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TRAINING SERVICES
COURSE CATALOG

- 100  Safety, Health, and Plant Science
- 200  Mechanical Maintenance
- 300  Electrical Distribution
- 400  Electrical Maintenance
- 500  Power Generating Systems and Operations
- 600  Instrumentation and Control
- 700  Process Systems and Operations
- 800  Industrial Machining and Welding

Martech Media, Inc.  9595 Six Pines Drive  Suite 6305  The Woodlands, TX 77380
+1.281.465.0625  contactus@martechmedia.com
www.martechmedia.com

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100 – Safety, Health, and Plant Science

101 Personal Protective Equipment (PPE)

101-01 Personal Protective Equipment

The purpose of a personal protective program is to protect employees by ensuring personal protective equipment (PPE) is provided and used, whenever it is necessary due to hazards from processes or in the work environment, and maintained in a sanitary and reliable condition. This lesson presents the responsibilities of managers, supervisors, and workers; assessment of hazards; selection and use of personal protective equipment (PPE); and training.

This lesson satisfies the required annual refresher training for OSHA standard 29 CFR 1910 132 (f) (1) through (3).

- Identify the responsibilities of the safety and health manager, supervisors, and employee regarding the use of personal protective equipment
- Identify the components of a training program for the use of PPE
- Distinguish the types of equipment necessary to protect employees when working in conditions affecting the workers’ health and safety
- Describe the hierarchy of controls as it relates to personal protective equipment

101-02 Hearing and Noise Safety

When you complete this lesson, you will be able to identify conditions that lead to hearing damage or loss and use both engineering controls and personal protective equipment to prevent such damage.

The 101 PPE lessons satisfy the training requirements and annual refresher requirements for OSHA standard 29 CFR 1910 section 95 (i) (4); (k) and (l).

- Identify employee responsibilities regarding wearing hearing protective devices
- Discuss the identification of hazardous noise areas
- Discuss workplace noise control methods that include engineering controls and personal protective equipment (PPE)
- Describe the proper use and maintenance of hearing protective devices

101-03 Respiratory Protective Program

When you complete this lesson, you will be able to identify respiratory hazards and utilize personal respiratory equipment to prevent injury or illness caused by poor breathing conditions in the workplace.

The 101 PPE lessons satisfy the training requirements for OSHA 29 CFR 1910 section 134 (k) (1) through (6).

- Define key terms used in the implementation of the respiratory protection program
- Distinguish the responsibilities of the safety and health manager from those of the area supervisors and employees when implementing the respiratory protection program
- Identify the need for respiratory protective equipment
- Describe the personal medical considerations and evaluation procedures pertaining to a respiratory protection program
101-70 Introduction to OSHA
When you complete this lesson, you will be able to describe the large role OSHA plays in maintaining employee health and safety as employees perform their daily work.

This course provides a general overview of basic topics related to OSHA (Occupational Safety and Health Administration) and how it operates. Information provided does not determine compliance responsibilities under OSHA standards or the Occupational Safety and Health Act of 1970 (OSH Act).

- Understand why OSHA is important to employees
- Describe rights employees have under OSHA
- List some of the employer’s responsibilities under OSHA
- Outline what applicable OSHA standards say
- Describe how OSHA inspections are conducted
- Identify where employees can go for help with occupational safety concerns

101-71 Introduction to Industrial Hygiene
When you complete this lesson, you will be able to discuss and apply principles of industrial hygiene towards a safer working environment.

- Identify types of health hazards in the workplace
- Identify types of chemical hazards in the workplace
- Identify types of biological hazards in the workplace
- Identify types of physical hazards in the workplace
- Identify types of ergonomic hazards in the workplace

102 Worksite Safety

102-01 Slip, Trip, and Fall Prevention
When you complete this lesson, you will be able to recall safe practices for preventing slips, trips, and falls in the workplace.

This lesson satisfies the training requirements for OSHA instructions 29 CFR 1926.21(a) and (b). and 29 CFR 1926.20.(b)(1),(2) and (4);(f)(2).

- Identify the dual causes of slips, trips, and falls
- Describe common workplace hazards associated with operating machinery and apply safeguards to prevent injury and death
- Recall safety measures to prevent slips, trips, and falls
- Identify employer requirements for ensuring slip, trip, and fall prevention
- Determine the responsibilities of employees in ensuring slip, trip, and fall prevention

102-02 Ladder Safety
When you complete this lesson, you will be able to identify the specifications regarding several different types of ladders and adhere to standard safety precautions for the use, maintenance, and storage of ladders.

This lesson satisfies the training requirements for OSHA standard 29 CFR 1926.1060 (a) (1) (i) through (v) and (b).

- Identify a variety of ladders and their specifications
- Describe safety concerns pertaining to the use of ladders
- Adhere to safety measures for the use, inspection, and maintenance of ladders

102-03 Portable Power and Hand Tool Safety
When you complete this lesson, you will be able to identify hazards associated with the use of hand and power tools. You will be able to prevent accident and injury in the workplace by adhering to safety practices and requirements.

This lesson satisfies the training requirements for OSHA regulation 29 CFR 1910 (Subpart P) section 241 through 244.

- Identify general tool safety procedures
- Identify hazards associated with power tools
- Identify different types of portable power tools
- Explain safety tips that should be utilized when using hand and power tools
- Describe general safety practices to be used when setting up a work area, selection of personal protective equipment, and utilizing tools at the work site
- Identify hazards and precautions taken when using electric powered tools, pneumatic powered tools, and fuel powered tools.
- Identify hazards and precautions taken when using hand tools and portable power tools

102-04 Machine Hazards and Safety
When you complete this lesson, you will be able to identify common workplace hazards associated with operating machinery and apply safeguards to prevent injury and death in the workplace.


- Identify common hazards associated with operating machinery
- Describe safeguards applied in the workplace to prevent accidents while operating machines
- Describe training requirements of a machine safety program
- Apply controls to the environment of machine operations to prevent injury and death
- Properly use personal protective equipment and machine guards to increase worker safety

102-05 Machine Guarding
When you complete this lesson, you will be able to adhere to machine guard safety requirements by describing the characteristics of a machine guard and explaining its function.

This lesson satisfies the training requirements for OSHA standards 29 CFR 1910.212, 213, 215, 217, and 219.

- Identify the responsibilities of management, supervisors, and operators in maintaining machine guard safety
- Describe the characteristics and functions of machine guards
- Identify the hazards associated with the operation of machines and explain the importance of machine guards
102-06 Accident Causes, Prevention, and Investigation

When you complete this lesson, you will be able to recognize factors that cause accidents and methods to prevent accidents. In addition, you will understand the process of investigating an accident.

- Explain the difference between an accident and near-miss
- Define an unsafe act and unsafe condition
- Identify factors that can lead to an unsafe act or condition
- Discuss methods used to prevent an accident
- Explain the importance of a Job Hazard Analysis (JHA)
- Describe the purpose of an accident investigation
- Identify the basic components of an investigation report

This lesson satisfies the training requirements for OSHA regulations 29 CFR 1910 (Subpart O) section 211 through 219.

102-07 Stationary Power Tool Safety

When you complete this lesson, you will be able to recall how to safely operate a number of stationary power tools by identifying general work area safety requirements and tool-specific requirements for many stationary power tools found in the workplace.

This lesson satisfies the training requirements for OSHA regulations 29 CFR 1910 (Subpart O) section 211 through 219.

- Recall work area safety standards and practices regarding stationary power tools
- Identify safety requirements for operating the following stationary power tools:
  - table saw
  - radial arm saw
  - band saw
  - jigsaw
  - wheel grinder
  - drill press
  - lathe
  - bending machine or brake
  - metal shears
  - welding machine
  - milling machine

102-08 Laboratory Health and Safety

When you complete this lesson, you will understand how to safely work in a laboratory. In addition, you will also be able to describe the proper disposal of laboratory waste.

This lesson satisfies the training requirements for OSHA regulation(s) 29 CFR 1910.1450.

- Identify the four categories of hazard identification signage
- Discuss common laboratory safe work practices
- Describe the appropriate personal protective equipment required when working in a laboratory
- Explain the proper usage of electrical and heating devices in a laboratory
- Identify the appropriate procedures when cryogenic liquids, laser-containing equipment and ultraviolet radiation are present in a laboratory
- Explain the general guidelines when using a centrifuge, microwave oven and autoclave
- Describe how to appropriately dispose of laboratory waste

102-09 Operator Fatigue

When you complete this lesson, you will be able to define and recognize symptoms of operator fatigue. You will also be able to recall the causes of operator fatigue, be familiar with ways to identify operator fatigue in yourself and others and identify ways to manage it.

- Define operator fatigue
- Define circadian rhythm
- Recognize the symptoms of operator fatigue
- Recall the causes of operator fatigue
- Identify ways to manage operator fatigue

102-10 Hazard Identification and Assessment

When you complete this lesson, you will be able to recall recommended practices for companywide safety and health programs regarding hazard identification and assessment.

- Know the steps for identifying and assessing hazards
- Identify what existing items can be collected to understand workplace hazards
- Describe how to inspect a workplace for safety hazards
- Describe how to identify workplace health hazards
- Explain the importance of incident investigation
- Identify emergency and non-routine situations
- Explain how to characterize, prioritize, and identify controls for hazards

103 First Aid

103-01 First Aid

When you complete this lesson, you will be able to describe common injuries that require first aid treatment and provide aid for such injuries. You will also identify major emergencies requiring the services of emergency personnel and provide initial treatment for such injuries. When providing aid, you will adhere to the universal precautions taken to prevent the transmission of bloodborne pathogens and prevent infections.

This lesson satisfies the training requirements for OSHA standard 29 CFR 1910.151 (a) (6).

- Describe and apply minor first aid treatments
- Describe emergency medical treatment
- Describe actions taken during a medical emergency to include:
  - Bleeding
  - Physical shock
  - Choking
  - Burns
  - Heat exhaustion
  - Poisoning
- Define bloodborne pathogens (BBP) and provide examples
- Identify the transmission of HBV and HIV
- Identify and apply universal precautions to prevent transmission of bloodborne pathogens
- Identify personal protective measures to prevent BBP infections
This lesson satisfies the initial and annual training requirements for OSHA standard 29 CFR 1910.1030 (g)(2);(h)(2) and (3).

- Define bloodborne pathogens and identify potentially infectious materials
- List diseases commonly caused by bloodborne pathogens
- Discuss safety measures and strategies to reduce exposure to bloodborne pathogens
- Identify the elements included in an exposure control plan

104-01 Fire Prevention and Protection Program

When you complete this lesson, you will be able to plan, practice, and apply the standards of the fire protection program in the workplace.

This lesson satisfies the required initial and annual refresher training for OSHA standard CFR 1910.39(a) through (d) and CFR 1910.38 (a) through (f).

- Describe the fire tetrahedron and its role in fire prevention and extinguishing
- Recall fire prevention strategies
- Identify the four classes of fires
- Recall fire extinguisher installation and maintenance standards in the workplace
- Describe the components of the fire protection training program

104-02 Fire Extinguisher Safety

When you complete this lesson, you will be able to identify the four fuel sources and the appropriate extinguisher to use to put out a small fire and apply the safest procedures for extinguishing a fire in the workplace. You will also be familiar with the maintenance, inspection and documentation requirements for maintaining fire extinguishers.

This lesson satisfies the training requirements for OSHA (Occupational Safety and Health Administration) standard 29 CFR 1910.155 (c) 41, 29 CFR 1910.157 (g) (1) through (4) and references NFPA (National Fire Protection Association) 10(13).

- Describe the principles of fire extinguisher operation
- Classify fuels to determine the proper fire extinguisher to use in case of fire
- Recall the safest method of extinguishing a fire in the workplace
- Identify what actions constitute an inspection
- List corrective actions for rechargeable and non-rechargeable fire extinguishers
- Describe the record-keeping requirements for the different types of inspections and maintenance activities

104-03 Combustible Dusts

When you complete this lesson, you will be able to identify common combustible dusts and their associated workplace hazards. You will also understand basic control measures that reduce the production of combustible dusts.

- Discuss hazards associated with combustible dusts
- Identify the 5 components of the “dust explosion pentagon”
- Explain where dust occurs in the workplace
- Describe general housekeeping steps that reduce dust production
- Discuss use of environmental controls
- List commonly found combustible dusts

103-02 Bloodborne Pathogens

When you complete this lesson, you will be able to identify the diseases commonly caused by contact with bloodborne pathogens. You will also be able to identify safety measures and strategies to protect you from exposure to bloodborne pathogens.

This lesson satisfies the initial and annual training requirements for OSHA standard 29 CFR 1910.1030 (g)(2);(h)(2) and (3).

- Define bloodborne pathogens and identify potentially infectious materials
- List diseases commonly caused by bloodborne pathogens
- Discuss safety measures and strategies to reduce exposure to bloodborne pathogens
- Identify the elements included in an exposure control plan

103-03 First Aid Resuscitation: Choking, CPR, and AED

When you complete this lesson, you will be able to demonstrate how to assist victims using appropriate first aid techniques including the Heimlich Maneuver, CPR, and the use of an AED (Automated External Defibrillator).

