature affect the type of boiler used.
- Describe the process of operating a high-pressure boiler at low pressure.
- Describe how proper maintenance of steam traps, valves, packing, flanges, and insulation improve the energy conservation rate in a boiler system.

Using Steam in the Power Plant

Course 113: Using Steam in the Power Plant
Covers how to conserve energy in turbines, auxiliaries, electric power generation, and air conditioning systems.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Turbines

Topics

Types; Operating principles; Condensers; Heat rejection; Thermal pollution; Boiler, turbine, and generator efficiency

Objectives

- Name the five main parts of a steam turbine system and explain the function of each.
- Contrast the operating principle of an impulse turbine and a reaction turbine.
- Define the terms tandem compound and cross compound.
- Explain how a condenser improves turbine efficiency.
- Explain how an overspeed trip is activated.
- List three causes of turbine rotor vibration.
- Name the main cause of bearing failure in a turbine.

Lesson 2: Boiler Instrumentation, Controls, and Safety

Topics

Pressure, flow, and temperature gauges; Manometers; Water glasses; Combustion and feedwater control; Safety devices

Objectives

- Define the term variable.
- Describe the three main classes of boiler instruments.
- List the four variables on which boiler instrumentation usually provides data.
- Name the four common types of pressure gauges, and describe the characteristics and uses of each.
- Name and describe the three types of flowmeters commonly used in power plants.
- Name and describe the four types of temperature gauges commonly used in power plants.
- Describe the uses for gauge glass assemblies in power plant instrumentation.
- Explain the purpose of combustion control systems and describe the three basic kinds.
- Describe the three kinds of feedwater regulators.
- Explain the importance of safety valves and flame safety devices in power plants.

Lesson 3: Electrical Power Fundamentals

Topics

Power in DC circuits; AC current; Generators; Phase difference; Power factor; Three-phase systems; Transformers; Metering principles

Objectives

- Explain the basic principles of electricity and electric power, including the significance of Ohm's Law.
- Identify the parts of an electrical circuit and describe the function of each part.
- Contrast series and parallel circuits.
- Explain the difference between the two main groups of generators and further describe each group in terms of its sources of mechanical power.
- Define phase difference and power factor, and describe a three-phase system.
- Explain the function of a transformer.
- Describe the variety of metering instruments used to measure the value of electric energy.
- Explain the purpose of an electric distribution system, and list the three main kinds.
- Name four kinds of protective equipment used in power systems.

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Lesson 4: Electrical Systems Analysis

Topics

Demand considerations, analysis, and cost; Power factor correction; Synchronous motors; Transformer losses; Maintenance

Objectives

- Explain the purpose of a line diagram.
- List the four kinds of charges normally found on a power bill.
- Define peak demand.
- Calculate a plant's load factor.
- Describe the steps involved in performing demand analysis.
- Calculate demand cost and explain the effect of short demand peaks on billing.
- Define power factor and explain how it is calculated, what causes it to be low, and how it can be improved.
- List the types of power losses that occur in transformers and describe the cause of each.
- Explain how to maintain protective devices, cable systems, and generators and motors.
- Explain the importance of energy conservation in power plants.

Lesson 5: Air-Conditioning Systems

Topics

Basic cycle; Compressors; Condensers; Evaporators; Metering devices; Accessories; Controls; Air handling; Maintenance practices

Objectives

- Define relative humidity and explain how it is measured.
- Define the terms refrigeration ton and refrigeration effect.
- Name and describe the three common kinds of compressors used in air-conditioning systems.
- Name and describe the three kinds of condensers used in air-conditioning systems.
- List the metering devices used in an air-conditioning system and explain their uses.
- List the accessories and controls that are found in an air-conditioning system and state their purposes.
- Describe the air-handling system and its components.
- Explain how to measure velocity pressure and static pressure.
- Explain several maintenance practices that will improve the efficiency of an air-conditioning system.

Waste-to-Energy Fundamentals

Course 114: Waste-to-Energy Fundamentals
Covers fundamentals of waste combustion—characteristics and handling of MSW fuel, furnace designs, waste combustion, and plant operations.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Introduction to Waste Combustion

Topics

Benefits of converting waste to energy; Environmental regulations; The Clean Air Act; Permit program; Reporting procedures

Objectives

- Summarize the history of waste handling.
- List some problems associated with landfills and the benefits of waste-to-energy conversion.
- Name the federal regulations that apply to MWCs.
- Explain how NSPS regulations affect the operation of MWCs.
- Explain the permitting program.

Lesson 2: Characteristics of MSW Fuel

Topics

MSW definitions, classification, and composition; MSW handling safety; MSW and refuse-derived fuel; MSW compared to fossil fuels

Objectives

- State the definition of MSW and list some kinds of waste excluded from MSW.
- Explain the various methods of classifying MSW.
- Discuss safety concerns related to the handling of MSW.
- Explain the differences between mass-burn MSW and RDF.
- Compare and contrast MSW and fossil fuels.

Lesson 3: MSW Handling

Topics

Solid materials flow path; Weight scale operation; Tipping floor and refuse pit; Receiving and feeding equipment; Front-end conveyor systems; Feed systems; Ash removal

Objectives

- Describe the MSW flow in a mass-burn and an RDF facility.
- Explain the responsibilities of the weight scale operator.
- Describe the tipping floor and refuse pit.
- Explain how odors are managed is an MSW facility.
- List typical receiving and feeding equipment and explain its functions.
- Describe how conveyors are used in a typical RDF facility.

Lesson 4: Furnace Designs

Topics

MWC designs; Mass-burn designs; Rotary combustors; RDF designs

Objectives

- Explain the impact of corrosion on MWC design.
- Describe mass-burn and RDF feed systems.
- Explain the operation of the following types of stokers: reciprocating grate, reversed reciprocating grate, oscillating grate, roller grate, and traveling grate.
- Define and contrast overfire air and underfire air and explain why the control of combustion air is important.
- Explain the advantages and disadvantages of a rotary combustor.

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Lesson 5: Municipal Waste Combustion

Topics

The combustion process; Theoretical and excess air; Heating value; Charging rate; Combustor capacity; Combustion temperatures; Reaction rates; Air pollution control equipment; Slag and soot

Objectives

- Explain the combustion process as it occurs in a municipal waste combustor.
- Name the two main factors that determine feed rate.
- Define the terms theoretical air and excess air and tell why they are important.
- Explain the use of common air pollution control equipment and processes.
- Tell how soot and slag are formed and how they are removed.

Lesson 6: Ash Handling and Material Recovery

Topics

Characteristics of MSW ash; Safety and handling requirements; Ash treatment and testing; Transport and loading systems; Material recovery

Objectives

- Describe the characteristics of MSW ash.
- Explain the safety considerations when handling MSW ash.
- List the major ash handling equipment.
- Describe the ash treatment and testing program.
- List the materials recovered from ash.
- List some potential uses for ash.

Lesson 7: Integrated Plant Operations

Topics

Principles of plant operation; Operator training; Upset conditions; Operating procedures; Troubleshooting; Basic plant economics

Objectives

- State the main responsibilities of an MWC operator.
- Define the terms turnover, parameter, and walkdown as they relate to MSW operations.
- Explain the importance of operator training.
- Describe the three upset conditions in an MWC that can be dangerous to personnel and property.
- List the causes and symptoms of common MWC process problems.
- List the three sources of profit in a typical MWC.

Introduction to Process Control

Course 271: Introduction to Process Control
Covers the function of basic devices for measuring and controlling different kinds of variables in process control. Introduces closed-loop control and PID functions. Introduces analog and digital devices and programmable logic controllers (PLCs). ISA and SAMA instrumentation symbols and interpretation and use of process diagrams are covered.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: The Nature of Process Control

Topics

Process variables; On-off control; Measuring data; Controlling variables, Error and feedback; Open- and closed-loop control

Objectives

- Define setpoint and error.
- Explain how measurement and control are related in industrial processes.
- Describe the four essential functions of an automatic control system.
- Discuss the functions of the CRT and PLC in control systems.
- Identify variables in industrial processes.
- Explain the importance of feedback in a closed-loop control system.

Lesson 2: Elements of Process Control

Topics

Analog and digital control signals; ASCII; Measuring pressure, level, and flow rate; Digital pulse control; System terminology; Controller action

Objectives

- Discuss the differences between modern automatic control systems and older ones.
- Identify the standard signals used in process control.
- Define the terms commonly used in control terminology.
- Explain the differences between open-loop control and closed-loop control.
- Describe on-off, proportional, integral, derivative, and PID controller action.

Lesson 3: Process Control Signals

Topics

Linear and nonlinear transducers; Signal operating values; Error; Controller output; Pneumatic and electrical signal transmission; Control loops

Objectives

- Discuss standard signals and linearity and explain how to calculate the value of a variable from an instrument's span and range.
- Describe five common sources of error in signal measurement.
- Discuss the basic principles governing pneumatic signal transmission and explain how a flapper-nozzle device works.
- Describe the function of the controller in a control loop.
- Discuss the basic principles governing electrical signal transmission, including Ohm's law, and list standard current and voltage signals.
- Explain the function of I/P devices in a typical control system and discuss the use of digital signals and optical signals.

Lesson 4: Process Control Diagrams

Topics

Symbol recognition; Piping and instrument drawing; Location and installation drawing; Loop and wiring diagram

Objectives

- Recognize standard symbols used in process control diagrams.
- Describe a process control system through the use of instrument symbols.
- Recognize and use four kinds of process control diagrams.
- Analyze a process control drawing for the elements, signal flow, and process flow.

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Lesson 5: Using Symbols and Diagrams in Process Control

Topics

Sequence of operation; Flowchart; Switches; Relays; Electrical elementary diagram; Pump system schematic; PLC diagram; Symbols

Objectives

- Convert sequence-of-operation text to a flowchart.
- Read electrical and electronic control diagrams and drawings.
- Recognize symbols used on electrical and electronic diagrams, including those for PLCs and SAMA logic.
- Convert electrical diagrams to PLC diagrams.
- Discuss the role of computers in process control.

Lesson 6: Process Control Loop Operations

Topics

On-off and proportional control; Controller sensitivity; Typical control loops; Reset; Derivative; Cascade control; Tuning a control loop; Ratio control

Objectives

- Explain how to increase the sensitivity of a control system.
- Explain the advantage of proportional control over on-off control.
- Describe the advantage of a proportional-plus-reset controller over a proportional controller without reset.
- List the elements in a single-variable control loop.
- Describe how a cascade control system works and identify the primary and secondary loops in a diagram of a cascade control system.
- State the sequence of loop tuning in a cascade control system.
- Describe how a ratio control system works.

Foundations of Measurement Instrumentation

Course 272: Foundations of Measurement Instrumentation
Covers basic principles of measurement and defines process control terms. Describes several kinds of signals and displays and traces the path of a signal through the system. Explains the operation of transducers, transmitters, signal conditioners, converters, and recorders. Discusses specification details, conversion between English and SI units, calibration methods, and the maintenance of records.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Introduction to Process Measurement

Topics

Measurement and display requirements; Remote and local display; Calibration; Noise; Response time; Measurement system and observation error

Objectives

- Explain why measurement is necessary and discuss conditions that affect the degree of accuracy required.
- Compare the advantages of linear and nonlinear displays.
- Compare analog and digital devices and explain how each is applied to measurement.
- Name five sources of measurement error.
- Discuss proportionality and explain how it applies to transmitters.

Lesson 2: Principles of Transducer Operation

Topics

Outputs; Mechanical, electrical, and pneumatic elements and response; Resistance, voltage, and frequency devices; Combining elements

Objectives

- Discuss the need for linearity in a process.
- List examples of mechanical and electrical transducer elements.
- Compare pneumatic response and electrical/electronic response in transducers.
- Describe the operation of the bourdon tube, bellows, and diaphragm.
- Name examples of resistance, voltage response, frequency response, and electromechanical devices and explain how they work.
- Discuss the use of the Hall-effect transducer and the differential transducer.

Lesson 3: Basic Process Measurement Systems

Topics

Interaction of system elements; Transmitters; Electrical vs. pneumatic output; Converters; Signal conditioning; Indicators and recorders

Objectives

- Discuss the basic elements of measuring systems and explain how they interact.
- Describe how a physical quantity is translated into another quantity.
- Discuss the use of transmitters to relay information from one location to another and explain the transfer function.
- Describe the operation of at least five kinds of converters.
- Compare analog and digital indicators and recorders.

Lesson 4: Systems Standards and Instrument Calibration

Topics

Interpreting specifications; Error; Accuracy; Precision; Resolution; Transfer function; Sensitivity; Hysteresis; Response time

Objectives

- Discuss the specifications of a typical measurement system.
- Explain how to read a graph showing a linear or nonlinear transfer function, hysteresis, or the time constant.
- Discuss SI and English systems of units and explain how to convert from one to the other.
- Describe the elements of instrument calibration.
- Discuss the standards commonly used in instrument calibration.

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Lesson 5: Maintaining System Quality

Topics

Equipment inventory and status records; Testing and calibration; Computer and PLC emulators; Equipment decontamination procedures

Objectives

- Discuss the forms used to keep track of equipment inventory, repairs, and procedures for testing and calibration.
- Describe the equipment and procedures used for electrical testing and calibration.
- Describe the equipment and procedures used for electronic testing and calibration.
- Describe the equipment and procedures used for pneumatic testing and calibration.
- Explain what an emulator is and how it is used.
- Discuss the elements of proper decontamination procedures.

Pressure Measurement

Course 273: Pressure Measurement
Covers units of pressure and discusses Boyle's and Charles' laws to explain relationships among pressure, volume, and temperature. Describes sensor operation of manometers, bourdon tubes, diaphragms, and bellows. Explains operation of potentiometric, capacitive, reluctive, servo, strain-gauge, and piezoelectric transducers. Discusses proper and safe methods for installing and servicing pressure instruments.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Principles of Pressure in Liquids and Gases

Topics

Properties of matter; Units of pressure; Density; Specific gravity, Gauge, absolute, and atmospheric pressure; Pressure and flow

Objectives

- Compare the three forms of matter.
- Define pressure and explain the difference between gauge pressure and absolute pressure.
- Discuss the conditions that affect the pressure of a liquid.
- Describe how changes in volume affect the pressure of a gas at a constant temperature.
- Describe how changes in temperature affect the volume of a gas at constant pressure, and the pressure of a gas with a constant volume.
- Discuss the two causes of pressure drop in a pipe carrying liquid from a tank.