Note: This lesson follows American Heart Association recommendations and guidelines. Please verify with your training coordinator this lesson fulfills the necessary training requirements for your industry and position.

- Describe the steps to perform the Heimlich Maneuver
- List the actions in the Cardiac Chain of Survival
- Explain the steps to administer Hands-Only CPR (cardiopulmonary resuscitation)
- Describe the steps to administer conventional CPR
- Describe the steps followed when using an AED

103-04 Temperature Related Stress and Illnesses

When you complete this lesson, you will be able to recognize the causes and effects of temperature related stress. In addition, you will be able to identify illnesses associated with temperature related stress.

- Discuss the causes of heat and cold related stress
- Identify the factors for heat and cold related stress
- Describe the major forms of heat and cold illnesses
- Discuss how to treat workers who are suffering from specific heat and cold illnesses
- Explain how to prevent heat and cold illnesses
105 Lockout/Tagout

105-01 Lockout/Tagout Safety Program
When you complete this lesson, you will be able to explain the necessity of a lockout/tagout program and adhere to the procedures and practices of lockout/tagout safety.
This lesson satisfies the training requirements for OSHA standard 29 CFR 1910.147.
- Explain the components of a lockout and tagout program
- Identify lockout and tagout terminology
- Recall the training requirements of a lockout and tagout safety program
- Identify the sequence of actions required by the lockout program
- Explain procedures for returning equipment or machines to service
- Recall communications requirements to ensure the safe lockout and tagout of equipment and machines

106 Confined Space Safety

106-01 Confined Spaces: Entrant and Attendant Duties
When you complete this lesson, you will understand the role of the authorized attendant, as well as the entrant working in confined spaces. You will also be able to describe steps taken to safely enter and work within a confined space.
This lesson satisfies the training requirements for OSHA standard 29 CFR 1910.146.
- Define and describe a confined space
- Explain the difference between permit and non-permit required confined spaces
- Describe the dangers associated with a confined space
- Detail the roles of the confined space attendant and authorized entrant
- List the general entry requirements for a confined space
- Describe atmospheric testing in a confined space
- Describe hot work procedures in a confined space
- Discuss the critical aspects of confined space rescue procedures

106-02 Confined Spaces: Entry Supervisor Duties
When you complete this lesson, you will be able to describe the role the entry supervisor plays in overseeing work and ensuring the safety of workers in confined spaces.
This lesson complies with OSHA Regulation 29 CFR 1910.146.
- Discuss the OSHA definition of an entry supervisor
- List the duties of an entry supervisor
- Identify the general entry requirements for a confined space
- Explain the steps to reclassify a permit required confined space
- Identify contractor requirements for working in confined spaces
- Discuss confined space rescue procedures and preparations
- Describe confined space training requirements

106-80 Confined Spaces: Entrant and Attendant Duties (CAD)
When you complete this lesson, you will understand the role of the authorized attendant, as well as the entrant working in confined spaces. You will also be able to describe steps taken to safely enter and work within a confined space.
- Define a confined space
- Identify the qualifying factors of permit-required confined spaces
- Describe the dangers associated with a confined space
- Detail the roles of the confined space attendant and authorized entrant
- Identify required entry permit information
- Recall requirements of atmospheric testing in a confined space
- Describe hot work procedures in a confined space
- Recall critical aspects of confined space rescue procedures

107 Electrical Safety

107-01 Electrical Safety
When you complete this lesson, you will be able to describe the flow of electrical current, describe common hazards of electricity, and practice safety procedures to prevent injury, damage, and death caused by electrical hazards.
This lesson satisfies the training requirements for OSHA standard 29 CFR 1910.137.
- Describe the flow of electrical current using the terms amp and volt
- Identify electrical hazards
- Minimize electrical hazards
- Follow safe practices regarding work with or near electrical sources and circuits
- Apply safety procedures to portable electrical equipment
- Adhere to safe practices regarding the handling and use of electrical plugs and cords

107-02 Energized Electrical Equipment Safety
When you complete this lesson, you will recognize the industrial workplace safety authority and be able to describe safe workplace practices.
This lesson satisfies the training requirements for OSHA regulation(s) 29 CFR 1910 Subpart S and NFPA 70E.
- Describe safe practices set by the industrial workplace safety authority for work on electrical equipment
- Identify the personal protective equipment needed to perform safe work on energized electrical circuits or equipment
- Describe each of the following electrical hazards of working with energized equipment: electrical shock, arc flash, and fire hazards
- Identify the purpose and content of hazard labels
- Describe how to conduct hazard analysis
- Explain the use of PPE (personal protective equipment)
107-03 Arc Flash Hazard Basics
When you complete this lesson, you will be able to define terminology applicable to arc flash, navigate the guidance of the NFPA 70E, and mitigate unsafe conditions potentially resulting in an arc flash.

- Define the term Arc Flash Hazard as listed in the National Fire Protection Agency (NFPA) code 70E
- Identify the basic concepts of an arc flash occurrences
- Identify and define common terms associated with arc flash occurrences
- Describe the formation of an arc
- Identify the personnel risks associated with an arc flash
- Describe the purpose and performance of an Arc Flash Hazard Analysis
- Identify procedures associated with arc flash effect mitigation

108 Materials Handling

108-01 Materials Handling and Storing Safety
When you complete this lesson, you will be able to minimize the risks of injury and illness by safe handling and storing materials in the workplace.

This lesson satisfies the training requirements for OSHA regulation 29 CFR 1910.178 - .180, Subpart N.

- Describe methods of materials handling in the workplace
- Apply safe lifting techniques
- Safely use non-powered trucks to handle materials
- Apply safety precautions when handling materials with or near powered industrial trucks
- Minimize risks and maximize efficiency when storing materials

109 Rigging Safety

109-01 Rigging Safety
When you complete this lesson, you will have a clear understanding of the factors you need to consider with every lift that involves the use of rigging.

This lesson satisfies the training requirements for OSHA regulations 29 CFR 1926.753 and 29 CFR 1926.251.

- List qualifications exhibited by competent personnel
- Describe the safe operation of lifting platforms
- Explain how pre-planning can facilitate efficient crane operations and elimination of major hazards
- Identify the hazards associated with working near power lines
- Describe the risk of overloading
- Discuss two-blocking and identify steps that can be taken to prevent it
- Summarize the standard and critical precautions taken when working with rigging

110 Scaffolding Safety

110-01 Scaffolding Safety
When you complete this lesson, you will be able to distinguish the responsibilities of those employees who work on or near scaffolding to assemble, maintain, and operate all scaffolding systems and adhere to safety requirements.

This lesson satisfies the training requirements for OSHA regulation 29 CFR 1926.454.

- Distinguish among the responsibilities of supervisors and employees to safely assemble, maintain, and operate scaffold systems
- Identify the specifications of required scaffold assembly, maintenance, and operation
- Distinguish among various scaffold systems
- Adhere to safe operating procedures regarding scaffold systems

111 Aerial Devices Safety

111-01 Scissor Lift Operations and Safety
When you have completed this lesson, you will be able to explain the importance of operating a scissor lift according to the step-by-step procedures listed in most operating manuals. You will also be able to explain the safety measures to be followed in detail and the importance of thorough pre-operation inspections.

This lesson satisfies the training requirements for OSHA section 29 CFR 1926 (Subpart L) section 453 including appendices and the American National Standard Institute (ANSI) ANSI/SIA/ A92.6-2006.

- State the importance of following all safety rules
- Identify steps in the pre-operation inspection of the scissor lift
- Recall the importance of good maintenance practices
- Identify a number of the function tests to be performed on the scissor lift
- Explain the importance of a workplace inspection
- Describe the operating instructions of a scissor lift

112 Crane Operations Safety

112-01 Crane and Hoist Safety
When you complete this lesson, you will be able to describe rules and responsibilities for the safe operation of cranes, hoists, and riggings; perform hand signals as well as perform a safety checklist for the operation of cranes and hoists.

This lesson satisfies the required training for OSHA standard 29 CFR 1910 179 (n)(3)(ix) and (o)(3).

- Identify operator responsibilities
- Recall general safety rules
- Describe operation rules
- Recall rigging safety requirements
- Identify relevant hand signals
- Describe a crane and hoist safety checklist
113 Forklift Safety

113-01 Forklifts and Powered Industrial Trucks Safety

When you complete this lesson, you will be able to adhere to the safe practices and procedures for minimizing the hazards of operating forklifts and other powered industrial trucks in the workplace.

This lesson satisfies the initial and refresher training requirements for OSHA standard 29 CFR 1910.178 (i)(1) through (7).

➢ Explain employee certification requirements
➢ Describe supervisor responsibilities
➢ Identify operator training requirements
➢ Describe the components of a lift truck
➢ Recall safe operating procedures
➢ Describe proper load handling

114 Fall Protection

114-01 Fall Protection

When you complete this lesson, you will be able to avoid falls and injury due to falling objects in the workplace by adhering to safety precautions and utilizing safety equipment.

This lesson satisfies the training requirements for OSHA standard 29 CFR 1910 Subpart R (1910.66 (i) (f)).

➢ Identify types of fall hazards associated with workplace environments
➢ Identify examples of situations requiring fall protection
➢ Identify fall protection systems utilized in the workplace
➢ Describe facts related to personal fall arrest systems
➢ Describe facts related to safety net systems
➢ Describe facts related to warning line systems
➢ Identify employee training requirements

114-81 Fall Protection (CAD)

When you complete this lesson, you will be able to recall best practices for avoiding falls and injury due to falling and falling objects in the workplace by adhering to safety precautions and utilizing appropriate safety equipment.

➢ Identify examples of situations requiring fall protection
➢ Identify fall protection systems utilized in the workplace
➢ Describe characteristics of personal fall arrest systems
➢ Describe characteristics of safety net systems
➢ Describe characteristics of warning line systems
➢ Recall employee training topics

115 Excavation and Trenching

115-01 Excavation and Trenching Safety

When you complete this lesson, you will be able to identify the safe procedures minimizing the hazards of working in or near excavation and trenching sites and adhere to safe practices applying to the heavy equipment used in excavation.

➢ Recall procedures for safe excavation and trenching
➢ Recall safe practices and procedures for trenching and excavation equipment
➢ Identify types of tools and equipment used for excavation and trenching
➢ Identify items on a safety checklist for excavations and trenches

116 Compressed Gas Cylinder Safety

116-01 Compressed Gas Cylinder Safety

When you complete this lesson, you will be able to safely handle, store, and use gas cylinders.

This lesson satisfies the training requirements for OSHA regulations 29 CFR 1910.253, 29 CFR 1926.350(d) and 29 CFR 1910.101.

➢ Identify and minimize hazards when handling and storing gas cylinders
➢ Describe the safety requirements of using pressure regulators and needle valves
➢ Safely test cylinders and connections for leaks
➢ Apply safe gas cylinder handling and use procedures to portable gas units
➢ Meet the requirements prescribed in the gas cylinder inspection checklist

117 Hazardous Materials Safety

117-01 Hazardous Materials Safety

When you complete this lesson, you will be able to identify hazardous materials common to the industrial and commercial workplaces and appropriately respond to spills, leaks, or other types of contamination within the workplace to protect personnel and the environment from the hazards presented by such materials.

This lesson satisfies the training requirements for OSHA standard 29 CFR 1910.1200 (h) (1) through (3).

➢ Identify and describe the four categories of hazardous chemicals
➢ Adhere to procedures to be followed in the event of a spill
➢ Adhere to procedures for cleanup of hazardous materials
➢ Identify and report abnormal physical reactions to a chemical or substance in the workplace
117-02 Acid and Caustic Awareness
When you complete this lesson, you will understand how substances are ranked on the pH scale. You will also be able to describe general safety precautions and emergency actions employed when working with acids and caustics.

- Describe the nature of an acid
- Describe the nature of a caustic
- List some examples of common acids and caustics
- Identify what the pH rating of a chemical indicates
- Discuss the process of neutralization
- Describe the steps for using an emergency eyewash station
- Discuss initial steps in the selection of personal protective equipment (PPE)

117-03 Asbestos and Silica Awareness
When you complete this lesson, you will recognize the health risks associated with both asbestos and silica. You will also be able to identify ways to prevent exposure to these materials in the workplace.

This lesson satisfies the initial and annual training requirements for OSHA standard 29 CFR 1910.1001 (j) (7) and (m) (4).

- Describe the health risks of asbestos and silica exposure
- List symptoms of diseases associated with exposure to asbestos and silica
- Discuss the effect of the delay between exposure and the onset of symptoms
- Identify permissible exposure limits (PEL) for asbestos and silica
- Discuss the use of proper personal protective equipment (PPE) used to reduce exposures
- Identify activities that commonly involve the potential for asbestos and silica exposure
- List other measures that can be implemented to reduce exposures

117-04 Ammonia Awareness
When you complete this lesson, you will be able to recognize the health risks associated with working around ammonia. You will also be able to identify steps to protect yourself during general maintenance or emergency activities.

- Describe the properties of ammonia
- Identify OSHA permissible exposure limits
- Discuss health effects related to ammonia exposure
- Identify personal protective equipment appropriate for working around ammonia

117-05 Hydrogen Sulfide Awareness
When you complete this lesson, you will understand the common warning signs, health effects, and personal protection requirements related to H₂S exposure.