Lesson 2: Pressure Sensors

Topics

Manometers; Bourdon tubes; Diaphragm sensor construction and capsule elements; Bellows sensors; Maintaining accuracy; Calibration

Objectives

- Explain how a manometer works.
- Describe four kinds of bourdon-tube sensors.
- Discuss construction details of bourdon tubes, diaphragms, and bellows.
- Explain how bellows pressure sensors work.
- Describe how calibration may be accomplished and list the steps in calibrating a pressure gauge.
- Explain how normally open and normally closed pressure switches work.

Lesson 3: Pressure Transducers

Topics

Pressure conversion; Potentiometric pressure transducers; P/I, P/P, reluctive, servo, strain-gauge, and piezoelectric transducers; Response

Objectives

- Discuss the advantages and disadvantages of the potentiometric pressure transducer.
- Explain how a P/I transducer works.
- Describe the operation of capacitive, reluctive, and servo pressure transducers.
- Compare the three kinds of strain gauge pressure transducers.
- Describe the operation and advantages of the piezoelectric pressure transducer.
- Discuss three environmental conditions that can affect transducer operation.

Lesson 4: Low-Pressure Measurement

Topics

Low pressure; Methods of conversion; DP transmitters, Pressure, slack-diaphragm, ionization, McLeod, thermal conductivity, Pirani, and thermocouple gauges

Objectives

- Define the pressure unit torr and calculate pressure in specified units when given the pressure in other units.
- Explain the operation of a differential-pressure transmitter and a slack-diaphragm gauge.
- Name two kinds of ionization gauges and describe how they work.
- Explain how the McLeod gauge works.
- Describe the capacitance manometer.
- Compare the operation of the Pirani gauge and the thermocouple gauge.

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Lesson 5: Installation and Service

Topics

Pressure transmitter components; Piping, connections, and fittings; Wiring; Guidelines for periodic maintenance; Calibration; Safety

Objectives

- List the components of a pressure-transmitter installation.
- Compare methods of joining pipes and other instrumentation components.
- Describe the procedure for placing a pressure instrument into service.
- Discuss the elements of periodic maintenance.
- Explain how to calibrate pressure instruments with electrical and pneumatic outputs.
- Describe three important techniques used in troubleshooting and repair.
- List five important safety rules.

Force, Weight, and Motion Measurement

Course 274: Force, Weight, and Motion Measurement
Covers force, stress, and strain. Explains operation of strain-gauge systems. Relates weight to mass and scales to balances. Describes belt-scale, nuclear-scale, and weigh feeder operation. Covers position measurements using proximity detection, air gauging, LVDT gauges, synchros, code disks, etc. Describes measurement of angular velocity and acceleration, vibration detection, and machinery balancing.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Force, Stress, and Strain

Topics

Units of force; Static forces; Elasticity; Strain gauges; Gauge factor; Gauge configurations; Other force-measuring devices

Objectives

- Define force, stress, strain, and deformation in terms of the English and SI units used for their measurement.
- Describe the relationship between stress and strain (Hooke's law).
- Describe the operation and construction of various kinds of strain gauges.
- Identify the electrical circuits used with strain gauges.
- Describe the piezoelectric effect and the capacitance mat and discuss typical applications.

Lesson 2: Weight and Mass Measurement

Topics

Weight vs. mass; Acceleration; Spring scales; Balances; Load cell scales; Hydraulic, LVDT, and pneumatic load cells; Batch scales

Objectives

- Define and compare weight and mass, including SI and English units.
- Explain the relationship between a mass and the acceleration of that mass.
- Discuss Newton's first law of motion.
- Describe spring scales, equal-arm balances, and unequal-arm balances.
- Discuss the operating principles governing load cells.
- Describe the operation and application of industrial batch scales.

Lesson 3: Weighing Materials in Motion

Topics

In-transit weights; Belt-scale systems; Roller scales; Nuclear scale operation; Radiation detectors; Weigh feeders

Objectives

- Name the parts of a belt scale and explain how a typical belt scale operates.
- Discuss the use of roller scales.
- Describe the scale comparison, calibration chain, and electronic integrator methods of calibrating in-transit scales.
- Explain how radiation detectors work and describe the operation of a nuclear scale.
- Describe how continuous weigh feeders operate and discuss typical applications.

Lesson 4: Position Measurements

Topics

Micrometers; Dial indicators; Potentiometers; Tracer systems; Variable-reluctance transducer; Proximity detection; Air gauging; Moving-coil transducer; LVDT gauge; Inspection gauging

Objectives

- Describe how micrometers and dial indicators are used to gauge an object and to make a position measurement.
- Explain how precision potentiometers, tracer systems, variable-reluctance transducers, and proximity detectors measure linear position.
- Describe how air gauging is used to measure inside and outside diameters.
- Discuss the operation and uses of LVDT gauge heads.
- Explain how typical rotary potentiometers, synchros, and code disks converters operate.
- Discuss applications for extensometers and full-field devices.

Lesson 5: Acceleration, Vibration, and Shock

Topics

Speed vs. velocity; Radar devices; Machine tool control; Linear and angular acceleration; Accelerometers; Vibration; Balancing machinery

Objectives

- Compare speed and velocity and calculate speed from distance and time.
- Explain how the accelerometer works.
- Contrast direct and indirect speed measurement and give examples of each.
- Discuss the operation of LVDT, potentiometric, and piezoelectric accelerometers.
- Describe the undesirable effects of vibration and discuss ways of preventing them.

Flow Measurement

Course 275: Flow Measurement
Covers fluid flow and primary devices that affect it. Describes flow measurement using several kinds of devices. Discusses rotameters and other variable-area instruments. Explains how weirs, flumes, and other arrangements measure open-channel flow. Describes less-common flowmeters and instruments that meter flow of solids. Provides guidelines for safe installation and maintenance of flow devices.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Properties of Fluid Flow

Topics

Fluids in motion; Establishing a pressure difference; Indicating flow; Factors affecting flow rate; Reynolds number

Objectives

- Explain the difference between density and relative density (specific gravity).
- Define fluid velocity, viscosity, and volume flow rate.
- Describe laminar flow and turbulent flow.
- Explain how static head, friction head, and velocity head differ from each other.
- Explain how pipe size, pipe friction, and fluid viscosity affect the measurement of fluid flow.

Lesson 2: Primary Measuring Devices

Topics

Flow measurement in filled pipes; Restricting flow; Pressure drop; Orifice plates; Flow nozzles; Turndown and rangeability; Pipe taps

Objectives

- Describe direct and indirect flow measurement methods.
- Describe how a primary device creates a differential pressure.
- Give at least three examples of common primary devices and explain how each works.
- Describe the significant features of orifice plates and explain their functions.
- Discuss the conditions that determine the length of straight pipe required for each kind of primary flowmeter.

Lesson 3: Secondary Measuring Devices

Topics

Manometers; Liquid pressure measurement; Hazards of mercury; Bellows meter; DP transmitter; Target meter; Deadweight tester

Objectives

- Explain why both accuracy and precision are required in a secondary measuring device.
- Describe how an inclined manometer differs from a conventional U-tube manometer.
- Explain how to calibrate dry and wet manometers.
- Give examples of secondary measuring devices and explain how they work.
- Explain how to calibrate a differential pressure transmitter and discuss the different outputs available.

Lesson 4: Variable-Area Instruments

Topics

Rotameters; Measuring gas flow; Specific gravity, pressure, and temperature; Float and tube shapes; Piston, vane, and special meters

Objectives

- Discuss the similarities and differences between rotameters and orifice instruments.
- Compare the benefits of linear and nonlinear scales and explain how a square-root extractor is used.
- Explain how calibration, relative density, viscosity, and temperature affect rotameter readings.
- Describe how changes in the pressure, temperature, and relative density of a gas affect the ability of a rotameter to measure its flow rate.
- Discuss the operation of piston- and vane-type flowmeters and explain why armored rotameters and orifice-plug flowmeters are used.

Lesson 5: Open-Channel Flow Devices

Topics

The weir; Notch shapes; Weir precautions and maintenance; Using nomographs to calculate flow; Flume terminology and uses; Ultrasonic and capacitance level sensors

Objectives

- Describe the structure and function of a weir.
- Identify various weir components—notch, crest, pond, bulkhead, and head gauge.
- Describe the construction and function of a Parshall flume.
- Identify the parts of a Parshall flume—crest, throat, stilling well, and diverging and converging sections.
- Explain how ultrasonic and capacitance-level measuring devices are used to detect open-channel flow rates.

Lesson 6: Positive-Displacement Meters

Topics

Piston and rotating-vane meters; Nutating-disk, lobed impeller, oval, and helix flowmeters; Dry-gas bellows meter; Calibration

Objectives

- Describe the advantages and disadvantages of positive-displacement meters.
- Describe the operation of the reciprocating piston meter and the oscillating piston meter.
- Describe the operating principles of the sliding-vane rotary meter and the nutating-disk meter.
- Identify the elements in lobed impeller, oval, and helical flowmeters.
- Explain the operation of a dry-gas bellows meter.
- Discuss the calibration of positive-displacement meters.

Lesson 7: Turbine and Magnetic Flowmeters

Topics

Turbine flowmeter types, components, principles, construction, and installation; Magnetic flowmeter construction, output, and installation

Objectives

- Describe the operating principles governing turbine flowmeters.
- Discuss the construction of turbine flowmeters.
- Discuss the advantages and disadvantages of turbine flowmeters.
- Describe the operating principle governing magnetic flowmeters.
- Describe significant advantages and disadvantages of magnetic flowmeters.

Lesson 8: Specialized Flowmeters

Topics

Vortex-precession and vortex-shedding meters; Mass, thermal, and ultrasonic flowmeters; Heat-transfer, immersion-probe, and hot-wire meters

Objectives

- Discuss in detail the operation of a vortex-precession meter.
- Define the term vortex-shedding and describe vortex-shedding meters and their output system.
- Explain mass flow and describe a Coriolis meter.
- Describe three kinds of thermal flowmeters.
- Describe the Doppler-shift, beam-deflection, and frequency-difference methods used by ultrasonic flowmeters.

Lesson 9: Metering the Flow of Solid Particles

Topics

Volumetric and mass flowmeters for solids; Belt-type solids meters; Slurries; Constant-weight feeders

Objectives

- Define the term meter factor and explain how it is obtained.
- Explain the operation of a mass flowmeter.
- Discuss the operation of the belt-type solids meter.
- Describe how a slurry is made, transported, and metered.
- Discuss the continuous measurement and control of the flow of solid material in a process.

Lesson 10: Installation and Maintenance of Flow Instruments

Topics

Primary flow elements; Pressure taps; Piping, fittings, and valves; Electrical hookup; Maintenance precautions; Preventive maintenance; Calibration

Objectives

- Describe components of a differential flow measurement system.
- List guidelines for correct installation.
- Discuss the principles of thorough and safe instrument maintenance.
- List the steps in instrument calibration.
- Discuss the basic rules of safety in instrument servicing.

Level Measurement

Course 276: Level Measurement
Covers principles governing various methods of measuring level. Explains operation of conductive, capacitive, resistive, ultrasonic, and photoelectric devices. Compares operation of several kinds of pressure-head instruments. Explains measurement of solids by ultrasonic, microwave, radiation, and other methods. Discusses several special-application devices for both continuous and point level measurement.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Principles of Level Measurement

Topics

Surface-sensing and storage tank gauges; Sight glasses; Magnetic and displacer gauges; Buoyancy; Level, mercury, and magnetic reed switches; Switches with multiple displacers

Objectives

- Define datum point, and contrast direct and indirect level measurement.
- Describe the main kinds of surface-sensing gauges.
- Define buoyant force and explain how it is used in displacer gauges to measure liquid level.
- Describe maintenance procedures for float devices, displacer gauges, and sight glasses.
- Compare the use of sight glasses, mercury level switches, and magnetic reed switches.

Lesson 2: Electrical Instruments

Topics

Conductivity and liquid level; Capacitance probes; Zero and span adjustments; Ultrasonic, resistance, and photoelectric level detectors

Objectives

- Differentiate between continuous and point level measurements, and between direct and indirect level measurement.
- Describe the operation of a conductance probe in a conducting liquid.
- Describe the operation of a capacitance probe in a dielectric liquid.
- Explain the operation of ultrasonic, resistance, and photoelectric level sensors.
- Describe conductance point level probes, capacitance point level probes, and ultrasonic point level detectors.

Lesson 3: Pressure Head Instruments

Topics

Hydrostatic pressure; Relative density; Pressurized fluids; Air bellows; Air/liquid purge systems; Force-balance diaphragm system

Objectives

- Define hydrostatic pressure and explain how it is calculated by means of the relative density (specific gravity) of a liquid in a tank.
- Discuss the relationship between pressure head and the location of the pressure (level) indicator.
- Compare the air bellows and air purge systems and discuss advantages for each.
- Explain how a force-balance diaphragm system works.
- Describe the operation of a differential pressure transmitter and explain how it is used to measure level and density.

Lesson 4: Solid Level Measurement

Topics

Weight method; Ultrasonic, microwave, and radiation level detectors; Capacitance and resistance probes; Bob-and-cable tension method

Objectives

- List the data needed to compute the level of a bulk solid in a bin.
- Describe and compare the operation of wire strain gauges and semiconductor strain gauges.
- Compare the advantages and disadvantages of ultrasonic and microwave level measuring methods.
- Discuss the operation of capacitance probes, resistance probes, and bob-and-cable units in measuring bulk solids.
- Describe how diaphragm switches and tilt switches are used for point level detection in automatic bin fillers.
- Discuss the use of rotating paddle detectors in controlling level within a band.