- Identify physical and chemical characteristics of H₂S
- Recognize common symptoms H₂S exposure
- Identify levels of PPE associated with H₂S
- Understand medical considerations for individuals exposed to H₂S
- Explain actions taken in the event of a H₂S release

117-06 Chlorine Awareness
When you complete this lesson, you will recognize the occupational hazards and potential health effects of chlorine exposure.

- Identify common properties of chlorine
- List common side effects of chlorine exposure
- Describe basic first aid measures performed for victims of chlorine exposure
- Identify OSHA (Occupational Safety and Health Administration) permissible exposure limits (PEL) for chlorine
- Identify proper personal protective equipment used around chlorine

117-07 Radiation Awareness
When you complete this lesson, you will understand a basic overview of radiation. In addition, you will be able to describe associated health risks commonly associated with radiation and identify methods to protect yourself and others from exposure.

- Discuss the basic relationship between elements, atoms, and particles
- Describe the difference between ionizing and non-ionizing radiation
- Explain some basic radiation protection concepts
- Identify the risks of exposure to radiation and radioactive materials
- Discuss some of the ways in which radiation monitoring is conducted
- Identity safety practices and actions that can protect you from exposure to radiation

117-08 Hazardous Gases – Methane, Carbon Monoxide, and Carbon Dioxide
When you complete this lesson, you will be able to understand the common health and safety hazards associated with methane, carbon monoxide, and carbon dioxide. You will also understand where these gases can be found in the workplace and be able to describe procedures and devices employed to protect employees from exposure.

- List the physical and chemical characteristics of methane, carbon monoxide, and carbon dioxide
- Identify health and safety hazards associated with methane, carbon monoxide, and carbon dioxide
- Describe where methane, carbon monoxide, and carbon dioxide are found in the workplace
- Describe gas monitor alarm levels for methane, carbon monoxide, and carbon dioxide
- Discuss the use of proper personal protective equipment (PPE) when working with high levels of methane, carbon monoxide, or carbon dioxide
117-09 Lead Awareness
When you complete this lesson, you will understand risks associated with lead, where you might encounter this element in the workplace, and the negative health effects it can cause. Additionally, you will be able to identify prevention measures, such as the use of personal protective equipment and good housekeeping practices.

- Identify the properties of lead
- Identify activities that commonly involve the potential for lead exposure
- Discuss health effects related to lead exposure
- Identify personal protective equipment (PPE) appropriate for working around lead
- List examples of good housekeeping used to reduce exposure to lead

117-20 Gas Monitoring Basics
When you complete this lesson, you will be able to describe the basic design and operation of a gas monitor.

- List the three major reasons gas monitors are needed
- Identify common types of gas monitors
- Describe the basic operation of a gas monitor
- Define each of the following terms:
  - Lower explosive limit
  - Upper explosive limit
  - Immediately Dangerous to Life or Health (IDLH)
  - Calibration
- Describe basic gas sampling techniques
- Explain why calibration and bump tests are performed

117-83 Asbestos Awareness (CAD)
General industry employees may be exposed to asbestos during manufacturing processes, cleanup operations, or while repairing equipment. Awareness of the hazards associated with this material can help prevent serious illnesses or disease.

- Describe the health risks of asbestos exposure
- Discuss the effect of the delay between exposure and the onset of symptoms
- Discuss the use of proper personal protective equipment (PPE) used to reduce exposures
- Identify activities commonly involving the potential for asbestos exposure

117-85 Hydrogen Sulfide Awareness (CAD)
When you complete this lesson, you will be able to recall the common warning signs, health effects, and personal protection requirements related to H2S exposure.

- Identify physical and chemical characteristics of H2S
- Recognize common symptoms of H2S exposure
- Recall how appropriate PPE is chosen
- Understand medical considerations for individuals exposed to H2S
- Explain actions taken in the event of an H2S release

118 HAZWOPER
These lessons, when taken with 101-01, 117-01 and 120-04 satisfy the OSHA requirements for 8-Hour Refresher Training.

118-01 HAZWOPER Regulation Overview
When you complete this lesson, you will be able to discuss an overview of federal acts and regulatory bodies that protect workers who deal with hazardous materials. In addition, you will have a basic understanding of terminology and numbering used to outline a typical regulation.

This lesson references OSHA (Occupational Safety and Health Administration) regulation 29 CFR 1910 (Subpart H section 120 with appendices, and section 1200 with appendices).

- Describe some of the justification behind the enactment of the Occupational Safety and Health Act of 1970
- Interpret the breakdown of a standard regulation citation
- Discuss the origin and overall purpose of each of the following:
  - OSHA
  - NIOSH (The National Institute for Occupational Safety and Health)
  - OSHRC (The Occupational Safety and Health Review Commission)
  - HAZWOPER regulations
  - RCRA (The Resource and Recovery Act)

118-02 Site Characterization and Analysis
When you complete this lesson, you will be able to describe how site characterization and analysis is used to protect the lives of employees and ensure a safe working environment at sites containing hazardous substances.

- Identify the type of information documented in the site plan and its purpose
- Describe the basic levels of personal protective equipment (PPE)
- Discuss air monitoring measures
- Identify the main components of a hazardous communications (HAZCOM) program
- Explain the three primary steps in risk identification
- Discuss the safety responsibilities of employees who work around hazardous materials
- Compare the attributes of the hot, warm, and cold zones in a site control program
118-03 Toxicology
When you complete this lesson, you will be able to explain the potential health effects of exposure to various toxic substances.

➢ Discuss the distinction between a hazardous substance and a toxic one
➢ Describe how toxic chemicals are classified
➢ Discuss routes of entry into the body
➢ Compare toxic effects of chemicals
➢ Explain different exposure levels when dealing with toxic substances

118-04 Medical Surveillance
When you complete this lesson, you will be able to describe the design and function of a medical surveillance program.

➢ Discuss the purpose of the medical surveillance program
➢ Identify a medical surveillance program’s main components
➢ Explain the use of pre-entry and post-entry evaluations
➢ Describe effective record keeping procedures

118-05 Decontamination
When you complete this lesson, you will be able to discuss principles of decontamination and describe activities performed in a standard decontamination corridor.

➢ Explain the purpose of decontamination and identify the priorities underlying the process
➢ Describe basic methods of decontamination
➢ Explain how the establishment of hot, warm, and cold zones facilitates decontamination
➢ Identify the decontamination steps implemented in a basic, six-step decon line
➢ Discuss the appropriate use of emergency decontamination procedures

119 Hazard Communications

119-03 Hazardous Communications Employee Training Program, Part 1
When you complete this lesson, you will be able to discuss the Hazardous Communication Program and describe the training provided under this program for every employee.

➢ Explain the employee’s rights under the Hazardous Communication Program
➢ Identify steps taken by the trainer to improve trainees’ comprehension and understanding
➢ Describe methods used to detect the presence of a release
➢ Identify the physical and health hazards presented by hazardous materials
➢ Describe methods for eliminating physical and health hazards of hazardous materials

119-04 Hazardous Communication Employee Training Program, Part 2
When you complete this lesson, you will be able to describe how exposure to hazardous materials occurs. You will also be able to explain how to choose and use equipment for personal protection.

➢ Name the three basic exposure pathways to hazardous materials
➢ List some factors that influence whether or not adverse health effects result from an exposure
➢ Identify the equipment used with each of the four levels of PPE
➢ Explain how to choose the right protective equipment
➢ List some limitations of protective equipment

119-06 Hazard Communication Programs in the Workplace
When you complete this lesson, you will be able to discuss the Hazardous Communication Program and describe the training and information provided under this program for every employee.

➢ Explain the employee’s rights under the Hazardous Communication Program
➢ Explain components of a workplace Hazard Communications Program
➢ Explain the purpose of The Globally Harmonized System of Classification and Labeling of Chemicals (GHS)
➢ Identify the components GHS addressed in developing a harmonized hazard communication system
119-07 Exposure to and Detection of Hazardous Chemicals

When you complete this lesson, you will be able to describe how exposure to hazardous materials occurs and what can influence the severity of the effects of the hazard. You will also be able to describe ways a hazardous release can be detected.

➢ Name the four basic exposure pathways to hazardous materials
➢ List some factors influencing whether or not adverse health effects result from an exposure
➢ Describe methods used to detect the presence of a release

119-08 Physical, Health, and Environmental Hazard Classes

When you complete this lesson, you will be able to discuss the physical, health, and environmental hazard classifications according to The Globally Harmonized System of Classification and Labelling of Chemicals (GHS). In addition, you will be able to recognize the effects of the various hazard classifications.

➢ Discuss the classes of physical hazards
➢ Identify hazardous effects caused by products classified as physical hazards
➢ Discuss the classes of health hazards
➢ Identify hazardous effects caused by products classified as health hazards
➢ Discuss the classes of environmental hazards
➢ Identify hazardous effects caused by products classified as environmental hazards

119-09 Labeling and SDS for Hazardous Chemicals

When you complete this lesson, you will understand proper labeling requirements according to the GHS. In addition, you will be able to recognize pictograms for GHS hazard classifications and describe the contents of the standardized, 16 sections of the SDS.

➢ Recognize the GHS standardized elements of a chemical label
➢ Describe the importance of a standardized safety data sheet (SDS) and its role in the workplace
➢ Identify and explain the information required in a GHS SDS
➢ Recall the use of pictograms, signal words, and hazard statements used for labeling hazardous substances

122 Transportation

122-01 Safe Driving Practices

When you complete this lesson, you will be familiar with the requirements of drivers of Department of Transportation (DOT) Class 1-6 light or medium duty vehicles. Additionally, you will be aware of defensive driving techniques, hazard perception, and driving attitude.

➢ Identify how the use of trip planning and conducting a pre-trip vehicle inspection can reduce risk
➢ Define distracted driving, its dangers, and steps to avoid it
➢ Describe ways to identify and react to distracted drivers
➢ List driving habits facilitating safe driving in hazardous weather conditions
➢ Explain situational awareness and what kind of actions support it

122-02 Drug and Alcohol Awareness

When you complete this lesson, you will be able to recall the effects of drugs and alcohol, be familiar with the DOT required testing process, and the result-based consequences.

➢ Identify the effects of drugs and alcohol
➢ Recall the DOT required testing process
➢ Identify result-based consequences resulting from testing

130 Behavior Based Safety Training

130-01 Behavior Based Safety Programs Basic Design

When you complete this lesson, you will be able to describe the basic design of a behavior based safety program. In addition, you will be able to explain how you can participate in safety committees and safety inspection teams to positively influence the safety program at your plant.

➢ Explain how a safety committee should be established and why
➢ Explain the process an effective safety committee would use to communicate an at-risk condition or behavior that is discovered during a plant safety inspection
➢ Describe five items an effective safety committee should report out to all plant employees during a monthly safety meeting
➢ Describe the difference between a near miss and an injury accident
130-02 Behavior Based Safety Program Concepts

When you complete this lesson, you will be able to describe the factors affecting your personal safety on the job including your capabilities, your work environment, and your attitude towards safety, and the behaviors you exhibit. In addition, you will be able to explain the difference between a positive safety attitude and safe working behaviors.

➢ Describe three key factors affecting safety in the workplace
➢ Describe three personal characteristics that affect an individual’s safety on the job
➢ Describe three factors affecting an employee’s work environment
➢ Explain the difference between a safe working attitude and safe working

130-03 Hazardous Material Procedures

When you complete this lesson, you will be able to describe some of the basic hazardous materials found in a power plant. Additionally, you will be able to discuss some of the procedures used while working with these products.

➢ Define hazardous material
➢ Describe the responsibility of the company and your responsibilities when working with hazardous materials
➢ Discuss the three key notifications that should take place during a hazardous material spill
➢ Describe one method of labeling asbestos containing material in a power plant

130-04 Confined Space Procedures

When you complete this lesson, you will be able to discuss the reason for a confined space procedure and discuss the basic information found on a confined space permit. In addition, you will be able to explain the difference between a non-permit required confined space and a permit required confined space.

➢ Describe the three key purposes of a confined space permit procedure
➢ Describe the basic information that can be found on a typical confined space permit
➢ Explain and describe the purpose of an atmospheric test
➢ Describe the primary difference between a non-permit required confined space and a permit required confined space

130-05 Hot Work Procedures

When you complete this lesson, you will be able to describe the purpose of a hot work permit procedure. In addition, you will be able to discuss the basic information that can be found on most hot work permits.

➢ Define hot work
➢ Describe the primary reason for hot work permit procedure
➢ Explain the key purposes of a hot work permit
➢ Describe the six key steps associated with a hot work permit

130-06 Root Cause Analysis

When you complete this lesson, you will understand the process of root cause analysis and how to properly identify a root cause. In addition, you will understand the common tools used in determining root cause.

➢ Explain the purpose of root cause analysis
➢ Identify the steps in performing a root cause analysis
➢ Understand the various tools used to identify the root cause

130-07 Safety and Health Programs

When you complete this lesson, you will be able to recognize the true cost of workplace accidents, see the benefits of an effective safety and health program, describe the critical elements of an effective safety and health program, and identify and prevent most workplace hazards.

➢ Recognize the costs of workplace accidents
➢ Understand the benefits of implementing an effective safety and health program
➢ Describe the elements of an effective safety and health program
➢ Identify methods to prevent workplace hazards

131 Ergonomics

131-01 Ergonomics in an Office Environment

When you complete this lesson, you will understand ergonomics and the disorders related to it. In addition, you will be able to recognize ergonomic hazards in an office environment and determine ways to mitigate these hazards.

➢ Describe the purpose of ergonomics
➢ Determine disorders associated with ergonomic hazards
➢ Identify common injuries associated with work related musculoskeletal disorders
➢ Explain ways to mitigate ergonomic hazards
➢ Determine factors that can cause ergonomic related injuries
➢ Discuss the importance of proper workstation design
➢ Demonstrate proper workstation use
➢ Evaluate your workstation for ergonomic hazards
131-02 Ergonomics in an Industrial Environment

When you complete this lesson, you will understand ergonomics and the disorders related to it. In addition, you will be able to recognize ergonomic hazards in an industrial environment and determine ways to mitigate these hazards.

➢ Describe the purpose of ergonomics
➢ Determine disorders associated with ergonomic hazards
➢ Identify common injuries associated with work related musculoskeletal disorders
➢ Explain ways to mitigate ergonomic hazard
➢ Determine factors that can cause ergonomic related injuries
➢ Discuss sources of industrial ergonomic hazards
➢ Identify industrial factors that may cause ergonomic hazards
➢ Describe ways to minimize task-specific ergonomic hazards
➢ Demonstrate proper tool selection for specific tasks

131-03 Proper Lifting Techniques

When you complete this lesson, you will be able to utilize proper lifting techniques when performing manual material handling tasks. In addition, you will be able to employ techniques to help prevent back injuries.

➢ Describe manual material handling activities in a work environment and everyday situations
➢ Identify variables that are required for the NIOSH Lifting Equation
➢ Discuss risk factors associated with manual material handling tasks
➢ Explain techniques that can be utilized to help prevent back injuries
➢ Determine common administrative and engineering controls to help prevent lifting injuries
➢ Demonstrate proper techniques when performing a lift alone
➢ Explain the proper technique when performing a lift with a team
➢ Discuss the disadvantages of using a back belt in an industrial environment

140 Qualified Electrical Worker

140-01 General Concepts and Job Briefings

When you complete this lesson, you will be able to recall general concepts regarding safety while performing electrical work. You will also be familiar with what job briefings are and how they can help a worker avoid accidents.

➢ Recall the circumstances in which OSHA 29 CFR 1910.269 applies
➢ Identify the training employers are responsible for providing under this regulation
➢ Recall examples of existing characteristics and conditions relating to installations
➢ Recall the roles and responsibilities for information transfer
➢ Define a job briefing
➢ Identify topics covered in a job briefing
➢ Recall the requirements for
  o Number of briefings
  o Extent of briefing
  o Working alone

140-04 Enclosed Spaces

When you complete this lesson, you will be able to identify the conditions of an enclosed space and how to eliminate or reduce the hazards associated with working in an enclosed space.

➢ Define
  o Enclosed space
  o Vault
  o Vented vault
➢ Identify examples of hazardous atmospheres in an enclosed space
➢ Recall OSHA’s regulations for handling enclosed space entry

140-09 Electrical Clearances

When you complete this lesson, you will be familiar with the requirements for the control of hazardous energy sources used in power generation, transmission, and distribution.

➢ Recall the regulation regarding electrical clearances for generation, transmission, and distribution
➢ Recall the general requirements outlined for using electrical clearances
➢ Identify steps for de-energizing lines and equipment
➢ Identify steps for transferring and releasing clearances
140-11 Mechanical Equipment
When you complete this lesson, you will be able to recall the general requirements for using mechanical equipment during electrical work.

➢ Recall the regulation regarding mechanical equipment in the electric power generation, transmission, and distribution industries
➢ Identify types of mechanical equipment to which this standard refers
➢ Define outriggers and their purpose
➢ Define minimum approach distance (MAD)
➢ Recall requirements for working near energized lines and equipment

140-18 Dog Bite Prevention
When you complete this lesson, you will be able to recall techniques for preventing a dog attack and techniques for minimizing the severity of the injury if the attack cannot be prevented.

➢ Identify common causes of dog bites
➢ Explain how interactions between dogs and humans can trigger dog bites
➢ Define diseases transmissible by dog bites
➢ Identify actions to take to avoid interactions with dogs on customer property
➢ Define tools used for preventing dog bites
➢ Identify ways to determine if a dog is present on the property
➢ Recall manager responsibilities for workers who may experience interactions with dogs

150-01 Environmental Awareness
When you complete this lesson, you will be able to identify ways your awareness can reduce the environment impact of various processes and tasks.

In addition, you will be able describe the process of designing and implementing an environmental management system (EMS) and discuss the overall goals of waste minimization and pollution prevention programs.

➢ Identify the primary reasons for developing an environmental policy
➢ Discuss common situations in which your environmental awareness can positively impact water and air quality
➢ Describe ways to protect the environment when handling solid and hazardous waste, petroleum products, and substances such as PCB and asbestos
➢ Describe the stages involved in the development of an environmental management system
➢ Discuss the purpose of the National Waste Minimization Program
➢ Identify common benefits of waste minimization and pollution prevention programs

150-02 Stormwater Regulations and Pollution Prevention Plans
When you complete this lesson, you will be able to describe ways that stormwater runoff can impact the environment. In addition, you will be able to discuss stormwater regulations and explain how to effectively develop a stormwater pollution prevention plan (SWPPP).

➢ Identify major industrial sources of stormwater discharges
➢ Discuss stormwater regulations implemented by the NPDES (National Pollutant Discharge Elimination System) and EPA (Environmental Protection Agency)
➢ Identify the components of a stormwater pollution prevention plan (SWPPP)
➢ Describe the steps to produce and maintain an SWPPP

150-03 Spill Prevention, Control, and Countermeasures
At the completion of this lesson, you will be able to describe the use of spill prevention, control, and countermeasure plans. In addition, you’ll be able to discuss common practices for preventing, responding to, and reporting spills.

➢ Outline SPCC (spill prevention, control, and countermeasures) regulation guidelines
➢ Explain how common secondary containment is used to prevent spills
➢ Describe spill response and reporting tactics and procedures
➢ Discuss the importance of performing visual inspections and routine maintenance

160 Construction Safety
160-01 Health Hazards in Construction
When you complete this lesson, you will be able to recall and discuss principles of industrial hygiene towards a safer working environment.

➢ Recall the importance of industrial hygiene
➢ Identify types of health hazards in the workplace
➢ Identify types of chemical hazards in the workplace
➢ Identify types of biological hazards in the workplace
➢ Identify types of physical hazards in the workplace
➢ Identify types of ergonomic hazards in the workplace
➢ Recall health hazard protection methods
➢ Recognize employer requirements to protect workers against hazards
160-02 Scaffolding Safety for Construction
When you complete this lesson, you will be able to distinguish the responsibilities of those employees who work on or near scaffolding to assemble, maintain, and operate all scaffolding systems and adhere to safety requirements.

➢ Define the role of a competent person related to scaffolding
➢ Recall the types of scaffolds commonly used on construction sites
➢ Identify the specifications of required scaffold assembly, maintenance, and operation
➢ Describe hazards associated with scaffolds and ways to prevent those hazards
➢ Recognize employer requirements to protect workers from scaffold hazards

160-03 Portable Power and Hand Tool Safety for Construction
When you complete this lesson, you will be able to identify hazards associated with the use of hand and power tools. You will be able to prevent accident and injury in the workplace by adhering to safety practices and requirements. You will also be familiar with the employer requirements put in place for the protection of construction workers.

➢ Recognize employer requirements
➢ Identify different types of hand and power tools used at construction worksites
➢ Describe hazards associated and precautions taken with hand and power tools
➢ Recall general tool safety guidelines
➢ Identify the sources of power available for power tools

160-04 Materials Handling and Storing Safety for Construction
When you complete this lesson, you will be able to minimize the risks of injury and illness by safely handling and storing materials in the workplace. You will be able to identify potential hazards when handling materials and identify ways to prevent those hazards. Finally, you will be able to recognize an employer’s responsibilities for safe materials handling.

➢ Describe methods and equipment used for materials handling in the workplace
➢ Identify hazards associated with material handling activities
➢ Recall safe lifting techniques
➢ State concepts regarding the safe use of non-powered trucks to handle materials
➢ State concepts regarding the safe use of powered industrial trucks to handle materials
➢ Identify methods to prevent hazards associated with material handling equipment
➢ Recognize employer requirements to protect workers from material handling hazards

160-05 Personal Protective Equipment for Construction, Part 1
When you complete this lesson, you will be familiar with the hierarchy of control for reducing risk and avoiding injury, illness, and death by properly selecting, using, and maintaining personal protective equipment (PPE).

➢ Describe the hierarchy of controls as it relates to personal protective equipment
  o Elimination/Substitution
  o Engineering controls
  o Administrative controls
  o PPE
➢ Distinguish the types of equipment necessary to protect employees when working in conditions affecting the workers’ health and safety, specifically for their:
  o Eyes
  o Face
  o Hearing
  o Respiratory system
  o Head

160-06 Personal Protective Equipment for Construction, Part 2
When you complete this lesson, you will be familiar with some of the requirements of employers and employees for reducing risk and avoiding injury, illness, and death by properly selecting, using, and maintaining personal protective equipment (PPE).

➢ Identify the responsibilities of the employer and employee regarding the use of personal protective equipment
➢ Identify the components of a training program for the use of PPE
➢ Distinguish the types of equipment necessary to protect employees when working in conditions affecting the workers’ health and safety, specifically:
  o Hands
  o Feet
  o Body

160-07 Excavation and Trenching Safety for Construction
When you complete this lesson, you will be able to identify hazards and methods of protecting workers from hazards during excavation and trenching operations. You will also be able to recognize the role of a competent person as well as the responsibilities of the employer and employee when engaged in these operations.

➢ Describe the role of a competent person at an excavation site
➢ Identify hazards associated with excavations
➢ Recall excavation hazard protection methods
➢ Describe the methods for protecting employees from cave-ins
➢ Recognize employer requirements to protect workers from excavation hazards
**170 Industrial Mathematics**

**170-01 Introduction to Industrial Math**

When you complete this lesson, you will be able to explain the mathematical order of operations, the use of exponents and square roots.

- Explain the rules for rounding numbers
- List the mathematical order of operations
- Identify the principles of exponents
- Solve problems using numbers that include exponents
- Identify the principles of square roots
- Explain how a calculator can be used for operations with exponents and square roots

**170-02 Industrial Math: Measurements and Calculations**

When you complete this lesson, you will be able to demonstrate how to use equations to solve industrial problems involving length, height, flow and temperature conversions and calculations. You will be able to explain how to read and interpret formulas, graphs, charts, and tables. You will also be able to apply several mathematical formulas to commonly used industrial calculations.

- Describe the use of conversion tables
- Use equations to solve problems using length, height, and flow temperature conversions
- Solve mathematical problems using each of the following:
  - Area formulas
  - Volumetric formulas
  - Velocity formulas
  - Flow formulas
  - Density and specific gravity
- Explain how to interpret circle, bar, and line graphs
- Explain how to read and interpret charts and tables

**170-03 Industrial Math: Fractions, Percentages, and Ratios**

When you complete this lesson, you will be able to interpret and solve problems using fractions, decimals, and percentages. You will also be able to interpret and solve problems using ratios and proportions.

- Explain basic terminology and functions related to fractions
- Calculate lowest common denominator
- Perform arithmetic operations on fractions
- Convert fractions to decimals
- Convert decimals to fractions
- Explain basic terminology and functions related to percentage
- Change percent values to decimals and fractions
- Compute bases, rates, or portions of numbers
- Determine differential percentages
- Determine maximum and minimum measurements given the percent tolerance
- Explain basic terminology used to describe ratios and proportions
- Solve problems using ratios and proportions

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**171 Industrial Sciences**

**171-01 Atomic Structure and Chemical Bonding**

When you complete this lesson, you will be able to describe the various components of an atom and discuss atomic theory. You will also be able to explain how chemical bonds are formed and describe the two most common types of chemical bonding.

- Define the terms nucleus, proton, electron, and neutron
- Describe the makeup of electron shells
- Outline Dalton’s Atomic Theory
- Discuss the chemical makeup of molecules and compounds and explain how they differ from mixtures
- Describe how an ionic bond is formed
- Describe how a covalent bond is formed
- Explain the Octet Rule

**171-02 Introduction to the Periodic Table of Elements**

When you complete this lesson, you will understand how elements are named, grouped, and listed on the periodic table.

- Discuss the history of the periodic table of elements
- Describe the role elements play in chemistry
- Explain the importance of an element’s atomic weight, atomic number, and symbol
- Discuss how electrons in the outer shell of an atom relate to chemical reactions and bonding
- Describe the organizational pattern of the periodic table of elements and list classifications of elements

**171-03 Chemical Formulas, Reactions, and Solubility**

When you complete this lesson, you will be able to describe different types of chemical formulas and chemical reactions. In addition, you will be able to discuss components and characteristics of solutions.