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Lesson 5: Other Level Measurement Instruments

Topics

Radiation level detectors; Ionization, semiconductor, and photoelectric radiation sensors; Infrared detectors; Interface levels

Objectives

- Explain how radiation level detectors are used for both continuous and point level measurement.
- Describe the operation of ionization radiation sensors, semiconductor radiation sensors, and scintillation counters.
- Discuss the operation of an infrared point level detector.
- Describe several methods of measuring interface levels.
- Explain how range suppression and range elevation are used.
- Discuss the important considerations in equipment selection.

Temperature Measurement

Course 277: Temperature Measurement
Covers units in thermal measurement and operation of RTDs (and wheatstone bridges), thermistors, and thermocouples and thermometers. Includes principles of pyrometry and operation of narrowband, broadband, and bandpass pyrometers. Discusses calibration standards, typical calibrating methods, and instrument testing.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Temperature Measurement Principles and Indicators

Topics

Temperature and temperature scales; Heat; Change of state; Measuring instruments; Color change and melting point indicators

Objectives

- Define thermal energy and explain the relationships among thermal energy, heat, and temperature in a substance.
- Correlate changes in temperature with changes in a substance's physical state.
- Compare four temperature scales, and convert temperature readings from one scale to another.
- Explain how primary and secondary temperature calibration standards are used.
- Describe various temperature-measuring devices and contrast thermometers and pyrometers.

Lesson 2: Bimetallic and Fluid-Filled Temperature Instruments

Topics

Bimetallic, liquid-in-glass, and filled-system thermometers; Liquid- and gas-filled systems; Vapor-pressure systems; Capillary and bourdon tubes; Temperature transmitters

Objectives

- Discuss the physical characteristics and operation of bimetallic thermometers.
- Describe how liquid-in-glass thermometers are constructed and how they operate.
- Compare liquid-, gas-, and vapor-filled systems and discuss their advantages and disadvantages.
- Explain how a mercury thermometer operates.

Lesson 3: Electrical Instruments

Topics

Resistance thermometers; Wheatstone bridge circuits; RTD elements; Thermistors; Thermocouples; Compensation

Objectives

- Discuss the relationship between temperature and electrical resistance.
- Describe the function of RTD bridge circuits and explain how to calculate lead-wire errors.
- Compare the accuracy, response time, stability, and circuit complexity of RTDs and thermistors.
- Describe the operation of a thermocouple and explain how to compensate for changes in the reference junction temperature.

Lesson 4: Pyrometry

Topics

Principles; Effects of emittance and temperature; Wavelength of radiated energy; Pyrometers

Objectives

- Discuss the principles that govern noncontact thermal measurements.
- Define electromagnetic radiation and emittance.
- Discuss the characteristics of a blackbody.
- Describe the effects of temperature and emittance on radiation intensity.
- Describe the operation of optical and radiation pyrometers.

Lesson 5: Temperature Instrument Maintenance and Calibration

Topics

Calibration standards; Instrument inspections; Controlled-temperature environments; Triple-point and ice baths; Calibration and testing

Objectives

- Compare and define primary, secondary, and working calibration standards.
- Describe typical testing procedures for temperature-measuring instruments.
- Describe routine maintenance and calibration procedures for temperature-measuring instruments.
- Explain how to use controlled-temperature environments—ice baths, triple-point baths, fluid baths, and fluidized baths.
- Explain how to calibrate liquid-in-glass thermometers, thermocouples, resistance thermometers, and pyrometers.

Analytical Instrumentation

Course 278: Analytical Instrumentation
Covers principles, installation, calibration, and maintenance of conductivity probes, and methods of stack gas monitoring. Includes how to install, calibrate, and maintain pH, ORP, and other optical analyzers. Discusses principles governing sensors used in measuring oxygen, carbon monoxide, and carbon dioxide. Concludes with operation, calibration, and system components in liquid and gas chromatography.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Measuring Conductivity

Topics

Ion concentration; Conductivity probes; Probe, liquid standard, and wire loop calibration; Grab samples; Stack gas analyzers; Maintenance

Objectives

- Define conductivity and discuss the basic principles governing conductivity.
- Compare the operation of electrode probes and inductive probes.
- Describe two procedures for calibrating conductivity probes.
- Discuss proper installation and maintenance practices for conductivity probes.
- Discuss the operation of stack gas analyzers.

Lesson 2: Measuring pH and ORP

Topics

Temperature and pH; pH and ORP reference and measurement electrodes; Calibration; Probe installation, mounts, and maintenance

Objectives

- Describe pH and ORP measurement processes.
- Describe the instruments used for the measurement of pH and ORP.
- Discuss calibration procedures for pH and ORP measurement instruments.
- Discuss general installation and maintenance procedures for pH and ORP measurement instruments.

Lesson 3: Optical Measurements

Topics

Transmission-type analyzers; Turbidimeter; Nephelometers; Refractometers; Capacity analyzers; Calibration, installation, and maintenance

Objectives

- Describe the components that make up an optical analyzer.
- Discuss the basic operating procedures of silica ion and COD optical analyzers, turbidimeters and nephelometers, refractometers, and capacity analyzers.
- Compare procedures for calibrating an optical analyzer with standards, with grab samples, and electronically.
- Discuss installation considerations and basic maintenance procedures for an optical analyzer.

Lesson 4: Measuring Products of Combustion

Topics

Gas, oxygen, carbon dioxide, and carbon monoxide sensors; Calibration; Maintenance

Objectives

- Identify the main components in the combustion process.
- Describe the various kinds of instruments used for measuring the products of combustion.
- Discuss the principles of operation of instruments that measure the products of combustion.
- Describe the basic maintenance procedures for instruments that measure the products of combustion.
- Discuss the various sampling techniques for measuring the products of combustion.

Lesson 5: Chromatography

Topics

Chromatograph operation; Gas and liquid chromatography; System valves; Detectors; Chromatograms; Calibration and maintenance

Objectives

- Discuss the principles of chromatograph operation.
- Describe four kinds of detectors used with chromatographs.
- Describe four kinds of liquid chromatographs.
- Explain how to read a chromatogram.
- Discuss chromatograph calibration techniques and identify variables that can affect chromatograph accuracy.
- Discuss chromatograph maintenance considerations.

Final Control Elements

Course 279: Final Control Elements
Covers how elements in a closed-loop system affect final control element. Describes components in final control subsystems. Discusses operations of solenoids, motors, relay systems, PLCs, pneumatic actuators, and positioners. Compares construction, characteristics, and applications of eight control valves. Traces operation of each element in typical feedwater, turbine, and robotic control systems.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Final Control Elements in Process Loops

Topics

Compensation; Feedback loops; Performance effects of disturbances; Final control subsystem parts; Amplifiers; Digital signals

Objectives

- Discuss the function of final control elements in process loops.
- Explain how an actuator is used with the final control element.
- Discuss the effect of a disturbance on the performance of a process loop.
- Describe the three parts of a final control element subsystem.
- Discuss the differences between electric and fluidic control signals in the operation of final control elements.

Lesson 2: Electric Actuators

Topics

Solenoids; Solenoid-operated valves; DC and AC motors; Three-phase and single-phase induction motors; Stepper motors; Relay systems; PLCs

Objectives

- Describe the operation of a solenoid with a valve.
- Name the basic components of dc and ac electric motors and explain how they work.
- Discuss the advantages of universal motors and stepper motors.
- Explain how an electromechanical relay works.
- Name at least three kinds of relays in use today and give typical applications for them.
- Discuss the applications and advantages of programmable logic controllers.

Lesson 3: Pneumatic and Hydraulic Actuators

Topics

Effects of changing pressure and temperature; Diaphragm, piston and hydraulic actuators; Mechanical advantage; One- and two-way systems

Objectives

- Describe the basic principles of operation for both pneumatic and hydraulic actuators.
- Discuss the relationships among pressure, temperature, and volume in a pneumatic system.
- Compare the operation of direct- and reverse-acting actuators.
- Describe the major components of a simple hydraulic system.
- Discuss the characteristics of proper hydraulic fluid and describe elements of hydraulic system maintenance.

Lesson 4: Control Valves

Topics

Valve components and characteristics; Globe, cage, butterfly, ball, sliding-gate, diaphragm, split-body, proportional/servo, and other valves

Objectives

- Describe the components of a control valve.
- Compare the operation and advantages of globe, cage, butterfly, ball, sliding-gate, diaphragm, and split-body valves.
- Discuss the operation, advantages, and disadvantages of proportional/servo valves.
- Explain the differences in linear, quick-opening, and equal-percentage flow characteristics.
- Discuss mechanical requirements for valves and valve actuator requirements.
- Explain the relationship of flashing and cavitation to proper control valve selection.

Lesson 5: Final Control Element Applications

Topics

Feedwater and turbine control systems; Sequential and automatic valve control; Control and block valves; Robotic systems

Objectives

- Describe the sequential valve control used in a typical feedwater control system.
- Describe a typical relay logic system.
- Discuss the use of limit switches for automatic valve control.
- Describe the operation of a hydraulic fluid supply system for a turbine generator.
- Describe the operation of an industrial robotic system.

Safety, Calibration, and Testing Procedures

Course 280: Safety, Calibration, and Testing Procedures
Covers the responsibilities of employer, employee, and regulatory agencies in maintaining safety. Discusses ways of identifying and handling chemical, electrical, biological, radiation, and mechanical hazards. Discusses importance of maintenance and record keeping. Offers guidelines for handling heavy equipment, decontaminating and servicing pneumatic and hydraulic equipment, and troubleshooting.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Safety Standards and Practices

Topics

Government safety regulations; Compressed gas, chemical, electrical, biological, radiation, and mechanical hazards; Noise pollution

Objectives

- Discuss kinds of hazards and compare employer and employee responsibilities relating to safe job practices.
- Describe safe procedures for working with compressed gases, acids, flammable solvents, and other hazardous chemicals.
- Describe ways to minimize the possibilities of hazardous or lethal electric shock, including safe lockout procedures.
- Explain the use of dosimeters.
- Identify potential safety hazards in the instrument shop and along the process control network and describe the use of appropriate safety equipment for each hazard.

Lesson 2: Servicing Fundamentals

Topics

Repair modes and records; Failure mode analysis; Maintenance, calibration modes, and records; Calibration seals; Tools and equipment

Objectives

- Compare methods of on-site and shop repair of malfunctioning instruments.
- Describe the differences between repairing, maintaining, and calibrating instruments.
- Describe the contents of an equipment history file and a process loop file.
- Discuss the benefits of failure mode analysis.
- Describe proper calibration procedures, including use of calibration seals, and explain what NIST-traceable means.
- Describe the typical main sections of an industrial instrument shop.

Lesson 3: Electrical and Electronic Stations

Topics

Electrical and electronic stations and test equipment; Pneumatic and hydraulic test equipment; Test stands; On-site operations; Calibration

Objectives

- Describe the differences between electrical and electronic test areas.
- Describe how the ammeter, megohmmeter, wattmeter, and dynamometer are used in electrical work.
- Describe how the multimeter, signal/waveform generator, oscilloscope, voltage and current source, and frequency counter are used in electronics.
- Discuss the benefits of accurate calibration and thorough equipment maintenance records.
- Explain how test stands are used and name three kinds of operations that are typically conducted on site.

Lesson 4: Pneumatic and Hydraulic Stations

Topics

Handling equipment; Cleaning and decontamination; Testing and evaluation; Disassembling and reassembling; Calibration; Test stands

Objectives

- Describe the layout and power requirements of a typical pneumatic/hydraulic station.
- Describe safe and efficient methods of cleaning pneumatic and hydraulic instruments and controls.
- Discuss procedures for testing and evaluating a faulty component, using the calibration of a pressure-to-current (P/I) transmitter as an example.
- Describe proper procedures for disassembling and reassembling pneumatic and hydraulic components.
- Name the steps in preparing to service instruments on site.

Lesson 5: Troubleshooting

Topics

Using manufacturer's literature, maintenance and repair records, tools, and test instruments; Calibration; Recording the repair

Objectives

- Explain how an understanding of the process and its instrumentation reduces troubleshooting time.
- List at least four kinds of information typically included in a manufacturer's manual or instruction book.
- Describe the contents of an instrument history file and explain its usefulness in troubleshooting.
- Discuss the kinds of tools, including calibration standards, you are apt to use in troubleshooting.
- Describe the steps in a typical troubleshooting procedure and explain how to use a branching troubleshooting chart.
- Describe cascading failure.

Working with Controllers

Course 281: Working with Controllers
Covers purposes and kinds of controllers and their relationship to other components in process control systems. Explains current-, position-, and time-proportioning control. Describes the operation of proportional, integral, and derivative modes. Discusses cascade, feedforward, ratio, and auctioneering control systems as well as other operations. Describes ways to eliminate or reduce controller problems.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Introduction to Controls

Topics

Process dynamics; Current, position, and time proportioning; Controller modes, actions, terminology, and options; Loop accuracy

Objectives

- Describe the kinds of controllers most often used in industrial applications.
- Discuss six important problems of process dynamics that controllers must overcome.
- Compare the actions of current proportioning, position proportioning, and time proportioning.
- Name four kinds of controller alarms.
- Discuss the importance of safety in control loops.

Lesson 2: Controller Operations

Topics

Automatic/manual control; Range and span; Direct-, reverse-acting, on/off, and proportional controllers; Current, time, and position-proportioning control; Control strategies

Objectives

- Explain why automatic/manual control is necessary.
- Explain how on/off controllers work and discuss the difference between on/off and proportional controllers.
- Describe a basic controller tuning process.
- Describe current-, time-, and position-proportioning controllers and name possible uses for each.
- Explain how split control works.

Lesson 3: Controller Modes and Tuning

Topics

Proportional mode; Offset; Integral mode (reset); Derivative mode (rate); Single, two, and three mode controllers; Loop tuning; Step-change response

Objectives

- Describe the effect of the proportional, integral, and derivative modes on a controller's response to process changes.
- Discuss proper uses for the proportional, integral, and derivative modes.
- Explain how the proportional, integral, and derivative modes affect the tuning of a controller.
- Describe the procedure for tuning a controller by the step-change response method.

Lesson 4: Special Controller Applications and Options

Topics

Cascade, feedforward, ratio, and auctioneering control; Hardware options; Remote setpoint; Auxiliary outputs; Indicators; Limits and alarms

Objectives

- Compare cascade, feedforward, ratio, and auctioneering control strategies.
- Describe three optional features used with auto/manual controllers.
- Discuss the use of remote setpoint, auxiliary outputs, and several kinds of indicators as hardware options for controllers.
- Explain how input signal conditioning, anti-reset windup, adaptive gain, error-squared calculation, and setpoint/output ramp and clamp affect controller operation.
- Discuss the use of limit and alarm options available for controllers.

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Lesson 5: Maintaining Controller Systems

Topics

Preventing problems; Electrical noise and suppression; Regulating power; Electrical coupling; Temperature variation; Troubleshooting

Objectives

- Describe five ways of suppressing electrical noise.
- Discuss the effects of an inadequate power supply and explain how to regulate it.
- Describe ways to avoid the harmful effects of electrical coupling.
- Explain how temperature variations affect controllers.
- Describe the kinds of equipment and proper connections needed to test controllers.
- Discuss elements of effective controller maintenance and troubleshooting.

How Control Loops Operate

Course 282: How Control Loops Operate
Covers definition of control loop terms and characteristics. Includes specific examples of operation of control loops of many kinds. Discusses proportional, integral, and derivative modes in detail. Describes advanced control methods by means of four strategies with specific examples. Examines the effects of loop dynamics on system stability.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Fundamentals of Control Loops

Topics

Definitions; Process sensors; Sensor characteristics; Controllers; Recorders; Signal conditioners; Final control elements

Objectives

- Explain the difference between an open loop and a closed loop.
- Define error, feedback, disturbance, and feedforward control.
- List several kinds of process sensors and describe the operation of each.
- Explain how accuracy, resolution, sensitivity, linearity, and step response affect sensor operation.
- Describe the functions of process controllers, recorders, signal conditioners, and final control elements.
- Explain the basic operation of a typical control loop.

Lesson 2: Control Loop Characteristics

Topics

Two-position and floating control; Proportional, integral, derivative, and PID mode; Supervisory control; DDC; DCS

Objectives

- Describe the difference between continuous and discontinuous control modes and give an example of each.
- Describe the action of the various continuous control modes.
- Define proportional band, reset time, and rate time.
- Discuss the advantages of each of the combination control modes.
- Name several advantages of digital controllers.
- Discuss the differences between supervisory control, direct digital control, and distributed control systems.

Lesson 3: Advanced Control Methods

Topics

Cascade and ratio control system; Feedforward control; Ratio control in a secondary loop; Multivariable control systems

Objectives

- Describe how a cascade control system works.
- Identify the primary and secondary variables in a cascade loop.
- Compare feedforward and feedback control.
- Identify dependent and independent variables in ratio control.
- Explain the advantage of having a secondary control loop in ratio control.
- Describe how a multivariable control system works and define interaction.

Lesson 4: Loop Dynamics

Topics

Effects of process time lag; Dead time compensation; System stability; Transient response; Gain; Phase shift

Objectives

- Describe two kinds of process time lags and give an example of each.
- Discuss the effects of capacitance and resistance on loop dynamics.
- State the three main objectives of a well-designed process control system.
- Describe how PI, PD, and PID controllers are adjusted to achieve optimum response.
- Discuss the effects of system gain and phase shift on system stability.

Lesson 5: Loop Protection

Topics

Explosion-proof enclosures; Intrinsically safe instrument systems; Fail-safe mechanisms; Hard and soft constraints; Alarms

Objectives

- Discuss the classification of hazardous locations as identified in the NEC Handbook.
- Define volatility and flash point, and explain the purpose of a purged enclosure.
- Describe two kinds of explosion-proof enclosures.
- Discuss ways of making a system intrinsically safe.
- Describe examples of fail-safe mechanisms, and differentiate between hard and soft constraints.
- Compare latching and nonlatching alarm systems, and explain the function of annunciators.
- Discuss the purpose and operation of interlocked and sequential control.

Data Transmission

Course 283: Data Transmission
Covers mechanical, hydraulic, pneumatic, and telemetric data transmission methods. Discusses indicators and methods used for electrical/electronic data transmission. Compares methods and standards for parallel and serial digital data transmission. Describes optical isolation and optical data transmission systems in detail. Provides specific methods for preventing common data transmission interference.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Process Data Transmission Methods

Topics

Data handling; Local and remote indicators; Mechanical, hydraulic, pneumatic, electronic, optical, and telemetric data transmission

Objectives

- Describe the differences between data transmission in open- and closed-loop systems and with local and remote indicators.
- Discuss the differences among analog, digital, and discrete control.
- Discuss the use of intrinsically safe and explosion-proof equipment.
- List the advantages and disadvantages of mechanical, hydraulic, and pneumatic data transmission.
- Compare voltage-loop and current-loop transmission for analog data and explain the importance of resolution for digital data transmission.
- List the advantages and disadvantages of optical and telemetric data transmission.

Lesson 2: Electrical Data Transmission

Topics

Analog and digital data; Electronic PV indicators; Signal conditioning and conversion; Compensation; Span and zero adjustment; Linearization

Objectives

- Compare analog and digital data representation.
- Discuss uses for bar graph displays, CRT displays, recorders, and data loggers.
- Describe the characteristics of the electrical output signals from analog sensors and transducers, using a strain gauge as an example.
- Discuss the significance of the common-mode rejection ratio in signal conditioning.
- Describe the processes of signal conversion, compensation, zero and span adjustment, linearization, and conversion to engineering units.

Lesson 3: Digital Data Transmission

Topics

Number systems; Data formats; ASCII; Error correction; Analog-to- digital conversion; Distributed process control; Parallel and serial data transmission

Objectives

- Discuss the differences between analog and digital data forms.
- Discuss several reasons for using digital data.
- Describe methods used to interface process control data signals to a communications network.
- Explain how analog data are converted to digital form for transmission and display.
- Discuss the differences between parallel and serial data transmission systems.

Lesson 4: Optical Data Transmission

Topics

Fiber optic cable, connection, and transmission advantages; Optical propagation; Installation of cables; Light sources; Detectors; Standards

Objectives

- Name the basic elements in a data transmission system based on light energy.
- Explain how optoisolators work and why they are used.
- Describe the advantages and disadvantages of optical data transmission.
- Explain how light rays are propagated down glass fibers.
- Discuss connection and installation methods for fiber optic cables.
- Discuss the selection of light sources and detectors.

Lesson 5: Data Transmission Interference

Topics

Electrical and process noise; Signal-to-noise ratio; Power line noise; Electromagnetic interference; Capacitive coupling; Ground loops; Noise reduction techniques; Electrostatic shielding

Objectives

- Define electrical noise, process noise, and the signal-to-noise ratio.
- Explain how ac power lines, EMI, capacitive coupling, and ground loops cause electrical noise.
- Describe two kinds of noise filters and explain three methods of reducing ac power line noise.
- Compare methods for reducing electromagnetic and electrostatic coupling.
- Discuss the use of differential measurements and the CMRR.
- Describe ways of reducing ground loop noise and RFI and explain when optical coupling might be used.

Computers in Process Control

Course 284: Computers in Process Control
Covers evolution of process control computer systems. Compares smart components to older conventional system devices. Covers architecture, configuration, and operation of distributed control systems, using a typical DCS controlling an ice cream plant as an example. Defines terms used in today's integrated plant and discusses integration of discrete and continuous processes with plant business functions.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: History and Overview

Topics

SCADA; Microprocessor-based instruments; Distributed control; Personal computers; PLCs; Artificial intelligence; Expert systems; Fuzzy logic; Integrated control systems

Objectives

- Discuss the history of the application of computers to continuous and batch process control.
- Describe the function of an RTU in a SCADA system.
- Describe the development of distributed control systems from microprocessor-based instruments, including programmable logic controllers.
- Compare the hardware, operating systems, software, and applications of a PC with a household VCR.
- Compare the concepts of artificial intelligence, expert systems, and fuzzy and crisp logic.

Lesson 2: Small Computers in Process Control

Topics

Smart sensors, transmitters, signal conditioners, and final elements; Single and multiloop controllers; Networks; PLCs

Objectives

- Describe the various kinds of small computers used in process control.
- Explain how a "smart" device differs from its conventional counterpart.
- Discuss the similarities between microprocessor-based instruments and conventional instruments and list several advantages of microprocessor-based instruments.
- Describe the roles of two kinds of PCs (programmable controllers and personal computers) in process control.

Lesson 3: DCS Architecture

Topics

Distributed control system hardware and software; Workstations; Remote processing units; Host/guest computers; Transmission systems

Objectives

- Describe the elements of a typical workstation.
- Discuss the functions of remote processing units and host/guest computers in DCSs.
- Compare star, hub, and ring network topologies and token-passing, contention, and polling protocols.
- Explain why today's DCS users must be more computer literate than previously.
- Discuss ways of calculating and ensuring DCS reliability.
- Describe the functions of six typical DCS peripherals.

Lesson 4: DCS Configuration and Operation

Topics

Configuring distributed control systems; Hierarchical displays; Configuring operating and auxiliary displays; Operation

Objectives

- Describe the basics of a simple configuration process.
- Discuss the preparatory steps required for configuration.
- Describe a typical hierarchical display arrangement and discuss the progression of the configuration process from level to level.
- Discuss the automatic configuration of auxiliary displays.
- Discuss the DCS functions for which the operator is and is not responsible.

Lesson 5: Systems and Application Integration

Topics

Total business operation; Discrete processes and manufacturing systems; Flexible manufacturing; Materials control; Statistical process control

Objectives

- Discuss the development of integration in industry.
- Describe how continuous and discrete processes fit into the concept of total business integration.
- Describe the purposes of MAP and OSI.
- Discuss the functions of CAD, CADD, CAE, CAM, and cell control in discrete processes.
- Discuss the importance of FMS, MRP, JIT, and MMS in today's integrated industrial plant.
- Explain how SPC ensures quality control in open-loop processes.
- Discuss the advantages of integrating batch, continuous, and discrete processes throughout a plant.

Programmable Logic Controllers

Course 298: Programmable Logic Controllers
Covers the basic hardware and operating principles of PLCs, their inputs and outputs, programming, maintenance/troubleshooting, and networking.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Introduction to Programmable Logic Controllers

Topics

The electromagnetic relay; Characteristics of programmable controllers; Applications of programmable controllers; Limitations of programmable controllers; Parts of a programmable logic controller system; The input side; The processor; The output side; Programming devices; Power supplies

Objectives

- Describe an electromagnetic relay and define the terms control circuit, power circuit, NO and NC.
- Define programmable logic controller.
- Describe the general type of application in which a programmable logic controller would best be used, and give examples.
- Define scan time.
- Name each of the blocks in a block diagram of a programmable logic controller system and explain how each functions within the system as a whole.
- Define memory and explain the different types

Lesson 2: Number Systems and Logic

Topics

Number systems; Binary-Coded Decimal (BCD); ASCII; Gray code; Boolean logic; Ladder logic

Objectives

- Compare the decimal, binary, octal, and hexadecimal number systems.
- Explain the purpose for using each of the following: BCD, Gray code, and ASCII.
- Explain what AND, OR, and NOT mean in Boolean logic, and identify the symbols for each.
- Identify AND and OR logic circuits in a relay ladder diagram, and construct a truth table for each.
- Explain the basic concepts of ladder logic.

Lesson 3: Programming the System

Topics

PLC programming; Ladder logic programming; Boolean programming; The AND instruction; The OR instruction; The stack register

Objectives

- Explain the relationship between a programmable logic controller processor and program.
- Define the term scan and explain the basic steps involved in a scan.
- Explain the basic concepts of ladder logic programming.
- Explain the purpose of a parallel branch in a ladder logic program.
- Explain the basic concepts of Boolean programming.
- Define stack register and state the stack rule.

Lesson 4: Input/Output Devices and Modules

Topics

Definition of I/O devices; Discrete input devices; Analog input devices; Digital input devices; Discrete output devices; Analog output devices; Digital output devices; Sourcing and sinking; Definition of I/O modules; Input modules; Output modules

Objectives

- Explain the operation of common input and output devices and identify their symbols.
- Describe the relationship of an input/output device to a terminal on an input/output module.
- Contrast the basic concepts of a sourcing device and a sinking device.
- Explain the operation of various input and output modules.

Lesson 5: Developing a Programmable Logic Controller System

Topics

Before you begin; Equipment operation specifications; Sizing the system; Program development; Assembling the documentation package; Functional model; Startup and debugging

Objectives

- Explain the importance of working with accurate information from a specification.
- Demonstrate how to size a system.
- List the elements in a good documentation package.
- Name the steps involved in specifying the hardware and developing the program for a simple control system.
- Describe system startup and debugging procedures.

Lesson 6: Maintenance and Troubleshooting

Topics

The importance of documentation in maintenance troubleshooting; Using the hardware documentation; The maintenance log; Using the program documentation; Operational documentation; Routine maintenance; Batteries; Troubleshooting; Problems in troubleshooting; Troubleshooting in practice

Objectives

- Explain the importance of good documentation.
- Tell what type of information can be found in user's manuals and operations manuals.
- Tell what types of logs are kept and why they are necessary.
- Explain the major concepts of troubleshooting, including problems sometimes encountered.
- Describe routine maintenance procedures required by a programmable controller system.

Lesson 7: System Expansion and Data Networks

Topics

I/O expansion; Configuring the system; Math and data handling instructions; Timers and counters; The shift register; Spray booth retrofit; Indexing table retrofit; Local area networks; Uses for LANs; Transmission media; Transmission schemes; Vendor offerings

Objectives

- Compare the procedures involved in local and remote I/O expansion.
- Explain what is meant by configuring a system.
- Describe the operation of the shift register instruction.
- Explain how math and data-handling instructions work and why they are added to PLC systems.
- List important items to consider in I/O expansion and retrofitting.
- Define the terms local area network, baud rate, and throughput.
- List and explain the contents of a data packet used in LAN data transmission.
- Name and define the three main applications of LANs.
- List advantages and disadvantages of the three common transmission media used with LANs.