- Describe the notation of various types of chemical formulas
- List the four common types of chemical reactions
- Identify the function of a catalyst
- Explain the difference between exothermic and endothermic chemical reactions
- Describe the relationship between a solute and a solvent
- Identify factors that can affect solubility
- Explain what is meant by the saturation point of a solution
171-04 Introduction to Hydrocarbon Chemistry
When you complete this lesson, you will be able to discuss the molecular structure, physical properties, naming conventions, and commercial uses of several common hydrocarbons.

- Compare the definitions of petroleum and crude oil
- Relate the physical states of hydrocarbons to their carbon content
- Discuss how covalent bonds are formed between hydrogen and carbon
- Explain the use of base names, prefixes, and suffixes to label hydrocarbons
- Describe and compare the structures of the following hydrocarbon families:
  - Paraffins
  - Napthenes
  - Aromatics
  - Olefins
  - Alkynes
- Identify correlations between physical properties of a hydrocarbon and the hydrocarbon's molecular structure
- List some contaminants commonly found in crude oil and discuss their adverse effects on oil refining

171-05 Chemical Equations
When you complete this lesson, you will have the knowledge necessary to write and balance chemical formulas and equations.

- Identify reactants, reaction products, and reaction arrows
- Identify atoms and molecules in a chemical equation
- Define polyatomic ions and diatomic molecules
- Identify balanced and unbalanced equations
- Balance a chemical equation

171-10 Introduction to Physics: Force and Motion
When you complete this lesson, you will be able to describe terms and types of force as they pertain to classical physics. In addition, you will be able to explain Newton’s laws involving motion and perform basic calculations using these laws.

- Explain the concept of vectors
- Compare scalar and vector quantities
- Describe Newton’s three laws of motion
- Explain the universal law of gravitation
- Explain the concept of momentum
- Discuss the relationship between mass and weight
- Describe different types of force
- Use Newton’s laws of motion to calculate force, weight, acceleration, velocity, and momentum
- Discuss the use of the Newton as a unit of measure

171-11 Introduction to Physics: Energy, Work, and Power
When you complete this lesson, you will be able to define different types of energy, work, and power. You will also be able to use formulas to calculate potential energy, kinetic energy, work done, and power used.

- Compare potential and kinetic energy
- Perform calculations involving potential and kinetic energy
- Describe relationships between energy, work, and power
- Calculate the amount of work performed in example scenarios
- Explain the law of conservation of energy
- Perform calculations involving power
200 – Mechanical Maintenance

201 Introduction to Industrial Maintenance and the Tools of the Trade

201-01 Working Principles of Simple Machines
When you complete this lesson you will be able to describe several simple machines used to make work easier. These simple machines are the inclined plane, wedge, lever, screw, pulley, gears, and the wheel and axle.

➢ Describe how the inclined plane serves to make work easier
➢ Describe how a wedge serves to make work easier
➢ Describe how a lever serves to make work easier
➢ Describe how a screw serves to make work easier
➢ Describe how a pulley serves to make work easier
➢ Describe how a wheel and axle serves to make work easier
➢ Describe how gears serve to make work easier

201-02 Hand Tools, Part 1
When you complete this lesson you will be able to explain safety precautions to take when working with hand tools. You will be able to explain and describe various types of wrenches, hammers, screwdrivers, and pliers commonly used in industrial facilities.

➢ Explain safety precautions to take when working with hand tools
➢ Identify and describe the types of wrenches used in industrial facilities
➢ Identify and describe types of hammers used in industrial facilities
➢ Identify and describe types of screw drivers used in industrial facilities
➢ Identify and describe different variations of pliers used in industrial facilities

201-03 Hand Tools, Part 2
When you complete this lesson, you will be able to explain and describe various types of saws, files, chisels, punches, vises, clamps, and levels commonly used in industrial facilities.

➢ Identify the characteristics and purposes of different types of hand saws used in industrial facilities
➢ Identify the characteristics and purposes of different types of files used in industrial facilities
➢ Identify the characteristics and purposes of various types of chisels and punches used in industrial facilities
➢ Identify the characteristics and purposes of various types of vises and clamps used in industrial facilities
➢ Identify the characteristics and purposes of different types of levels used in industrial facilities

201-04 Portable Power Tools
When you complete this lesson, you will be able to explain some safety precautions to follow when working with portable power tools. You will be able to identify and describe various types of grinders, impact wrenches, power drills, power screwdrivers, and power saws used in industrial facilities.

➢ Explain some safety precautions to take when working with portable power tools
➢ Describe various types of grinders used in industrial facilities
➢ Describe impact wrenches used in industrial facilities
➢ Describe portable power drills used in industrial facilities
➢ Describe powered screwdrivers used in industrial facilities
➢ Identify and describe types of power saws used in industrial facilities
201-05 Torque Wrenches
When you complete this lesson, you will be able to explain the need for torque wrenches in machining and maintenance operations. You will also be able to describe the various types of torque wrenches available and explain the proper procedures for their use.

- Identify the purpose of a torque wrench
- Describe basic types of torque wrenches
- Explain the proper procedures for using a torque wrench
- List some techniques to ensure accuracy when using a torque wrench

202 Belt Drive Maintenance

202-01 Introduction to Belt Drive Maintenance
When you complete this lesson, you will be able to knowledgeably discuss the general use and maintenance of belt drive systems.

- Define common belt drive terminology including:
  - Belt pitch length
  - Center distance
  - Arc of contact
  - Speed ratio
  - Sheave, driven sheave, driver sheave, idler sheave, and sheave pitch diameter
- Identify advantages and disadvantages of belt drive systems
- Explain basic techniques for proper belt drive tensioning
- Describe some ways to alter a belt’s arc of contact

202-02 V-Belts
When you complete this lesson, you will be able to explain the design and use of the most common variations of V-belts.

- Describe how a V-belt transfers power
- Discuss the following types of V-belt sizing:
  - Conventional
  - High capacity
  - Light duty
- Identify specialized V-belts
- Describe the construction of V-belts

202-03 Positive Traction Belt Drives
When you complete this lesson, you will be able to describe the major components and proper operation of positive traction drive belt systems used in an industrial facility.

- List advantages of positive traction belt drive systems
- Describe the sheave design used on these systems
- Describe positive traction belts
- Explain proper belt tensioning and identify the effects of over-tensioned and under-tensioned belts

202-04 Sheave Maintenance
When you complete this lesson, you will be able to describe the design and operation of sheaves and explain basic techniques employed to maintain them.

- Describe the construction of V-Belt sheaves
- Describe the construction of positive traction belt sheaves
- Discuss design and methods used with manually adjusted, variable speed sheaves
- Explain the principle of operation behind spring-loaded, adjustable, variable speed sheaves
- Explain how to align sheaves using a straightedge
- State the reason for adjustable sheave lubrication

202-05 Introduction to Conveyor Systems
When you complete this lesson, you will be able to identify basic conveyor designs and explain how various general configurations are used to move different products and materials from point to point.

- Describe a basic conveyor
- Identify three types of gravity conveyors
- Identify two types of power conveyors
- Explain the difference between a material handling belt conveyor and a bulk material handling conveyor
- Describe the key feature common to all automated roller conveyors
- Recall the four most common automated roller conveyor belt drives

202-06 Conveyor System Designs
When you complete this lesson, you will be able to describe the components of a typical belt conveyor used in an industrial setting. In addition, you will be able to identify the equipment commonly found in large-scale, industrial conveying systems, and describe the purpose of each piece of equipment.

- Discuss the purpose of a drive pulley
- Recall the primary components collectively comprising a typical industrial conveyor drive
- Identify two functions of a snub idler
- Describe the purpose of the adjustment screws on a belt conveyor
- Explain the purpose of the feeders in an industrial conveying system

202-07 Conveyor Belt System Inspection and Operation
When you complete this lesson, you will have the ability to describe the equipment that is used to protect plant personnel and conveying system equipment. In addition, you will be able to list the inspections that should be conducted on conveyor belt systems.

- Discuss the purpose of a safety cord on a conveyor belt system
- Explain the function of a lateral motion switch, when used in conjunction with a conveyor belt
- Describe the difference between overspeed protection and holdback protection, as it relates to conveyor belt operation
- List three checks you should make when inspecting a running conveyor belt
- Discuss the purpose of a belt wiper
When you complete this lesson, you will be able to describe the basic technique used to install and adjust new belting on a large industrial conveyor.

- Define splicing
- Describe two common techniques used to splice a conveyor belt together
- Discuss the advantages and disadvantages of vulcanized splices
- Explain the purpose and method of training a belt

203 Bearing Maintenance

203-01 Introduction to Bearings
When you complete this lesson, you will be able to explain the basic concepts behind the use of bearings. In addition, you’ll be able to describe their mechanical functions, loading forces, common lubricants, main classifications, and the types of friction they encounter.

- Describe the types of friction forces that affect bearings
- Explain the basic mechanical functions of bearings
- Describe the loading forces affecting bearings
- Explain types of lubricants used in bearings
- Identify the two main categories of bearings

203-02 Rolling Contact Bearings
When you complete this lesson, you will be able to identify the most common types of rolling contact bearings, and recognize some of their design considerations and common operating characteristics.

- State the operating principle behind rolling contact bearings
- Describe the two common categories of rolling contact bearings
- Identify different ball bearing designs
- Identify different roller bearing designs
- Explain how various types of rolling contact bearings are used for axial loads

203-03 Sliding Surface Bearings
When you complete this lesson, you will be able to identify the most common types of sliding surface bearings, and recognize some of their design considerations and common operating characteristics.

- List the common names used for sliding surface bearings
- State the operating principle behind sliding surface bearings
- Define boundary and full film lubrication
- Describe bushings and sleeve bearings
- Describe split bearings
- Explain lubricating grooves, oil rings, and wick lubricators
- List advantages of sliding surface bearings

203-04 Bearing Installation and Removal
When you complete this lesson, you will be able to explain some basic techniques for the installation and replacement of rolling contact and sliding surface bearings.

- Describe tools used to install a rolling contact bearing
- Explain methods of installing a shrink fit bearing
- Explain methods of checking an installed rolling contact bearing for proper operation
- Describe sounds an improperly installed rolling contact bearing can make and explain the cause
- Describe alignment of a sliding surface bearing
- Describe tools used in the removal of sliding surface and rolling contact bearings
- Explain the removal process for rolling contact and sliding surface bearings

203-05 Bearing Seals
When you complete this lesson, you will be able to describe and identify the seals most commonly used on bearings, their specific applications, and their design considerations.

- Explain the function of bearing seals and describe their main components
- Identify the two types of bearing seals
- Describe the types of materials used in the manufacture of oil seal lips
- Discuss the selection of oil seals based on speed of the application
- Name some oil seals that are classified by their use
- Name some oil seals that are classified by service conditions
- Explain labyrinth seal construction
- Describe labyrinth seal classifications
- List the advantages of a labyrinth seal

203-06 Troubleshooting Bearing Failures
When you complete this lesson, you will be able to recognize symptoms indicating failing bearings. In addition, you will be able to troubleshoot bearing failures and use the information you gain to prevent a reoccurrence.

- Identify symptoms of failing bearings
- Discuss bearing failure due to:
  - Normal fatigue (spalling)
  - Overheating
  - Lubricant
  - Corrosion
  - Brinelling and false brinelling
  - Equipment misalignment
  - Fretting
  - Electrical arcing
  - Thrust forces
- Identify common questions asked when troubleshooting bearing failures related to the following categories:
  - Lubrication
  - Rotating race
  - Fixed race
  - Rolling element cage or retainer
  - Rotating elements
205 Gear Maintenance

205-01 Introduction to Gear Drives
When you complete this lesson, you will be able to describe and explain the function of a gear and define common terms utilized working with gears and gear drives.

➢ Explain the design and function of a gear
➢ Define the following:
  o Tooth
  o Pitch
  o Pitch circle
  o Pitch diameter
  o Circular pitch
  o Diometrical pitch
  o Outside diameter
  o Root circle
  o Addendum
  o Dedendum
  o Clearance
  o Whole depth
  o Working depth
  o Flank of the tooth
  o Face of the tooth
  o Fillet
  o Face width
  o Backlash
  o Pressure angle
  o Top land
  o Bottom land
  o Crown
  o Gear-tooth ratio
  o Gear Hardness

205-02 Types of Gears
When you complete this lesson, you will be able to describe six common types of gears used in industrial facilities.

➢ Describe spur gears
➢ Describe helical gears
➢ Describe bevel gears
➢ Describe hypoid gears
➢ Describe worm gears
➢ Describe non-circular gears

205-03 Maintaining Gear Drives
When you complete this lesson, you will be able to analyze and troubleshoot common gear drive problems. You will also be able to explain factors affecting gear backlash and proper gear lubrication.

➢ Describe gear maintenance troubleshooting tips
➢ Explain factors affecting gear backlash
➢ Describe ways to measure and control backlash in gears
➢ Explain factors that influence proper lubrication of gear drives
➢ Describe various methods of lubricant application to gear drive systems
➢ Explain how to properly analyze failures in gear drives

205-04 Clutches
When you complete this lesson, you will be able to explain the purpose of clutches and identify the operating principles of common industrial clutch designs.