Industrial Rigging Principles and Practices

Course 318: Industrial Rigging Principles and Practices
Covers techniques and safeguards in the use of rope, chain, hoists, and scaffolding when moving heavy plant equipment and maintaining plant utilities.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Introduction to Industrial Rigging

Topics

Rigging tools; Determining weight and center of gravity; Vertical and horizontal force; Slings; Hooks; Hoist hooks; Special-purpose rigging hooks

Objectives

- Identify the tools used in rigging and explain the purpose of each.
- Give examples of three methods of calculating the weight of a load.
- Explain center of gravity and its importance in rigging a load.
- Describe four common sling arrangements and the relation between sling angle and horizontal force.
- Name five types of hooks frequently used in rigging and explain the purpose of each.
- Discuss proper hook use and cite four reasons for removing a hook from service.

Lesson 2: Wire Rope and Wire-Rope Slings

Topics

Wire rope construction, classification, and strength; Seizing, cutting, and splicing; Wire-rope slings; Inspection

Objectives

- Identify the component parts of wire rope and describe its construction and classification.
- Identify and discuss the factors that affect wire rope strength.
- Describe the basic single-leg and multiple-leg slings and the calculation of their allowable loads.
- Enumerate the signs of damage that would probably cause a wire rope to be removed from service.

Lesson 3: Chain and Metal-Mesh Slings

Topics

Welded-link chain; Chain grades and strength; Chain slings; Inspecting slings; Metal mesh slings; Sling materials

Objectives

- Identify the different grades of chain and name some of their applications.
- Define the terms working load limit, proof test, and minimum breaking force.
- List and discuss four factors that affect the strength of chain slings.
- Describe three types of damage you might see in a daily inspection of chain slings that would lead you to set the sling aside for more thorough examination.
- Describe the two standard types of end fittings for metal mesh slings and the hitches for which each can be used.
- Name several advantages of, and applications for, metal mesh slings.
- List the visible signs of damage that would cause you to recommend a sling's removal from service.

Lesson 4: Fiber Rope and Webbing Slings

Topics

Natural and synthetic-fiber rope; Sling strength; Whipping rope ends; Splicing fiber rope; Synthetic webbing; Inspecting slings

Objectives

- Identify the grades of manila rope that can be used for overhead lifting.
- Name the three commonly used synthetic-fiber ropes and list three of their advantages over manila.
- Discuss the factors that affect the strength of fiber rope.
- Name the signs of wear or damage that would warrant setting a fiber-rope sling aside for more detailed inspection.
- Describe an encased polyester fiber sling.
- Explain the construction of synthetic-web slings and name four of the basic types.
- List examples of visible damage that should cause a synthetic-web sling to be removed from service.

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Lesson 5: Industrial Hoists and Cranes

Topics

Overhead manual chain, power, and wire-rope hoists; Side pull; Overload limit device; Underhung and top-running cranes; Jib cranes; Inspection

Objectives

- Describe the characteristics of the various kinds of overhead hoists.
- Explain the differences between single and double reeving.
- Explain the proper function and operation of an upper limit switch and an overload limit device.
- Describe and contrast the construction of top-running and underhung cranes.
- Identify the three basic types of jib cranes.
- Describe what the rigger's daily visual inspection should include.
- List examples, from the additional criteria given in this lesson, of conditions that should warrant removal of wire rope or hoist load chain from service.

Lesson 6: Operating Practices

Topics

Hoist and crane operation; Special heavy lifts; Pulling, setting, and turning a load; Eyebolts; The thought process of rigging

Objectives

- Enumerate the general operating practices that apply to all tools of rigging.
- Explain the 11 operating practices that apply to slings.
- Discuss nine operating practices that should be observed when using a hoist or crane.
- Detail the special circumstances under which a hoist or crane may be used to pull a load or lift a load heavier than the equipment's rated capacity.
- Describe three methods of turning a load.
- Discuss the eight questions that a rigger must answer in the thought process that should precede any lift.

Lesson 7: Scaffolds and Ladders

Topics

Types of scaffolds; Guy lines; Accessories; Ladders; How to raise and inspect a ladder; Life belts; Scaffold and ladder safety

Objectives

- Explain the construction of pole and suspension scaffolds and lift platforms, and the safety measures that apply to them.
- Name several scaffolding accessories and explain their use.
- Discuss recommended usage and inspection of the three common types of ladders.

Equipment Installation

Course 319: Equipment Installation
Covers installation procedures for large plant equipment. Considers factors affecting proper installation in detail, from preparatory relocation of underground piping and wiring, through equipment anchoring, aligning, and test running.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Preparing the Site

Topics

Relocating underground piping, wiring, and cables; Barricading the work area; Removing excavated materials; Foundations and footings; Reinforced concrete; Safetyprecautions for excavating

Objectives

- Tell who plans the installation of new equipment and list the steps involved.
- Define the terms foundation and footing.
- Tell which type of ground will support the most weight.
- Explain how steel rods are held in position when pouring a concrete footing.
- Name the best materials for filling around a foundation.
- Explain how to protect concrete that might come into contact with oil or chemicals.
- Tell how long new concrete must sit before equipment is installed on it.

Lesson 2: Vibration Control and Anchoring

Topics

Selecting anchors and isolators; Isolator mounts; Anchor bolts; Using power hammers; Grouting

Objectives

- Define vibration and tell how it enters and leaves equipment.
- Tell what type of isolation is best to use on sensitive testing instruments.
- Explain how to isolate anchor bolts when mounting equipment on pads.
- Tell what type of wrench to use for tightening anchor bolts.
- Name the best tool for drilling anchor bolt holes in concrete.
- Tell why the bases of production and processing equipment should be grouted.
- Explain why you must not use a concrete mix to grout anchor bolts.

Lesson 3: Moving and Setting

Topics

Uncrating; Relocating; Lifting; Raising with jacks and slings; Crowbars; Making the move; Personal safety

Objectives

- Explain the procedures involved in relocating existing equipment.
- Tell two things you must know before lifting equipment with a hoist.
- List three things to consider when selecting a jack.
- Explain the operation and uses of a roller skid.
- Tell where to find a floor's allowable load.

Lesson 4: Leveling and Aligning

Topics

Leveling devices; Wedges and shims; Checking alignment; Aligning equipment on the foundation; Alignment screws; Aligning machine tools

Objectives

- Explain the correct way to handle a master precision level.
- Explain how to check the accuracy of a level.
- Name the greatest enemy of precision tools.
- Explain how to level V-shaped ways.
- Tell which leveling device is used most often on small equipment.
- Name three tools commonly used to check alignment.
- Tell how to set an alignment screw to prevent its movement.

Lesson 5: Checking and Test Running

Topics

Electric, hydraulic, and pneumatic connections; Coolant systems; Safety devices; Settings and adjustments; Making the test run; Safety

Objectives

- Explain how to test for the presence of moisture in electrical equipment.
- Tell what device is commonly used to prevent excessive pressure in a hot water heater.
- Explain the function of a pressure regulating valve.
- List the steps to take before initial equipment startup.
- Tell the usual cause of excessive temperature during equipment startup.

Introduction to Robotics

Course 501: Introduction to Robotics
Provides the background required for a detailed study of robot systems and their maintenance. Introduces the trainee to the basics of robotics, using clear, easy-to-follow language. Includes expanded coverage of robot safety and updated sensor and programming information.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Robotics in Automated Manufacturing

Topics

Evolution of robotics; What is an industrial robot?; Essential characteristics; Robots and automated manufacturing; Project manufacturing; Job shop; Batch manufacturing; Repetitive (flow) manufacturing; Continuous manufacturing; Robot safety

Objectives

- Identify why robots did not appear in large numbers in manufacturing until the late 1970s.
- State the Robot Industries Association's definition of an industrial robot and explain the two key words.
- Describe how industrial robots are used in batch production systems.
- Explain how industrial robots are used in repetitive manufacturing systems that utilize transfer lines.
- List at least three factors that should be considered as part of a risk assessment when a robot system is in the development stage.
- Describe and contrast the following guarding methods: barrier, presence-sensing device, awareness device, warning system.
- Define the term zero-energy state.

Lesson 2: The Basic Robot System

Topics

Manufacturing and robot systems; Robot arm; Robot controller; Power source; Tooling; Teaching/programming device; Data storage; Definition of terms; Critical specifications; Payload; Degrees of freedom; Drive power; Repeatability; Accuracy; Work envelope dimensions; Speed; Memory capacity; Programming support; End-of-arm Tooling; Environmental requirements

Objectives

- Name and describe the basic building blocks of an industrial robot.
- Name and describe the additional components that make up a robot system.
- Define the following robot terms: degrees of freedom, position axes, orientation axes, work envelope, tool center point.
- Define and give an example of the following specifications for industrial robots: payload, repeatability, memory capacity, and environmental requirements.
- Explain the difference between accuracy and repeatability in robots.

Lesson 3: Robot Classification I

Topics

Robot classification; Classification by control system; Open-loop control; Nonservo operation; Advantages of open-loop control; Disadvantages of open-loop control; Applications for open-loop control; Closed-loop control; Advantages of closed-loop control; Disadvantages of closed-loop control; Applications for closed-loop control; Classification by application

Objectives

- Identify the five methods of classifying industrial robots.
- Explain the difference between robots with closed-loop control and those with open-loop control.
- Describe the techniques used in closed- and open-loop control in robot systems.
- List the advantages and disadvantages of open-and closed-loop control in robot systems.
- Distinguish between assembly and nonassembly robots according to the application for which they were designed.

Lesson 4: Robot Classification II

Topics

Classification by arm geometry; Cartesian (rectangular) arm geometry; Cylindrical arm geometry; Spherical (polar) arm geometry; Articulated arm geometry; Classification by power source; Classification by path control; Classification by intelligence level

Objectives

- Classify robots by arm geometry, power source, and path control techniques.
- Identify the basic robot work envelopes and name the arm geometries that produce them.
- Name the basic power sources used for robot motion and give an advantage and disadvantage of each.
- Identify the basic path-control techniques and describe their characteristics.

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Lesson 5: Work-Cell Sensors

Topics

Sensor overview; Simple contact sensors; Simple noncontact sensors; Simple process control sensors; Complex sensors; Complex sensor interface; Complex contact sensors; Complex noncontact sensors; Complex process control sensors

Objectives

- List the two types of interfaces and three groups of sensors used in industrial robot systems.
- Describe the primary simple contact sensor commonly found in robot systems.
- Identify and explain the operation of the two simple noncontact sensors most often used in industrial robot installations.
- Explain the difference between the simple sensor interface and complex sensor interface.

Lesson 6: End-of-Arm Tooling

Topics

General requirements; Tooling terms; Tooling power sources; Tooling overview; Standard grippers; Servo or nonservo grippers; Vacuum devices; Magnetic devices; Flexible pneumatic devices; Special-purpose tooling; Protecting end-of-arm tooling; Compliance

Objectives

- Name the five general requirements all tooling must satisfy.
- Identify and describe briefly the four basic tooling power sources.
- Describe the five categories of end-of-arm tooling used in robot applications.
- Explain the function and advantages of a quick-change device.
- Define the term compliance and explain why it is important.

Lesson 7: Robot Teaching and Programming

Topics

Work-cell programming; Controller functions; Robot programming; On-line programming; On-line programming example; Off-line programming; Defining programmed points; Writing program statements; Work cell control with a PLC; PLC programming example

Objectives

- List and describe the four basic functions of the computer(s) controlling an automated work cell.
- Name the two major types of robot programming and give advantages and disadvantages of each.
- Name and describe two basic methods of teach programming and tell when each is used.
- List three advantages of off-line programming.
- Name the two elements of a computer program for off-line robot programming.
- Explain the basics of ladder logic programming.

Introduction to Water Technology

Course 381: Introduction to Water Technology
Covers the nature, use, and properties of water. It traces the history of water treatment methods from ancient times to today's sophisticated systems. The effects of chemical and biological factors on the purity of water are explained.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Water: The Basic Resource

Topics

Precipitation; Surface runoff; Groundwater; Municipal, industrial, and agricultural use; Waste disposal; Upgrading water quality

Objectives

- Name the continuing processes that make up the water or hydrologic cycle.
- Describe the atmospheric process that produces precipitation.
- Identify the users of municipal water supplies.
- Point out some of the important advances made in water treatment since 1900.
- List the benefits of the Federal Water Pollution Control Act Amendment of 1972.

Lesson 2: Water Collection, Treatment, and Distribution

Topics

Collecting surface water and ground water; Transmission of water; Treatment types; Distribution; Primary, secondary, and tertiary treatment

Objectives

- Explain the differences between a confined aquifer and an unconfined one.
- Tell why it is necessary to treat water for drinking and for manufacturing purposes.
- Describe the treatment processes of sedimentation and coagulation.
- Describe how a system for the distribution of treated water operates.
- Tell what takes place during the primary treatment of wastewater.

Lesson 3: Physical Properties of Water

Topics

Color, taste, odor, and temperature of water; Solids in the water; Turbidity; Suspended matter; Measuring electrical conductivity

Objectives

- Distinguish between the apparent color and the true color of water.
- Name the four basic tastes of water that a person can sense.
- Tell how a rise in temperature affects the various properties of water.
- Name the sources of organic and inorganic solids that pollute wastewater.
- Explain the differences between suspended solids and dissolved solids.

Lesson 4: Chemical Properties of Water

Topics

Atoms and molecules; Acids, bases, and salts; Ionization; Alkalinity and acidity; Hardness of water; Unwanted chemicals; Dissolved oxygen

Objectives

- Identify the particles in an atom, and tell how they fit together to form the atom.
- Describe the relationship between a pH number and the concentration of H+ ions.
- Name the two color tests for alkalinity of water and tell what colors they produce.
- Describe the ion exchange and lime-soda processes for removing hardness from water.
- Tell why a certain amount of dissolved oxygen (DO) is necessary in surface water.