➢ Explain the purpose of a clutch
➢ Identify the types of mechanical clutches and their operating principles
➢ Explain the operating principles of electric clutches
➢ Identify the types of fluid clutches and their operating principles
➢ Explain the function of clutch brakes

207 Lubrication of Rotating Machinery

207-01 Lubrication Selection and Sampling in Rotating Machinery
When you complete this lesson, you will be able to describe factors that influence the selection of lubricants. In addition, you will be able to explain how to monitor the condition of lubricant.

➢ Identify lubricant additives and identify their function
➢ Describe four degrees of lubricant film protection
➢ Describe the factors that influence the selection of bearing lubrication
➢ Explain the purpose and process of lubrication sampling

207-02 Lubrication Failures and Management in Rotating Machinery
When you complete this lesson, you will be able to describe the process and the importance of good lubrication management.

➢ Describe common causes of lubrication failure
➢ Identify steps you can take to ensure proper operation of a lubricating oil system
➢ Describe the path of the oil through the components of typical oil circulating system
➢ Describe a good lubrication management program
➢ Identify some benefits of lubrication management
207-03 Lubrication Analysis in Rotating Machinery

When you complete this lesson, you will be able to discuss the characteristics of lubricants and describe how they influence use.

- Describe the typical composition of lubricants
- Define the following terms:
  - Friction
  - Static friction
  - Limiting friction
- Describe the following characteristics of a lubricant:
  - Viscosity
  - Flash point
  - Fire point
  - Pour point
- Identify the effect of temperature on viscosity
- Describe the characteristics of greases
- List the four main factors that influence lubricant selection

208 Piping and Tubing

208-01 Pipe Connections and Symbols

When you complete this lesson, you will be able to describe the methods most commonly used to connect lengths of piping, and identify advantages and disadvantages of each. You will be able to recognize symbols commonly used to indicate types of pipes, pipe-fittings, and welding connections.

- Discuss the use of threaded piping connections
- List and describe different types of threaded fittings
- Describe flanged piping connections
- Explain the use of gaskets in piping connections
- Describe welded piping connections
- Identify welding symbols used for pipe-fitting
- Identify line symbols used in pipe-fitting
- Describe how pipe-fitting symbols can represent the:
  - Size of a pipe
  - Method of branching and coupling
  - Purpose for which the pipe will be used

208-03 Piping Construction and Sizing

When you complete this lesson, you will be able to discuss the materials, sizing methods, and construction techniques used in the construction of pipe systems in industrial facilities.

- Identify commonly used piping materials
- Describe systems that classify the wall thickness of pipe
- Explain variations in piping’s inside and outside diameters
- List the two main pipe construction techniques

208-04 Piping Expansion, Support, and Insulation

When you complete this lesson, you will be able to explain the effects of changing temperatures on industrial piping and describe ways to allow for those effects.

- Describe how temperature change affects piping
- Identify methods used to manage expansion
- Describe various methods of supporting pipes
- Identify the reasons for insulating piping
- Describe materials used to insulate pipes and pipe-fittings

208-05 Piping Auxiliaries

When you complete this lesson, you will be able to describe the design and function of steam separators and traps commonly used in piping systems.

- Explain how steam separators remove moisture from piping
- Describe the purpose and operation of following types of steam traps:
  - Mechanical
  - Thermostatic
  - Thermodynamic
- Explain proper steam trap installation
- Define water hammer and discuss its consequences

208-06 Tubing Types and Applications

When you complete this lesson, you will be able to describe the design and function of tubing. In addition, you will be able to apply criteria to appropriately select tubing for various common applications.

- List some differences between piping and tubing
- Describe some advantages of tubing
- List types of materials used in the manufacture of tubing
- Discuss some applications for common types of tubing
- Identify factors considered when choosing tubing for an application
- Explain how to properly handle tubing

208-07 Tube Fittings and Connection Methods

When you complete this lesson, you will be able to describe various methods to properly cut and join tubing segments.

- Compare the use of a tube cutter and a hacksaw to cut tubing
- Identify methods to remove burrs from tubing cuts
- Describe different types of tube fittings and their materials of construction
- Explain how to perform each of the following activities:
  - Flare tubing
  - Use compression fittings
  - Solder tube and fitting joints
  - Bead a tube
208-08 Tube and Conduit Bending
When you complete this lesson, you will be able to describe how to properly bend tubing and conduit into a variety of angles and offsets.
- Describe tube bending tools
- Explain how to properly bend small metal tubing
- Define conduit bending terms
- Describe conduit bending tools
- Explain how to make each of the following conduit bends:
  - Stub-up bends
  - Back-to-back bends
  - Offset bends
  - Three point saddle bends
  - Four point saddle bends

209 Shaft Alignment

209-01 Couplings
When you complete this lesson, you will be able to identify different styles of couplings and how to maintain them.
- Recall the purpose of couplings
- Identify the relationship of torque and speed as it relates to couplings
- Identify the various types of couplings
- Describe coupling maintenance procedures

209-03 Pre-Alignment Procedures
When you complete this lesson, you will be able to identify industry standard pre-checks, types of couplings, and types of misalignment.
- Identify various types of couplings
- Describe types of misalignment
- Recall industry standard pre-alignment inspections

209-04 Rough Alignment
When you complete this lesson, you will be able to identify the planes, tools, and criteria necessary to perform a rough alignment.
- Recall the rough alignment basics
- Identify the tools required for a rough alignment
- Recall the planes of the rough alignment

209-05 Mathematical Rim-and-Face Alignment
When you complete this lesson, you will be able to identify the methods of performing a mathematical rim-and-face alignment and the types of misalignment identifiable and correctable by this method.
- Identify types of misalignment
- Recall steps for the mathematical method of rim-and-face alignment
- Recall the advantages of the rim-and-face alignment method

209-06 Graphical Rim-and-Face Alignment
When you complete this lesson, you will be able to recall the graphical method of performing rim-and-face alignment and the types of misalignment identifiable and correctable by this method.
- Identify types of misalignment
- Recall steps for the graphical method of rim-and-face alignment
- Recall the advantages of the rim-and-face alignment method

209-07 Reverse Dial Alignment
When you complete this lesson, you will be able to recall the theories and types of equipment associated with a reverse dial alignment.
- Identify the fundamentals of the reverse dial alignment process
- Identify how reverse dial equipment functions
- Recall steps for preparing for reverse dial alignment
- Recall the fundamentals of the graphing method of reverse dial alignment

209-09 Laser Alignment
When you complete this lesson, you will be able to understand the theory, and equipment associated with laser alignment.
- Recall laser alignment theory
- Recall steps for mounting the laser alignment sensors
- Describe how the laser alignment system operates
- Recall steps for laser beam adjustment
- Describe how to take measurements with the laser alignment system
- Describe how to correct misalignment with the laser alignment system

211 Chain Drive Maintenance

211-01 Introduction to Chain Drives
When you complete this lesson, you will be able to describe the design and function of typical chain drive systems.
- Explain the principles behind chain drive operations
- Define common terminology used when working with chain drives
- Compare the advantages and disadvantages of chain drives to those of other drive systems
- List the common types of chains and sprockets used in chain drive systems
211-02 Chain Drive Maintenance and Troubleshooting

When you complete this lesson, you will be able to describe techniques for maintaining and troubleshooting chain drive systems in industrial facilities.

- Describe methods for determining appropriate chain length
- Describe procedures for proper installation of chains and sprockets
- List the four most common methods of chain lubrication
- Explain what to look for when inspecting chains and sprockets for wear
- Describe techniques for troubleshooting chain drive systems

213 Lubrication

213-01 Lubrication Basics

When you complete this lesson, you will be able to explain how lubrication is used in machinery to reduce friction. In addition, you will be able to explain why certain types of equipment require lubricants with specific viscosities.

- Define friction and describe the following types of friction:
  - Static friction
  - Solid friction
  - Sliding friction
  - Rolling friction
  - Fluid friction
- Explain the relationship between friction and lubrication
- Describe three key roles of a lubricant in an operating piece of equipment
- Identify the three basic categories of lubricants and give an example of each
- Define viscosity

213-02 Types of Lubricants

When you complete this lesson, you will be able to describe the factors you must take into consideration when selecting a lubricant for a specific piece of equipment. In addition, you will be able to identify different viscosity grades and explain what each grade represents.

- Describe the importance of base oil viscosity when selecting a grease
- Discuss additives and explain how they impact grease selection
- Recall organizations with common viscosity grading systems
- Identify common types of oil lubrication methods

213-03 Lubrication Sampling and Analysis

When you complete this lesson, you will be able to explain the importance of lubrication sampling and describe basic techniques used to collect lubricant samples. In addition, you will be able to explain how to use lubrication schedules to ensure completion of proper preventative maintenance.

- List four benefits of frequent lubricant sampling
- Describe the basic procedure for taking a lubrication sample
- Explain the purpose of sample labels
- Identify four things that commonly contaminate lubricants
- Describe five tasks you must perform when inspecting a lubricant
- List six basic tests that can be performed on an oil sample

213-04 Lubrication Filtration and Purification

When you complete this lesson, you will be able to explain how to use mechanical filters and lube oil purifiers to keep lubricating oil free of contaminants. In addition, you will be able to describe methods used to filter and purify lubricating oil in a power plant.

- Identify the two most common types of lube oil contamination found in power plant lubricating oil systems
- Explain the effect contamination has on the lubricating oil and the equipment it serves
- Describe how mechanical filtration removes contaminants from lubricating oil systems
- Discuss the basic procedure for cleaning a permanent, in-line filter
- Explain how each of the following oil purification methods removes contaminants from lubricating oil:
  - Centrifugal purification
  - Coalescence purification
  - Vacuum dehydration

213-05 Lubrication Delivery Methods and Systems

When you complete this lesson, you will be able to describe common lubricant delivery methods and systems.

- Discuss common lubrication delivery methods and systems
- Explain manual lubrication application methods
- Explain automatic feed lubrication systems
- Identify gravity fed lubrication systems
- Identify reservoir fed lubrication systems
- Identify controlled feed lubrication systems
- Identify controlled feed lubrication methods
215 Valve Selection and Maintenance

215-01 Introduction to Valves and Their Components

When you complete this lesson, you will be able to explain the basic design and function of valves, major valve components, and flow control elements.

➢ Discuss the overall purposes served by valves in a system or process
➢ Illustrate various valve types and highlight their differences
➢ Explain how valve stem leakage is controlled
➢ Describe the operation of root and throttle valves
➢ Identify the following valve components:
  o Body
  o Bonnet
  o Stem
  o Actuator
  o Packing
  o Seat
  o Disk
➢ Identify common valve markings and their meanings

215-02 Valve Actuators

When you complete this lesson, you will be able to discuss the use, selection, and design of various actuators, from simple manual hand-wheels to relatively complex electrical and hydraulic manipulators.

➢ Describe the construction and principle of operation for the following types of valve actuators:
  o Manual
  o Electric motor
  o Pneumatic
  o Hydraulic
  o Solenoid
➢ Identify several types of valve position indicators

215-03 Gate Valves

When you complete this lesson, you will be able to explain the use, selection, and design of a gate valve. You will also be able to describe how different service conditions affect gate valve configuration.

➢ Discuss the operation of a gate valve
➢ Discuss some advantages and disadvantages of a gate valve
➢ List various gate valve disk configurations and identify the conditions under which they are used
➢ Describe different gate valve stem and valve seat designs

215-04 Globe Valves

When you complete this lesson, you will be able to describe the use, selection, and design of globe valves.

➢ Explain the operation of a globe valve
➢ Describe the three primary body designs
➢ Describe the three basic disk designs used in globe valves
➢ Discuss the advantages and disadvantages of these designs
➢ Explain how the disk and stems are attached in globe valves
➢ Describe seating arrangements and direction of flow through globe valves

215-05 Butterfly Valves

When you complete this lesson, you will be able to explain the use, selection, and design of typical butterfly valves found in industrial applications.

➢ Describe the operation of a butterfly valve
➢ Compare the butterfly valve to other valve types, and list its advantages
➢ Describe the seat and body construction of a typical butterfly valve
➢ Explain the types of disk and stem assemblies available on a butterfly valve

215-06 Ball Valves

When you complete this lesson, you will be able to explain the use, selection, and design of ball valves found in industrial applications.

➢ Describe the operation of a ball valve
➢ Identify the ball valve’s advantages and disadvantages
➢ List the four common ball valve port designs
➢ List the four general ball valve body styles
➢ Explain the significance of valve handle positions on a ball valve

215-07 Check Valves

When you complete this lesson, you will be able to explain the use, selection, and design of check valves found in industrial applications.