Lesson 5: Biological Properties of Water

Topics

Pathogenicity; Disinfection; Stabilization of organic matter; Biochemical oxygen demand; Bacteria; Viruses; Algae; Protozoa

Objectives

- List the methods commonly used to disinfect water.
- Tell how temperature changes affect the rate at which living organisms grow in water.
- Tell how—and how rapidly—common bacteria reproduce.
- List the most effective methods used to inactivate viruses.
- Explain how the presence of algae speeds the process of eutrophication.

Wastewater Treatment Processes

Course 382: Wastewater Treatment Processes
Covers the various stages of wastewater treatment. Goes into detail on the removal of solids, then explains the use of chemical and biological processes for water purification. Covers the treatment and disposal of the extracted solids.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Overview of Wastewater Treatment

Topics

Collection systems; Treatment facilities; Influent; Preliminary, primary, secondary, and tertiary treatment; Disinfection; Solids handling

Objectives

- List the purposes of wastewater treatment.
- Describe the way organic wastes pollute water.
- Identify elements of wastewater collection systems.
- Stages of wastewater treatment at typical treatment facility.
- Explain what happens to wastewater during preliminary, primary, secondary, and tertiary treatment.
- Describe methods of solids handling.

Lesson 2: Physical Separation of Solids

Topics

Screening; Grinding; Grit removal; Sedimentation; Clarifiers; Air flotation; Filtration; Effluent disposal

Objectives

- Identify and describe the different types of bar and woven screens used for screening.
- Identify and describe common types of grit-removal equipment.
- List factors affecting settling rates.
- Figure the length of detention time needed to settle out settleable particles.
- Describe the three principal methods of land disposal.

Lesson 3: Chemical Treatment Processes

Topics

Solids in wastewater; Chemical coagulants; Phosphate removal; Chemical clarification; Disinfection; Equipment used in chlorine feeding

Objectives

- Describe what colloidal particles are and outline the problems associated with removing them from wastewater.
- List chemicals used as coagulants.
- Explain how the flocculation process works.
- Explain the function of a precipitant.
- List chemical agents commonly used as disinfectants.
- Identify factors affecting disinfection.
- Describe methods for applying chlorine to wastewater.

Lesson 4: Biological Processes

Topics

Lagoons; Activated sludge; Aeration; Trickling filters; Activated biofilter process; Rotating biological contactors; Secondary clarifiers

Objectives

- Differentiate between the way unaerated and aerated lagoons function.
- Distinguish between suspended growth and fixed-growth systems.
- List and describe different methods of utilizing activated sludge to stabilize wastewater.
- Tell how trickling filters, ABFs, and RBCs operate.
- Explain how secondary clarifiers are used in conjunction with fixed- and suspended-growth systems.

Lesson 5: Solids Treatment and Disposal

Topics

Sludge conditioning; Thickening; Dewatering; Drying beds; Lagoons; Vacuum filtration; Filter presses; Composting; Ultimate disposal

Objectives

- Distinguish between conditioning, thickening, and dewatering.
- List the factors that affect which conditioning, thickening, and dewatering methods are used.
- Describe four methods of sludge conditioning.
- Describe three methods of thickening.
- List factors that affect drying-bed operation.
- Describe methods for disposing of digested or dewatered sludge.

Maintaining Wastewater Equipment

Course 383: Maintaining Wastewater Equipment
Covers the equipment used in handling and treating wastewater. Outlines correct facility maintenance procedures, including necessary checks and testing of solids handling equipment. Covers the maintenance of flow measurement devices and the safety precautions of workers in the treatment plant environments.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Pumping Stations

Topics

Pump stations; Pump types, operation, and maintenance; Drive units; Piping; Controls; Level detection; Safety

Objectives

- Describe a typical collection system layout.
- Name the three types of pumping stations currently in use and explain how they differ.
- List seven basic components of wet-well and dry-well stations.
- Use the following terms in an explanation of pump operation: impeller, shroud, volute case, stuffing box, shaft sleeve, wearing ring.
- Name the important elements of a good preventive maintenance program for pumps.
- Explain the importance of a pump station ventilation system.
- Demonstrate the necessary procedures to follow before pump start-up.

Lesson 2: Screening and Grinding Equipment

Topics

Bar screens; Grinders; Rotating drum comminutors; Stationary screen comminutors with oscillating cutters; Barminutors

Objectives

- Name the two basic parts of a hand-cleaned bar screen and explain their functions.
- Describe the operation of a mechanically cleaned bar screen.
- Explain why grinders are used and how they are maintained.
- Compare and contrast a rotating drum comminutor and a stationary screen comminutor with an oscillating cutter.
- Explain how a Barminutor combines the functions of a bar screen and a comminutor.
- Give examples of important safety rules to follow when working with screening and grinding equipment.

Lesson 3: Grit Removal Systems

Topics

Grit chambers; Detritus tanks; Chain and flight grit collectors; Aerated grit chambers; Cyclone separators

Objectives

- Tell why grit removal is important.
- Name the three phases of the grit removal process.
- Explain the functions of slide gates and dewatering drains in hand-cleaned grit chambers.
- Describe the action of a reciprocating rake and explain its purpose.
- List several maintenance checks to make on chain and flight grit collectors.
- Explain how an aerated grit chamber works and how to tell if it is not working correctly.
- Describe the operation of a cyclone grit separator.

Lesson 4: Sludge- and Scum-Collection Apparatus

Topics

Sedimentation; Clarifiers; Scum and sludge removal; Lab testing; Maintenance; Troubleshooting; Safety

Objectives

- List the five major components common to all clarifiers.
- Describe the operation of slotted pipe and helical-type skimmers.
- Name the two flow patterns possible in circular clarifiers.
- Discuss the daily maintenance requirements of clarifiers.
- Explain the importance of laboratory testing on the contents of a clarifier.
- Identify possible safety hazards associated with clarifier operation.

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Lesson 5: Flow Measurement Devices

Topics

Flow measurement in batch processes, filled pipes, open channels, and freely discharging pipes; Depth and pressure measurement

Objectives

- Define flow and differentiate between flow rate and total flow.
- List the three basic types of flow systems.
- Distinguish between direct and indirect flow measurements, and between primary and secondary devices.
- Give a brief description of a current meter, a pitot tube, a weir, and a flume, and tell how each functions in open channels.
- Describe several methods of measuring flow from freely discharging pipes.
- Name at least five level detection devices and explain their operation.
- Describe the following flow measurement devices as they are used in completely filled pipes: orifice, venturi, flow nozzle, rotameter, magnetic flowmeter, and ultrasonic flowmeter.

Blueprint Reading for Welders

Course 416: Blueprint Reading for Welders
Covers basic shop math and measurement skills. Explains how to read, use, and make blueprints. Discusses various welds, weld joints, and weld symbols. Explains advanced shop math and measurement skills.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Shop Math and Measurement

Topics

Fractions; Common fractions; Reducing common fractions; Improper fractions; Mixed numbers; Calculations involving common fractions; Shortcuts for working with common fractions; Decimal fractions; Calculations involving decimal fractions; Converting common fractions to decimal fractions; Converting decimal fractions to common fractions; Standard rules and tape measures; Reading a rule or tape measure; Using a calculator

Objectives

- Define and identify common fractions and decimal fractions.
- Define the term equivalent fraction.
- Perform calculations using common fractions and decimal fractions.
- Convert between common fractions and decimal fractions.
- Read and perform measurements using a standard rule or tape measure.
- Explain the use of calculators in welding

Lesson 2: Introduction to Blueprints

Topics

Purpose of blueprints; Types of blueprints; Making blueprints; Parts of a blueprint; Body; Title block; Bill of material; Revision block; Zoning; Security; Care and handling of blueprints

Objectives

- Explain the importance of information on blueprints.
- Explain the differences between assembly drawings and detail drawings.
- Describe methods used to create and reproduce blueprints.
- Define and describe parts of a blueprint.
- Identify elements located within the title block of a detail drawing.
- List methods of care and security of blueprints.

Lesson 3: Lines and Views on Blueprints

Topics

Lines used on a blueprint; Views on a blueprint; Perspective; Orthographic projections; Oblique projections; Isometric projections; Other views; Selecting views; Sketching

Objectives

- Identify the standard lines used on blueprints.
- Explain the meaning and applications of standard lines on blueprints.
- Identify common views used on a blueprint.
- Name the advantages and disadvantages of various projection types.
- Explain the concept of visualization.

Lesson 4: Welds and Weld Joints

Topics

Basic weld joints; Butt joint; Lap joint; Tee joint; Corner joint; Edge joint; Weld types; Groove welds; Fillet welds; Plug and slot welds; Spot and seam welds; Stud welds; Surface welds; Backing welds; Welding positions and locations

Objectives

- Identify and describe the five basic weld joints.
- Define the following terms: bead, stringer bead, weave bead, base metal, filler metal, root pass, hot pass, fill pass, cap, hardfacing.
- Identify and describe the basic weld types.
- Name the basic welding positions and give advantages of the flat position.

Lesson 5: Welding Symbols

Topics

Structure of welding symbols; Reference line; Arrow; Weld symbol; Dimensions; Special symbols; Tail; Reading welding symbols

Objectives

- Identify which side of a structure a weld is to be made from.
- Identify the kind of chamfer to be cut on a joint to be welded, and which part is to be chamfered.
- State the required dimensions of a weld.
- Identify the contour required on a finished weld.
- State how a weld contour is to be finished.
- Differentiate between welds that are to be made at the site of final assembly and welds that are to be made before the parts are shipped to the site.

Lesson 6: Advanced Shop Math and Measurement

Topics

Squares and square roots; Angles; Triangles; Circles; Linear measurement; Calipers; Slide calipers; Vernier calipers; Micrometer calipers; Angular measurement; Metric measurement

Objectives

- Explain the concepts of squares and square roots of numbers.
- Define the following kinds of angles: zero degree, acute, straight, right, and obtuse.
- State the Pythagorean Theorem and explain its usefulness.
- Define the following terms related to circles: radius, diameter, arc, and circumference.
- Give the equations for finding a circle's circumference and area if you know its radius.
- Explain the use of the following measuring tools: calipers, micrometers, and protractors.
- Demonstrate how to convert measurements from inches to millimeters and from millimeters to inches.

Welding Principles

Course 417: Welding Principles
Covers fundamentals of welding, Discusses welding safety considerations and precautions. Covers both oxyfuel and arc welding equipment. Describes welding techniques. Discusses ways to avoid weld faults.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Fundamentals of Welding

Topics

Metals; Common and production welding processes; Kinds of welds and welded joints; Weld parts; Fusion; Penetration; Joint design and fitup

Objectives

- Describe fusion welding, resistance welding, filler rods, and electrodes.
- Compare the oxyfuel and arc welding processes and compare the SMAW, GMAW, and GTAW processes.
- Describe and sketch the following kinds of joints—butt, lap, tee, corner, and edge.
- Describe the following kinds of welds—groove, fillet, plug, slot, spot, and seam.
- Name and locate the parts of a weld.
- Discuss basic considerations in joint design and fitup.

Lesson 2: Welding Safety

Topics

Fire and explosion hazards; Burns; Fumes and gases; Respiratory, eye, face, and hearing protection; Protective clothing; Handling cylinders; Shock

Objectives

- Explain the importance of good housekeeping in an area where welding is taking place.
- List at least three precautions to take to avoid fires and explosions when welding.
- Describe two methods of protecting yourself against the fumes and gases associated with welding.
- Describe the personal protective equipment required when welding.
- Explain the precautions to take when using and handling cylinders and regulators.

Lesson 3: Oxyfuel Welding Equipment

Topics

Gas pressure regulators; Check valves; Hoses, torches, and tips; Filler rods; Protective gear; Preparing to weld; Making the weld; Shutdown

Objectives

- Briefly describe the oxyfuel welding process and the components of an oxyfuel welding outfit, including the lighting device.
- Discuss safety precautions and personal protective gear required for working with oxyfuel equipment.
- List the steps involved in preparing to weld.
- Compare the neutral, carburizing, and oxidizing flames.
- List the steps in safely shutting down an oxyfuel welding system.

Lesson 4: Arc Welding Equipment

Topics

Welding with electricity; Constant current, voltage power sources; Welding machines, cables, electrodes, and electrode holders; Safety

Objectives

- List similarities and dissimilarities between oxyfuel welding and arc welding.
- Describe the electric welding circuit, including choice of ac or dc, dc polarity, and power sources.
- Discuss welding machine ratings in terms of amperage and duty cycle and describe features and uses of transformer, generator, rectifier, and inverter welding machines.
- Discuss welding cable considerations and describe the electrodes and electrode holders used for SMAW, GMAW, and GTAW processes.
- Discuss the personal safety gear and precautions necessary for arc welding and explain how arc welding accessories are used.

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Lesson 5: Welding Techniques

Topics

Selecting a process; Welding positions; Oxyfuel, SMAW, GMAW, and GTAW procedures

Objectives

- Explain what considerations affect the selection of a welding process.
- Describe the four welding positions.
- Explain why overhead welds are difficult to make and tell how to make them.
- Describe the preparation required for oxyfuel welding, SMAW, GMAW, and GTAW processes.
- Describe the procedures involved in oxyfuel welding, SMAW, GMAW, and GTAW processes.

Lesson 6: Avoiding Weld Faults

Topics

Common weld problems; Poor fitup; Shape problems; Internal defects; Effects of heat; Expansion and contraction; Identifying metals

Objectives

- Describe the effects of electrode selection, current, arc length, and travel speed on arc welding procedures.
- Describe common causes of arc blow, a hard-to-start arc, and spatter, and explain why proper fitup is important.
- Define the terms overlap, undercut, blowhole, and inclusion and explain the causes of each.
- Explain how expansion and contraction can be controlled when welding.
- Name and describe the various tests used to identify metals.

Oxyfuel Operations

Course 418: Oxyfuel Operations—Joining, Cutting, and Surfacing
Covers the welding of ferrous and nonferrous metals. Describes oxygen cutting as well as brazing and soldering. Discusses surfacing techniques.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Welding Ferrous Metals

Topics

Fusion welding; Fluxes; Flame characteristics; Temperature control; Welding common mild steels, stainless steel, cast iron, and wrought iron

Objectives

- Explain how oxyfuel welding joins metals and how it differs from arc welding.
- Explain how braze welding and torch brazing are different from oxyfuel welding and from each other.
- Discuss the purposes for using flux and characteristics that make a flux suitable for an application.
- Compare the appearance and general uses of the carburizing flame, neutral flame, and oxidizing flame.
- Explain why preheating and postheating are used.
- List important considerations in welding common mild steels, stainless steel, and cast and wrought iron.

Lesson 2: Welding Nonferrous Metals

Topics

Joint preparation; Welding aluminum, copper, brass, bronze, lead, nickel, and magnesium

Objectives

- Discuss characteristics of aluminum that are important in welding.
- Explain how to use aluminum alloy designations.
- Describe procedures used in aluminum joint preparation and in aluminum welding.
- Discuss characteristics of copper and copper alloys that are important in welding.
- Discuss procedures for welding copper, brass, and bronze.
- Discuss procedures for welding lead, nickel, and magnesium.
- Summarize general standard procedures for making optimum welds.

Lesson 3: Oxygen Cutting

Topics

Oxygen cutting process, torch, and tips; Cutting safety; Cutting bevels; Piercing holes; Cutting circles; Removing rivets; Gouging; Scarfing

Objectives

- Explain the similarities and differences between oxyfuel cutting and oxyfuel welding.
- Describe the equipment and safety precautions necessary for torch cutting and list standard steps in the torch cutting operation.
- Describe special equipment or methods used in cutting bevels, piercing holes, cutting circles, and cutting away rivets.
- Explain why gouging, scarfing, and washing are used.
- Explain methods used on metals that are otherwise difficult to cut.

Lesson 4: Brazing and Soldering

Topics

Filler alloys and fluxes; Brazing and braze welding cast, malleable iron, aluminum, and steel; Safety; Soldering; Kinds of solder; Soldering tools

Objectives

- Compare and contrast brazing, braze welding, and oxyfuel fusion welding.
- Describe the materials and procedures used in brazing and braze welding.
- Explain important special considerations in braze welding cast and malleable iron, brazing aluminum, and brazing stainless steel.
- List the safety precautions necessary for brazing and braze welding operations.
- Explain how soldering differs from brazing and describe the materials and procedures used in soldering.

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Lesson 5: Surfacing Techniques

Topics

Thermal spraying; Hard facing; Flame spraying; Surfacing materials; Preparation; Safety

Objectives

- Define hard face welding and thermal spraying as used for surfacing purposes and discuss general uses of each.
- Discuss advantages and disadvantages of detonation-gun, plasma, and electric arc thermal spraying and explain how each is done.
- Describe the processes of torch hard facing and flame spraying.
- Name several common surfacing materials and discuss one or more characteristics of each.
- List the steps, including those for surface preparation, in repairing a shaft by means of thermal spraying.
- Discuss the safety precautions necessary to prevent or minimize hazards from surfacing processes.

Arc Welding Operations

Course 419: Arc Welding Operations
Covers shielded metal arc welding, selecting electrodes for SMAW, gas metal and tungsten arc welding, preheating, reheating, welding ferrous and nonferrous metals, pipe welding, hard facing, and rebuilding.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Shielded Metal Arc Welding

Topics

Welding current; Arc length; Welding machines; Polarity; Tools and accessories; Electrodes; Setup and operation; Personal protection

Objectives

- Explain how the shielded metal arc welding process works.
- Tell what provides the shield in shielded metal arc welding.
- Define arc length and explain its importance.
- List factors to consider when selecting an electrode.
- Describe the personal protective equipment necessary for welding.

Lesson 2: Selecting Electrodes for SMAW

Topics

Electrode identification; Current ranges; Electrode coverings; Handling, storing, and conserving electrodes

Objectives

- Explain the factors involved in selecting SMAW electrodes.
- Explain how to identify different welding electrodes.
- Give examples of several kinds of electrode coverings and tell when each is used.
- Describe correct procedures for handling, storing, and conserving electrodes.

Lesson 3: Gas Metal Arc Welding

Topics

GMAW vs SMAW; Metal-transfer methods; Shielding gases; Electrode wire; Equipment and accessories; Gun operation; Safety

Objectives

- Name and describe the three basic types of metal transfer for GMAW.
- Name the most common shielding gases used in GMAW and tell what factors influence their selection.
- List factors that affect the selection of an electrode for GMAW.
- Describe GMAW gun operation.

Lesson 4: Gas Tungsten Arc Welding

Topics

GTAW process, equipment, current, torches, and electrodes; Shielding gases; Filler metals; Adding filler metal; Spot welding; Safety

Objectives

- List the advantages of GTAW over other welding processes.
- Describe the equipment and supplies needed for GTAW.
- Explain the purpose of the electrode in GTAW and tell how this differs from other types of welding.
- Properly select shielding gases and filler metals for GTAW.
- Describe how to use GTAW to weld common metals.

Lesson 5: Other Welding Processes

Topics

Resistance, flash, percussion, flux-cored arc, submerged arc, plasma arc, stud, electron beam, laser beam, friction, and ultrasonic welding

Objectives

- Describe resistance spot welding and resistance seam welding.
- Define flash welding, upset welding, and percussion welding, and tell how they differ.
- Explain how submerged arc welding and plasma arc welding differ from other arc welding methods.
- Describe the three forms of friction welding.
- Describe two advantages of ultrasonic welding.

Lesson 6: Preheating and Postheating

Topics

Stress; Changes in properties; When to preheat and postheat; Preheating equipment and methods; Spot preheating; Postheating methods

Objectives

- Describe the effects of uneven or rapid heating and cooling on base metals and weld beads.
- Define the heat-affected zone and tell what changes can occur there during welding.
- Explain the benefit of preheating and when it should be used.
- List several factors in welding jobs that make postheating advisable.
- Describe methods and materials for preheating and postheating.

Lesson 7: Welding Ferrous Metals

Topics

Ferrous metal identification; Edge preparation; Welding cast iron, carbon steel, and alloy steel

Objectives

- Define ferrous metals and describe their characteristics, including weldability.
- Explain cleaning and edge preparation required prior to welding ferrous metals.
- Name the welding processes and practices that are used for different types and thicknesses of ferrous metals.
- List several different electrode types and their advantages for welding ferrous metals.
- Explain specific procedures to use when welding alloy steels.

Lesson 8: Welding Nonferrous Metals

Topics

Nonferrous metal identification; Edge preparation; Cleaning; Welding aluminum, stainless steel, nickel, and copper

Objectives

- Name the special properties of several nonferrous metals and explain how these properties affect welding preparations and procedures.
- Describe some of the methods of identifying different nonferrous metals.
- Compare seven arc cutting processes used for edge preparation of nonferrous metals.
- Explain proper methods of cleaning nonferrous metals prior to welding.
- Identify the welding processes that are suitable for nonferrous metals.

Lesson 9: Pipe Welding

Topics

Piping systems and joints; Codes; Pipe materials; Repair safety; Arc, oxyfuel welding processes; Types of welding joints; Edge preparation and fitup

Objectives

- Compare the advantages of welded pipe joints to bolted or screwed connections.
- Discuss pipe welding codes and what they cover.
- List the welding processes used for joining pipe and their advantages and disadvantages.
- Identify some special methods and accessories that are used in pipe welding as opposed to flat welding.
- Give examples of the uses of preheating and postheating in pipe welding.

Lesson 10: Hard Facing and Rebuilding

Topics

Surfacing alloys; Base metals; Preheating; Surface bonding; Oxyacetylene, manual arc, and automatic hard facing; Thermal spraying

Objectives

- List several purposes of hard facing and rebuilding.
- Identify the different types of surfacing alloys and their particular uses.
- Describe effective cross-checking and explain why it is desirable.
- Explain the special techniques used in hard facing and tell why they are necessary.
- Name the welding processes used in hard facing and tell why they are adapted to this work.

Maintenance Organization

Course 901: Maintenance Organization
Covers the basic types of maintenance organizations. Discusses cost-saving concepts of using work order systems. Explains how to develop and use information sources to implement maintenance management. Shows how to apply work standards and planning procedures to simplify a supervisor's job. Introduces the use of computers for first-line supervisors.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Types of Maintenance Organization

Topics

Maintenance management; Objectives and priorities; Comparing organizations; Span of control; Organizational charts; Department changes

Objectives

- Describe the functions of the first-line supervisor, the middle-level supervisor, and the top-level supervisor.
- List some of the common problems that lead to difficulties in operating a maintenance department.
- Outline the differences among functional organizations, area organizations, and the centrally controlled maintenance organization.
- Explain the chain of command of a company using its organizational chart.
- Identify the elements that make employees resistant to reorganization, and what can be done to counter this resistance.

Lesson 2: Maintenance Planning and Operations

Topics

Assigning work; Reporting labor, stock use; PM inspections; Planned vs. unscheduled maintenance; Contract work; Forecasting

Objectives

- Describe the way the first-line supervisor's position fits into the overall maintenance system.
- List five types of written orders that can be used for assigning work.
- Classify different kinds of repairs and list them in proper order of importance.
- List the duties of the maintenance planner and the maintenance engineer as they relate to the duties of the first-line supervisor.
- Define standard terms of the maintenance supervisor's vocabulary.

Lesson 3: Work Order Systems

Topics

Controlling costs with work standards; Engineering vs. maintenance work orders; Standing work orders

Objectives

- Describe the use of the maintenance work order.
- Explain the importance of job priorities.
- Identify two basic types of work standards.
- Distinguish between the uses of the engineering work order and the maintenance work order.
- Describe the uses of the master schedule and the PM work order

Lesson 4: Using Information Sources

Topics

Computer-based system; Labor control information and reporting; Controlling major jobs; Material control; Maintenance costs

Objectives

- Explain the importance if using information sources.
- List the types of information that originate within the maintenance department and from other sources.
- List the elements that must be considered when developing a computer-based information system.
- Describe the uses of labor control information.
- Calculate manhour performances indexes.

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Lesson 5: Controlling Backlog through Planning

Topics

Planning as a management tool; Planning concepts; Special considerations; Effect of planning on manpower use

Objectives

- Explain the role planning plays in reducing downtime costs and improving manpower use.
- List the five steps of the decision-making process.
- Define goals, objectives, policies, procedures, and programs in the context of maintenance planning.
- Describe the role of the maintenance planner.
- List six areas in which planning enhances labor use.

Lesson 6: Applying Work Standards

Topics

Time standards; Engineered performance standards; The spreadsheet; Controlling backlog; Assigning priorities; Scheduling

Objectives

- Explain why standards are used.
- Describe quality and quantity standards and their uses.
- List five conditions a maintenance department must meet in order for standards to be workable.
- Describe how different types of standards are developed.
- State how the backlog can be analyzed to evaluate the makeup of the workforce.

Lesson 7: Managing Maintenance by Computer

Topics

Computer files; Processing data; Data processing support; Package programs; Computerizing essential maintenance information

Objectives

- Describe the function of the computer in maintenance information management.
- List the types of information that should be stored in a computer.
- List types of data processing support available to maintenance departments.
- Use basic computer terminology.

Implementing Preventive Maintenance

Course 902: Implementing Preventive Maintenance
Covers what PM is and why it is necessary. Develops procedures for setting up a practical PM program, and describes effects of PM on scheduled and unscheduled work. Explains the requirements and advantages of the program as it applies to maintenance management. Provides information on the relationship of PM to production and quality control.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: The Need for PM

Topics

Good programs cut costs; Inspections; Maintenance routes; Job priorities; Scheduling

Objectives

- List the six functions of a typical PM Program.
- List the major benefits of PM.
- Explain the three stages involved in the planning process.
- Describe the function of the maintenance job order.
- Explain the use of a priority system.

Lesson 2: Setting Up a PM Program

Topics

Predictive and preventive maintenance; Inspection checklists; Securing cooperation of production; Setting up a lube program

Objectives

- Describe the elements needed to establish a preventive maintenance program.
- List the data that can be obtained from review of inspection reports.
- Distinguish between preventive and predictive maintenance.
- Explain the preparation of inspection checklists.
- Explain how to set up a lubrication program.

Lesson 3: Scheduling PM

Topics

Long-range planning; Forecasting; Short-range scheduling; Scheduling meetings; Measuring schedule compliance; Work orders

Objectives

- Describe the importance of scheduling to the maintenance program.
- Describe the role that the production department plays in maintenance scheduling.
- Explain the uses of forecasting and long-range planning.
- List the types of jobs that should appear on a weekly schedule.
- Explain how and why weekly scheduling meetings should be held.
- Measure compliance with scheduling.

Lesson 4: Controlling Work

Topics

Control of emergency and unscheduled work; Repetitive preventive maintenance; Work order flow; Handling assignments; Communication

Objectives

- List the criteria for assigning emergency status to a situation.
- Describe the use of the master schedule and standing work order.
- Describe the techniques for controlling emergency, scheduled, unscheduled, and preventive maintenance work.
- Explain the role forecasting plays in planning and scheduling.
- Report labor and material use.

Lesson 5: Quality Control

Topics

Organizing materials; Tool control; Sizing up labor requirements; Control during the job; Follow-up report

Objectives

- List short cuts for obtaining spare parts and other materials that are often used in routine repairs.
- Estimate crew labor necessary for efficient job execution.
- Describe the supervisor's role at the work-site in terms of labor control, accident prevention, and quality control.
- Explain the role of quality control.
- Describe the steps involved in evaluating a completed job.