➢ Discuss the operation of check valves
➢ Describe the construction of each of the following types of check valves:
  o Swing
  o Tilting disk
  o Lift
  o Piston
  o Butterfly
  o Stop
215-08 Needle Valves
When you complete this lesson, you will be able to describe the use, selection, and design of a needle valve.
➢ Explain the operation of a needle valve
➢ Describe the construction of a needle valve
➢ Describe a needle valve’s body design and discuss how it contributes to its function

215-09 Plug Valves
When you complete this lesson, you will be able to describe the use, selection, and design of plug valves commonly found in industrial settings.
➢ Describe the operation of a plug valve and identify its advantages
➢ List the types of plug valve port designs available
➢ Identify the advantages and disadvantages of multi-port plug valves
➢ Discuss the use of lubricated and non-lubricated plug valve design
➢ Explain proper care of a plug valve gland

215-10 Diaphragm Valves
When you complete this lesson, you will be able to describe the use, selection, and design of the two basic types of diaphragm valves.
➢ Discuss the operation of a diaphragm valve
➢ Describe the construction of the diaphragm
➢ Explain the uses of different diaphragm valve stem assemblies
➢ Describe the diaphragm valve’s bonnet assembly

215-11 Pinch Valves
When you complete this lesson, you will be able to describe the use, selection, and design of pinch valves.
➢ Discuss the operation of pinch valves
➢ Explain how a pinch valve’s construction facilitates its function
➢ Identify applications where pinch valves operate most effectively

215-12 Safety and Relief Valves
When you complete this lesson, you will be able to describe the use, selection, and design of safety valves and relief valves.
➢ Describe the major difference between safety valves and relief valves
➢ Explain the principle of operation behind a safety valve
➢ Explain the principle of operation behind a pilot operated safety valve
➢ Explain the principle of operation behind a relief valve
➢ Describe the use of a pilot operated relief valve

215-13 Solenoid Valves
When you complete this lesson, you will be able to describe the overall design and function of various solenoid valves.
➢ Explain the basic principle behind the operation of a solenoid
➢ Identify the components of a solenoid valve
➢ Describe solenoid valve operation
➢ Compare tape-wrapped and encapsulated coil designs
➢ Define the terms “normally open” and “normally closed” as they relate to solenoid valves
➢ Explain the difference between two-way and three-way solenoid valves

215-14 Valve Positioners
When you complete this lesson, you will be able to describe the basic design and function of common types of valve positioners used in industrial facilities.
➢ Identify common tasks that might prompt the use of valve positioners
➢ Describe various types of positioners
➢ Compare basic operation of the three categories of digital positioners
➢ Explain how a pneumatic positioner works
➢ Describe the operation of an electro-pneumatic positioner

215-15 Pressure Regulator Valves
When you complete this lesson, you will be able to describe the basic design and function of common types of pressure regulating valves used in industrial facilities.
➢ Identify basic characteristics of pressure regulating valves
➢ Describe the basic operation of self-operating/pilot valves
➢ Describe the basic operation of direct control valves
➢ Describe the basic operation of fluid pressure regulating valves
219 Centrifugal Pumps

219-01 Introduction to Centrifugal Pumps
When you complete this lesson, you will be able describe the principle behind centrifugal pump construction and state the basic design and function of both single stage and multi-stage centrifugal pumps.

- Describe the principle behind the operation of a centrifugal pump
- Identify the basic components that comprise a single stage centrifugal pump
- State the difference between a radially split and axially split centrifugal pump design
- Explain the difference between single-suction and double-suction centrifugal pumps
- Describe what is meant by a multi-stage centrifugal pump

219-02 Centrifugal Pump Design
When you complete this lesson, you will be able to describe centrifugal pump designs and explain the role design plays in matching a pump to a process application.

- Explain the design of a volute pump casing
- Identify when diffuser rings are employed and describe where a volute would apply when diffuser rings are also employed
- State the difference between a solid casing and a split casing
- Describe the difference between an axially split and radially split casing
- List three primary purposes of a pump casing
- Identify four ways impellers can be classified
- State the purpose of a thrust bearing on a centrifugal pump
- State the purpose of a mechanical seal on a centrifugal pump

219-03 Centrifugal Pump Fundamentals
When you complete this lesson, you will be able to use appropriate terminology when discussing the selection and operation of centrifugal pumps.

- Define the following terms:
  - Static head
  - Suction head
  - Discharge head
  - Friction head
- Explain what is meant by the phrase "suction lift"
- Describe the relationship between head pressure and pump capacity
- Define net positive suction head
- Describe the relationship between pump cavitation and net positive suction head

219-04 Centrifugal Pump Operation and Maintenance, Part 1
When you complete this lesson, you will be able describe the basic start-up procedures used on single and multi-stage centrifugal pumps. In addition, you will be able to explain the basic inspctions to be completed on operating centrifugal pumps during each shift.

- Identify basic pre-start checks and inspections to complete prior to starting a centrifugal pump
- Discuss additional checks required for large, multi-stage centrifugal pumps
- Describe what is meant by the phrase "priming a pump"
- State inspections conducted on an operating centrifugal pump
- Define the term “air bound pump” in reference to a centrifugal pump

219-05 Centrifugal Pump Operations and Maintenance, Part 2
When you complete this lesson, you will be able to Identify different types of pumps, recall pump operations and maintenance items, identify predictive maintenance concepts, and recall common pump operating problems.

- Identify types of pumps
- Recall best practices for pump maintenance
- Identify predictive/preventative maintenance items
- Recall common operating problems

219-08 Impellers and Wear Rings
When you complete this lesson, you will be able to describe the principles behind centrifugal pump mechanical impellers, pump stages, fluid flow paths, and basic information regarding wear rings.

- Describe the fundamentals of an impeller
- Identify the difference between single and multi-stage pumps
- State the difference between mechanical impeller types
- Explain the difference between single-suction and double-suction from modes
- Identify types of wear rings

219-10 Pump Troubleshooting
When you complete this lesson, you will be able to describe basic pump troubleshooting and identify pump visual, audible, and tangible symptoms of equipment malfunction.

- Recall fundamentals in pump troubleshooting
- Identify visual symptoms
- Identify audible symptoms
- Identify tangible symptoms

219-12 Pump Internal Inspection and Troubleshooting
When you complete this lesson, you will be able to describe an internal inspection of a centrifugal pump and identify unsatisfactory component conditions.

- Describe when a pump must be internally inspected
- Identify internal pump component inspectable items
223 Heat Exchangers

223-01 Heat Exchanger Theory
When you complete this lesson, you will be able to explain how heat is transferred from one substance to another via the use of heat exchangers. In addition, you will be able to describe the basic differences between heat exchangers and their supporting equipment.

- Describe how heat exchangers transfer heat from one substance to another
- Define conductivity and explain its relationship to heat exchanger design
- Define convection and explain its relationship to heat exchanger design
- Identify different heat exchanger designs and how they function
- Recall necessary supporting equipment for a heat exchanger

223-02 Open Heat Exchanger Design and Operation
When you complete this lesson, you will be able to explain how open heat exchangers use direct contact to heat condensate and remove non-condensable gases from the condensate. In addition, you will be able to describe the three basic types of open heat exchangers and the operational characteristics of each.

- Describe the operation of open heat exchangers
- Recall the purposes of a deaerator
- Identify the location of a deaerator in a typical condensate system
- Describe the operational characteristics of each of the following types of deaerators:
  - Spray-type
  - Tray-type
  - Spray-and-tray-type
- Recall the purpose of a venting orifice on a deaerator
- Describe the function of pegging steam, and explain how it is used during deaerator start-up and shutdown
- Explain the relationship between the DA storage tank and the net positive suction head to the boiler feed pumps

223-03 Closed Heat Exchangers
When you complete this lesson, you will be able to identify the difference between single and multi-pass heat exchangers, the components of a typical closed heat exchanger, flow types, and common maintenance and troubleshooting procedures.

225 Compressors

225-01 Plant Compressed Air Systems
When you complete this lesson, you will be able to describe the basic classifications of air compressors used in industrial facilities. In addition, you will be able to explain the operation of service air and control air systems.

- Define air compressor
- Recall the primary difference between the two basic categories of air compressors
- Give four examples of prime movers used to power a compressor
- Describe the purposes of the service air and control air systems, and identify examples of equipment powered by each
- Define the term ‘air quality’ with regard to a compressed air system
- Describe the relationship between temperature, pressure, and volume in a compressed air system
- Explain the benefit of a staged compression system

225-02 Compressed Air System Components
When you complete this lesson, you will be able to describe the basic components that make up a typical compressed air system. In addition, you will be able to explain some basic troubleshooting techniques used to detect problems in compressed air systems.

- Describe the purpose and design of an intercooler on a multi-stage air compressor
- Describe the purpose and design of an aftercooler
- Identify the three basic categories of air purifiers
- Compare the action of a refrigerant dryer unit to a desiccant dryer unit
- Explain how ultrasonic analyzers and vibration analyzers can be used to diagnose problems in compressed air systems

225-03 Positive Displacement Compressors
When you complete this lesson, you will be able to explain the basic design and operation of positive displacement air compressors, including both the reciprocating and rotary types.

- Describe a positive displacement air compressor
- Identify the basic design characteristics
- Recall the operation of a reciprocating air compressor
- Explain the operation of the following types of rotary air compressors:
  - Screw type
  - Lobe type
  - Vane type
225-04 Dynamic Compressors
When you complete this lesson, you will be able to describe the basic design and operation of dynamic air compressors, including both centrifugal and axial types.
- List the basic operational characteristics of dynamic air compressors
- Describe the basic design and operation of a centrifugal air compressor
- Identify the difference between a single stage and multistage centrifugal air compressor
- Explain the minimum requirements of the basic start-up procedure used to put a dynamic air compressor in service
- Describe the basic design and operation of an axial air compressor

225-06 Axial Compressor Control Schemes
When you complete this lesson, you will be able to recall the fundamentals of axial compressor control, control system selection, surge control components, and surge control and avoidance.
- Recall fundamentals of axial compressor control
- Describe axial compressor control system selections
- Identify axial compressor surge control components
- Recall fundamentals of axial compressor surge control and avoidance

229 Fasteners and Seals

229-01 Bolted Joints
When you complete this lesson, you will be able to describe commonly used bolt types and grades and discuss their proper use. You will be able to list common modes of joint failure and identify some preventive measures.
- Identify and describe commonly used types of bolts
- Explain proper tightening of flange bolts
- Define bolt preload and discuss methods of controlling the preload of a fastener
- Describe how to identify the grade of a bolt
- Describe failure modes of bolted connections
- Define locking mechanisms used on fasteners

229-02 O-Rings
When you complete this lesson, you will be able to describe the design and purpose of O-rings. You will also be able to discuss how to use them successfully.
- Describe the function of an O-ring
- Explain the sealing of an O-ring
- Describe the two main types of O-ring sealing applications
- List some considerations when using an O-ring in a vacuum sealing application
- Identify various materials used in the production of O-rings
- Discuss common failure modes and troubleshooting these failures
- Describe proper techniques for installing and caring for O-rings

225-03 Making Gaskets
When you complete this lesson, you will be able to describe different types of gaskets and explain common methods for making gaskets from stock materials.
- Identify different gasket materials and describe conditions for their use
- List the three flange face types generally available
- Describe three common methods for making gaskets
- Explain methods for locating bolt holes on gaskets
- Explain the proper use of a gasket cutter

229-03 Making Gaskets

229-04 Fasteners
When you have completed this lesson, you will be able to describe the design and identify the purpose of various types of fasteners used in industrial facilities.
- Define the purpose of a fastener
- Identify and describe various types of each of the following:
  - Screws
  - Bolts
  - Nuts
  - Washers
  - Fastener head designs
  - Nails
  - Retaining rings
  - Rivets

229-05 Packing Material Use and Installation
When you complete this lesson, you will be able to describe what packing is and identify common packing designs, components, and construction. In addition, you will be able to explain general procedures for installation and removal of packing from pumps and valves.
- Discuss the need for pump and valve packing
- Identify types of packing and explain variables considered in packing selection
- Describe components of packing glands
- Explain typical procedures for removal of pump and valve packing
- Explain typical installation procedures for pump and valve packing

229-06 Mechanical Seals Use and Installation
When you complete this lesson, you will be able to describe how mechanical seals work and identify the features of commonly used seal types. In addition, you will be able to explain proper seal care.
- Describe the operation of mechanical seals
- Recall some advantages and disadvantages of mechanical seals
- Describe a typical stationary mechanical seal
- Describe a typical rotating mechanical seal
- Identify the difference between a balanced and an unbalanced mechanical seal
- Describe some ways to properly care for mechanical seals
- Identify some common causes of mechanical seal leakage
- Explain the steps typically employed to install and remove mechanical seals
231 Positive Displacement Pumps

231-01 Introduction to Positive Displacement Pumps

When you complete this lesson, you will be able to describe the basic design and operation of positive displacement pumps and identify operating conditions under which they are commonly implemented. Additionally, you will be able to discuss the operational differences between the two main classes of positive displacement pumps, which are reciprocating and rotary.

➢ Discuss the operating principle behind positive displacement pumps
➢ State three operating conditions under which a positive displacement pump would best be employed
➢ Identify the basic components of a positive displacement pump
➢ Discuss the difference between the basic operations of reciprocating and rotary positive displacement pump categories

231-02 Reciprocating Positive Displacement Pumps

When you complete this lesson, you will be able to describe the design and function of reciprocating positive displacement pumps commonly used in industry.