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Controlling Maintenance Resources

Course 903: Controlling Maintenance Resources
Covers methods of using maintenance resources for greatest efficiency, and tells how to implement the techniques effectively. Explains what workload is and how to measure it. Provides a thorough investigation into the control of labor, parts, and materials—both in the field and in the shop. Examines the budget process and how to control costs through budgeting.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Measuring Workload

Topics

Categories of workloads; Techniques for computing workloads; Distributing the workload; Effects of absenteeism, overtime

Objectives

- Define workload and explain its importance in control of maintenance work.
- List the seven workload categories.
- Compute workload measurements for each of the seven categories.
- Explain how the workload should be distributed.
- Describe the effects of absenteeism and overtime on the workload.

Lesson 2: Controlling Labor

Topics

Control of maintenance labor; Handling absenteeism; Overtime vs. bringing on extra people; Vacation schedules; Productivity

Objectives

- Identify the seven categories of maintenance labor discussed.
- Describe the most effective means of controlling each of the seven categories of maintenance labor.
- Explain the effect a well-executed PM program has on other maintenance work.
- State the leading factors contributing to absenteeism.
- Determine the breakeven point between overtime and hiring additional workers
- Schedule vacation periods so that production still proceeds smoothly.

Lesson 3: Controlling Parts and Materials

Topics

Inventory control; Reordering stock; Rebuilt and fabricated parts; Calculating economical order quantities; Reorder points; Two-bin system

Objectives

- Explain the importance of effective material control to maintenance work.
- Describe the duties of the material controller.
- Describe the operation of a typical manual inventory control system.
- Calculate economic order quantities and reorder points.
- Operate a two-bin inventory control system.

Lesson 4: Managing Shop Operations

Topics

Shop control; Liaison with field work; Engineering project support; Rebuilds and overhauls; Shop, work area layout; Shop care and cleanup

Objectives

- Describe the differences in labor control between shop and field work.
- Describe the role played by a shop that supports a field crew.
- List the steps required to rebuild parts.
- Explain how shop location, layout, and configuration affect work.
- List the advantages and disadvantages of central and area shops.

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Lesson 5: Controlling Costs through Budgeting

Topics

Cutting maintenance costs; Improved productivity; Budgeting; Types of budgets; Key equipment in the budget

Objectives

- Describe the effect increased productivity has on maintenance costs.
- List the uses of a budget.
- Describe zero-based budgeting.
- Describe the factored budgeting.
- List the eight steps in formulating equipment repair projections.
- Explain the reason why all maintenance work should be approved before it is performed.

Improving Performance in Maintenance

Course 904: Improving Performance in Maintenance
Covers instructions to first-line supervisor in the strategies involved in improving performances, and presents proven methods for increasing maintenance productivity. Develops ways of evaluating training effectiveness and the management of time. Describes the information necessary to stimulate improvement in all facets of the maintenance program.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Evaluating Performance

Topics

Areas of responsibility; Performance measures and trends; Utilizing labor; Measuring material use; Controlling costs, personnel

Objectives

- Give examples of the different interest levels of key maintenance personnel.
- Compute annual productive hours per worker.
- Compute costs per productive hour.
- List indicators that can help a supervisor control costs.
- Tell how performance trends are established.

Lesson 2: Increasing Productivity

Topics

Factors affecting productivity; Improving labor use; Work sampling; Observation periods; Tabulating results

Objectives

- List factors that adversely affect maintenance labor utilization.
- List factors that have an adverse effect on maintenance labor effectiveness.
- Describe the role of the supervisor in improving labor productivity.
- State how and why random sampling and work sampling are conducted.

Lesson 3: Effects of Training

Topics

Supervisor's role in training; Safety, apprentice training; Creating a learning environment; Motivating workers; Using competition

Objectives

- Describe the first-line supervisor's role in training crew members.
- List the various forms in which training materials are available.
- Recognize the importance of on-going safety training.
- Give examples of how to conduct effective training sessions.
- Identify the roles that motivation, competition, and performance evaluation play in training crew members.

Lesson 4: Managing Time

Topics

Handling pressure; Establishing time objectives, Deadlines; Progress reports; Handling a crisis; Delegation; Improving your own productivity

Objectives

- Describe the influence that the quality and amount of supervision has on crew productivity.
- Explain the importance of setting deadlines and using progress reports.
- Indicator the importance of delegating work.
- List procedures a supervisor can follow to increase his or her own productivity.

Lesson 5: Stimulating Improvement

Topics

Performance improvement factors; Facility manager's and maintenance supervisor's roles; Developing a maintenance concept, objective

Objectives

- List the 15 factors that influence the success of any maintenance improvement effort.
- Recognize the importance and use of the maintenance concept.
- Trace the importance and use of the maintenance objective.
- Explain the importance and formation of maintenance policies
- Identify the development and role of maintenance procedures.

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Effective Communication for Supervisors

Course 905: Effective Communication for Supervisors
Covers how to use verbal and written communication tools. Explains how to motivate personnel through effective communication. Discusses how to organize written communication, best utilizing the elements of writing—parts of speech, phrases, clauses, sentences, structure, punctuation, and syntax. Gives examples of business writing used for reporting progress and motivating employees.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Communication Objectives

Topics

Training new employees; Setting an example; Giving instructions; Using communication tools; Speaking on the telephone; Interviews

Objectives

- Explain how communication works.
- Explain how to use the various communication tools.
- Give examples of effective telephone use.
- Tell how to give and receive instructions effectively.
- Demonstrate effective interview techniques.

Lesson 2: Verbal and Nonverbal Communication

Topics

Understanding circumstances and the receiver's background; Eye contact; Personal appearance; Body language; Understanding verbal clues; Word awareness; Understanding varied meanings; Changes in workplace vocabulary

Objectives

- Describe the importance of context in communication.
- Describe how a receiver's background affects the message.
- Define and give examples of nonverbal language.
- Describe ways to improve vocabulary.
- Explain the importance of precise word choice.

Lesson 3: How to Listen

Topics

Good vs. poor listening; How to be a good listener; The importance of feedback; Asking questions; Paraphrasing; Be open to new ideas

Objectives

- Tell how to be a good listener.
- Explain what makes a poor listener.
- Give techniques for identifying problems through good listening.
- Explain the importance of getting feedback.
- Show how to ask questions and paraphrase.

Lesson 4: Communication Maintenance

Topics

Making sure instructions are clear; Handling bad news; Motivating your crew; Checking language skills; Developing your vocabulary; Listening

Objectives

- Give techniques for developing a management vocabulary.
- Tell how to check and maintain language skills.
- Show how to make sure instructions are clear.
- Explain how communication can motivate a crew.
- Give techniques for improving listening as a supervisory skill.

Lesson 5: Planning Your Writing

Topics

Write to inform; Persuasive writing; Know your audience; Point of view; Tone; Organizing your writing; Thinking before you write

Objectives

- Tell how to determine the purpose for writing.
- Explain why it is crucial to know the audience.
- Give examples of a writer's point of view.
- List techniques used in prewriting.
- Describe how to organize a written piece.

Lesson 6: The Mechanics of Writing

Topics

Syntactical problems; Active vs. passive voice; Parallel structure; Punctuation

Objectives

- Explain the importance of syntax.
- Compare the passive voice with the active voice.
- Recognize parallel structure.
- Identify the different types of punctuation.
- Give examples of comma usage.

Lesson 7: Business Writing

Topics

Email memos; Letters; Letter, email memo, and report formats; Recommendation reports

Objectives

- Give examples of memo, letter, and report format.
- Explain how to use and write a memo.
- Explain how to use and write a letter.
- Explain how to use and write a report.

Employee Relations

Course 906: Employee Relations
Defines the supervisor's job in terms of maintenance planning, operations, and employee interaction. Demonstrates how good leadership requires administering discipline fairly, recognizing employee needs, and preventing employee strife. Discusses the basic information supervisors need in handling grievances and union disputes.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Defining the Supervisor's Job

Topics

Administrative vs. job-related duties; Performance evaluations; Orientation and training; Discipline; Supervisory duties; Trouble symptoms

Objectives

- List the elements of the supervisor's administrative duties.
- Calculate workload.
- Explain why a strong preventive maintenance program is desirable.
- Calculate crew efficiency.
- Explain the values and uses of counseling, progressive discipline, and training.
- Calculate productivity.
- List the elements of the supervisor's job-related duties.

Lesson 2: Supervising Hourly Personnel

Topics

Promoting productivity; Evaluating crew members; Absenteeism; Leadership; Motivation; Getting along with the union; Communication

Objectives

- Explain the importance of safety and comfort in the workplace.
- Explain the importance of further training both to crew members and in terms of increased productivity.
- Describe the effect that a supervisor's good attitude can have on crew members.
- Describe the effect that dishonesty, incompetence, or indifference has on crew members

Lesson 3: Becoming a Successful Leader

Topics

Positive leadership; Enforcing rules; Motivation; The supervisor's limits

Objectives

- Explain the need to encourage the full participation of employees and methods for obtaining this participation.
- Describe positive leadership style.
- Explain how a supervisor can win the respect of his or her employees.
- List several factors to consider when determining corrective action measures.
- Identify three different management styles.

Lesson 4: The Supervisor's Role in Employee Relations

Topics

Relationships and productivity; Your role; Your leadership style; Relations with a union; The grievance procedure

Objectives

- Explain how good labor relations affect productivity.
- List several characteristics of a successful leader.
- Explain why it is important for a supervisor to be directly involved with employees.
- Give examples of different leadership styles.
- Identify the functions of labor unions and company management.
- Tell what to expect and what not to expect from union representatives.

Lesson 5: Responding to Interpersonal Problems

Topics

Refusal to comply with orders; Failure to follow directions; Threats; Obscene language; Physical assault; Horseplay; Fighting

Objectives

- Define insubordination.
- Give examples of refusals to comply with orders and explain how to deal with such acts.
- Describe instances in which employees fail to follow directions, along with the appropriate corrective action.
- Explain how to deal with threats, obscene language, and physical assault.
- Explain how to deal with horseplay.
- Describe ways of dealing with fighting among employees.

Lesson 6: Taking Corrective Action

Topics

Handling personal misconduct;Objectives of corrective action; Backing up corrective action; Consistency with corrective action; Examples of misconduct; Third party viewing your role

Objectives

- List the steps of progressive discipline.
- Recognize the types of evidence that you should or should not use to support your corrective action measures.
- Explain how to deal with absenteeism and other forms of lost time.
- List the factors that must be considered when correcting employees who have damaged company property.
- List procedures for dealing with employees who are suspected of theft.
- Contrast the performance of substance abusers against the performance of other employees.
- Recognize the types of false statements workers might make.

Lesson 7: The Grievance Procedure

Topics

Purpose of the grievance procedure; The supervisor's responsibilities; Steps in the procedure; Selecting an arbitrator; Preparation for arbitration; Avoiding problems leading to grievances

Objectives

- Explain a supervisor's responsibilities with regard to a grievance procedure.
- Describe the various steps involved in a grievance procedure.
- Explain the importance of a no-strike/no-lockout clause.
- Describe the processes used to select arbitrators.
- List ways a supervisor can help a company prepare for an arbitration hearing.
- Tell why it is important to rehearse testimony before a hearing.
- Discuss ways to avoid problems leading to grievances.

Lesson 8: Labor Law Basics

Topics

EEO and the supervisor; Labor/management legislation; The Wagner, Taft-Hartley, and Landrum-Griffin Acts; Unfair labor practices; OSHA

Objectives

- Explain the supervisor's responsibilities in relation to equal employment opportunity.
- Name the basic labor law of the United States and two Acts that amended it.
- List the functions of the National Labor Relations Board.
- Give examples of unfair labor practices.
- Explain how an unfair labor practice charge is handled.
- State an employer's basic responsibility under the Occupational Safety and Health Act.
- Explain what happens if an employer fails to comply with OSHA standards.

Managing a Training Program

Course 907: Managing a Training Program
Defines the supervisor's job in terms of maintenance planning, operations, and employee interaction. Demonstrates how good leadership requires administering discipline fairly, recognizing employee needs, and preventing employee strife. Discusses the basic information supervisors need in handling grievances and union disputes.

The lessons, topics, and objectives for this course are listed below.

Lesson 1: Analyzing Your Training Needs

Topics

Reasons for training; Kinds of training; Front-end analysis; Written performance objectives; Making sure training works

Objectives

- Define training and state the main reason for training today.
- Explain the problems involved with trial-and-error learning.
- List three important steps in administering training.
- Explain why good communication is important in training.
- Name three distinct kinds of training.
- Explain the steps involved in a front-end analysis.
- Tell why it is important to write performance objectives.

Lesson 2: The Supervisor as Trainer

Topics

Self-and group-paced training; The environment; Getting started; Developing your own training programs; Using commercially prepared packages

Objectives

- List the advantages, disadvantages, and applications of self-paced and group-paced training.
- Lists several important aspects of the training environment and tell why each is important.
- Explain several group management techniques.
- Name at least three advantages of supervised self-study.
- Explain the importance of determining the level of your training needs.
- Evaluate the suitability of commercially prepared training programs.

Lesson 3: Using Training Media

Topics

Lectures; Visual aids; Computer slide shows; DVDs and videotapes; Manuals; Programmed instruction; Computer-based training

Objectives

- List at least six factors that influence the usefulness of a training medium.
- Name several types of visual aids and explain how each can be used to improve a lecture.
- Explain how to put together a useful sample set.
- Trace the steps involved in the making of a computerized slide show.
- List several advantages of videotapes over films.
- List the advantages of DVDs over videotapes.
- Give the main reason programmed instruction is effective.
- Describe the usefulness of computers in training.

Lesson 4: Teaching and Evaluating Success

Topics

Rules for adult learners; Making training relatable; Record keeping; Data collection; Time standards; Evaluating training; Pretest/post-test; Writing tests; On-the-job observation

Objectives

- List several reasons for keeping training records.
- Name the three types of training records that are important to keep.
- Explain how time standards are established and how they can be used to measure performance.
- Name three common training evaluation methods and explain the applications of each.
- Give examples of five types of written test questions and give advantages and disadvantages of each type.
- Tell why an on-the-job observation checklist is an important evaluative tool.
- Describe the purpose of a questionnaire.

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