➢ Describe the operating characteristics of piston and plunger reciprocating pumps
➢ Identify the difference between single-acting and double-acting reciprocating positive displacement pumps
➢ Discuss the operation of each of the following types of reciprocating pump configurations:
  o Simplex
  o Duplex
  o Multiplex
➢ Describe the basic operating characteristics of a reciprocating diaphragm pump

231-03 Rotary Positive Displacement Pumps

When you complete this lesson, you will be able to describe the design and operation of rotary positive displacement pumps commonly used in industry.

➢ Describe the operating characteristics of rotary positive displacement pumps
➢ Identify the primary difference between an internal rotary gear pump and external rotary gear pump
➢ Describe the design and operation of each of the following types of rotary pumps:
  o Screw pumps
  o Vane pumps
  o Lobe pumps
➢ Explain the purpose of a metering pump

243 Hydraulics

243-01 Introduction to Hydraulics

When you complete this lesson, you will be able to describe the basic components that comprise a typical hydraulic circuit and explain the function of each. In addition, you will be able to explain the use of hydraulic multiplication to increase the capacity of the hydraulic system.

➢ Describe the basic principle of hydraulics
➢ Explain the effect air can have on hydraulic systems
➢ Identify five components common to most hydraulic systems
➢ Describe two key considerations that must be taken into account when selecting a hydraulic pump
➢ Identify the two most common types of hydraulic circuits

243-02 Hydraulic Systems

When you complete this lesson, you will be able to identify and describe the purpose of the various components used in hydraulic circuits. In addition, you will be able to describe the components used to control flow through a hydraulic circuit.

➢ Describe four purposes the reservoir serves in a hydraulic circuit
➢ Identify the three most common types of pumps used in hydraulic circuits
➢ Explain the purpose control valves serve in a hydraulic circuit
➢ Describe the basic operation of a directional control valve
➢ Describe the purpose of the actuator in a hydraulic circuit

243-03 Hydraulic Fluids

When you complete this lesson, you will be able to identify the three basic types of hydraulic fluids. In addition, you will be able to describe some of the considerations that need to be taken into account when selecting a hydraulic fluid for a specific hydraulic circuit.

➢ Define hydraulic fluids
➢ Identify the three basic categories of hydraulic fluids
➢ Identify the most important factor to consider when selecting a hydraulic fluid for a specific hydraulic circuit
➢ Discuss the difference between mono-grades and multi-grades
➢ Describe the three major causes of hydraulic fluid contamination
271 Vibration

271-01 Vibration Introduction

When you complete this lesson, you will be able to define basic terms and measurement units associated with vibration. You will also be able to describe the relationship between a machine’s operating speed and vibration problems.

➢ Explain the relationship between excitation and vibration
➢ Describe the time and frequency domains of vibration measurement
➢ Describe the three basic measurements for vibration amplitude:
  o Displacement
  o Velocity
  o Acceleration
➢ Identify the mathematical relationship between those three attributes and give reasons for measuring each
➢ Describe the relationship between a machine’s rotational speed expressed in revolutions per minute (rpm) and cycles per minute (cpm)
➢ Explain the relationship between machine rpm and orders

271-02 Vibration Causes and Characteristics

When you complete this lesson, you will be able to describe the characteristics of common, vibration-causing mechanical faults.

➢ Discuss the common characteristics of a machine vibrating due to misalignment
➢ Identify the signs of an unbalanced machine
➢ Recognize the characteristics of vibration caused by:
  o Mechanical looseness
  o A faulty bearing
  o A faulty gear or belt
  o An electrical fault
➢ Recognize the vibration characteristics exhibited by a machine experiencing oil whirl

271-04 Plant Vibration Program

When you complete this lesson, you will be able to describe a typical plant’s vibration program and discuss how it contributes to the plant’s operational readiness.

➢ Describe the components of a typical vibration database
➢ Explain why some equipment has permanently installed vibration equipment and describe how that equipment works
➢ Describe how periodic vibration data collection with portable equipment fits into a plant’s vibration program
➢ Identify the difference between vibration warnings and alarms, and discuss appropriate responses
➢ Identify groups typically involved in a plant vibration program and describe their roles

273 Boiler Repair

273-01 Boiler Tube Repair

When you complete this lesson, you will be able to describe different types of tube assemblies which may need repair in a boiler. You will be able to list common causes of these leaks and procedures for repairing the tube and tube assemblies.

➢ Describe different types of boiler tube assemblies
➢ List causes of tube leaks and ruptures
➢ Explain the procedure for repairing a ruptured tube by closing
➢ Explain the procedure for cladding or shielding a damaged boiler tube
➢ Explain the procedure for replacing a damaged section of a tube or tube assembly
➢ Explain the procedure for repairing a boiler tube using replacement window

273-02 Inspecting the Fireside of a Boiler, Part 1

When you complete this lesson, you will be able to explain some specific items to look for when doing a fireside inspection on the watertubes of a large watertube boiler.

➢ Describe how to inspect the fireside of the boiler waterwalls for support failures
➢ Describe how to inspect the fireside of the boiler waterwalls for refractory failures and clinker damage
➢ Describe how to inspect the fireside of the boiler waterwalls for tube erosion and corrosion
➢ Describe how to inspect the fireside of the boiler waterwalls for tube overheating
➢ Describe how to inspect the fireside of the boiler waterwalls for ash accumulations
➢ Describe how to inspect the fireside of the boiler waterwalls for weld failures
➢ Describe how to inspect the burner openings, air ports, and inspection doors on the fireside of the boiler
➢ Describe some ways used to determine tube thickness on the waterwalls of a boiler

273-03 Inspecting the Fireside of a Boiler, Part 2

When you complete this lesson, you will be able to explain some specific things to look for when doing a fireside inspection on the superheaters, reheaters, economizers, ash hoppers, baffles, sootblowers, and the boiler bottom seal on the fireside of a large watertube boiler.
➢ Describe how to inspect the fireside of a superheater in a large watertube boiler
➢ Describe how to inspect the fireside of a reheater in a large watertube boiler
➢ Describe how to inspect a bottom ash hopper in a large watertube boiler
➢ Describe how to inspect the fireside of an economizer in a large watertube boiler
➢ Describe how to inspect baffles on the fireside of a large watertube boiler
➢ Describe how to inspect the boiler bottom seal in a large watertube boiler

273-04 Inspecting the Waterside of a Boiler
When you complete this lesson you will be able to identify unacceptable conditions when performing a water side inspection on steam drums, moisture separators, headers and tubes of a large water-tube boiler.

➢ Describe how to inspect on a large water-tube boiler:
  o The water side of the steam drum
  o Moisture separators of a large water-tube boiler
➢ Identify facts pertaining to how to inspect on a large water-tube boiler:
  o Headers
  o Tubes

273-05 Inspecting a Boiler’s Exterior
When you complete this lesson, you will be able to describe some specific areas to look at, and what to look for when inspecting the exterior of a large watertube boiler.

➢ Describe inspection techniques for the boiler casing
➢ Describe inspection techniques for the steam drum
➢ Describe inspection techniques for safety valves
➢ Describe inspection techniques for downcomers and pumps
➢ Describe inspection techniques around casing stiffeners and intrusions

273-06 Waterside and Fireside Cleaning of Boiler
When you complete this lesson, you will be able to explain some methods and procedures for cleaning and testing the waterside and fireside of a large watertube boiler.

➢ Recall how to perform a chemical cleaning procedure to clean the waterside of a large watertube boiler
➢ Recall how to use a hydrostatic testing procedure to test for leaks in a large watertube boiler
➢ Recall how to use a compressed air testing procedure to test for leaks in a large watertube boiler
➢ Define what a fireside cleaning of a large watertube boiler entails
➢ Recall how to close a boiler after fireside cleaning
➢ Recall how to pressurize a boiler and check for leaks after a fireside cleaning
When you complete this lesson, you will be able to recognize and understand the process and purpose of designing an electrical power distribution system.

- Identify the most common sources of electric power generation
- Identify the purpose of electrical distribution system design
- Identify the key principles of electrical distribution system design
- Identify the elements comprising a load area
- Identify the technologies considered in electrical distribution system design
- Identify the goals of electrical distribution system design
- Identify the organizations regulating the standards for electrical distribution systems
- Identify the most common voltage systems
- Recognize common Electrical Distribution System types and common components

301-03 Primary and Secondary Distribution Systems

When you complete this lesson, you will be able to describe primary and secondary distribution systems, including common system designs. In addition, you will be able to discuss the benefits of these network systems and have the knowledge to create a riser diagram.

- Recall the history of network distribution systems
- Recognize the difference between two and one breaker system designs
- Identify the function of a primary distribution system
- Identify the function of a secondary distribution system
- Recognize the benefits related to network distribution systems
- Identify the common types of system design
- Identify the stages of system design

301-04 Distribution System Components and Application

When you complete this lesson, you will be able to explain the common components of a distribution system. In addition, you will be able to describe the role of the substation and its common components.

- Recognize distribution system components
- Identify the common configuration, function, and elements of a simple distribution system
- Identify primary supply line applications
- Recognize the relationship between transmission, subtransmission, and primary distribution
- Identify the role of the substation
- Identify the considerations of branch lateral design
- Recognize the differences in overhead and underground component configuration
301-05 Characteristics of Distribution Switchgear
When you complete this lesson, you will be able to identify various types of electrical switchgear encountered in common distribution systems. In addition, you will understand how to effectively make modifications to system designs by combining and replacing switchgear applications.

- Recognize the impact of switching operations in distribution system safety
- Identify the common types of switchgear
- Identify the function of disconnect equipment
- Identify common applications of switchgear
- Identify the purpose of a fused switch disconnect
- Recognize the fundamental elements of circuit breakers serving as switchgear

301-06 Load Characteristics and Management
When you complete this lesson, you will be able to discuss characteristics common to load area demand. In addition, you will understand how to utilize load and load-duration curves to assist in balancing of interchange scheduling and conducting time error correction.

- Identify the common terms associated with load characteristics
- List the categories of load demand areas
- Explain the difference between kVA and kW
- Identify the characteristics of a load demand area
- Explain how different load demand areas affect the total system
- Explain the purpose of a load curve
- Draw and label a load curve
- Explain the purpose of a load-duration curve
- Draw and label a load-duration curve
- Explain the function of the load and load-duration curves
- List the four contributing factors of demand deviation
- Conduct a load forecasting exercise
- Define power factor correction
- List the formulas used to calculate load growth
- Demonstrate the ability to complete a load curve model
- Demonstrate the ability to assist with a power factor correction

301-07 Principles of Revenue Metering
When you complete this lesson, you will be able to understand the principles of revenue metering and how they affect the provider and customer relationship.

- Define common terminology related to utility revenue metering
- Identify general requirements regarding reliability, accuracy, and documentation to ensure accurate revenue metering
- Recognize detailed requirements regarding meters, instrument transformers, and data transmission subsystems
- Identify the responsibilities for installation, calibration, and maintenance of revenue meters
- Identify revenue data and meter authority requirements

301-08 Single and Poly-Phase Metering
When you complete this lesson, you will be able to discuss single and poly-phase specific meters including meter constants. In addition, you will be able to describe the process for meter reading, testing, and calibration.

- State the purpose of the watt-hour meter
- List the units of measurement used in revenue metering
- Identify the electrical and mechanical principles of meter operation
- Explain meter constants and their purpose
- State the differences in single and three phase construction
- Explain Blondel’s Theorem
- Explain the purpose of calibrating single and poly-phase meters
- Explain the difference between as-found and as-left information
- Demonstrate inspection and maintenance procedures for single-phase and poly-phase meters
- Explain the process of calibrating a single phase meter
- Explain the process of calibrating a poly-phase meter
- Identify the function of a solid-state digital meter
- Explain the purpose of the rotating standard
- Locate requirements pertaining to use of a rotating standard
- Perform a digital meter calculation
- Demonstrate applications for load profile data
345 Introduction to NERC

345-01 NERC Overview and Application for Generator Operators
When you complete this lesson, you will be able to identify the requirements and standards associated with NERC accountable non-system operator Generator Operators.
➢ Identify the purpose of NERC and the role of a GOP
➢ Identify BAL standards applicable to the GOP
➢ Identify COM standards applicable to the GOP
➢ Identify CIP standards applicable to the GOP
➢ Identify EOP standards applicable to the GOP
➢ Identify IRO standards applicable to the GOP
➢ Identify PRC standards applicable to the GOP
➢ Identify TOP standards applicable to the GOP
➢ Identify VAR standards applicable to the GOP

345-02 NERC Overview
When you complete this lesson, you will be able to recall the history, purpose, and key roles in the NERC System Operations realm.
➢ Recall the history and structure of NERC
➢ Recognize Real-Time Functional Entity tasks and responsibilities
➢ Identify NERC standards common to the Real-Time horizon

350 System Protection

350-01 Elements of System Protection
When you complete this lesson you will understand the basic principles of system protection. Additionally, you will understand the basic equipment and methods deployed to realize protection principles.
➢ Identify the philosophy and objectives of system protection
➢ Recall zones of protection
➢ Identify the importance of protection coordination
➢ Identify the three different levels of backup protection
➢ Recall different types of breaker construction
➢ Recall the function of a basic relay protection schematic
➢ Identify the basic functions of commonly used relays

350-02 Types of Protective Relays
When you complete this lesson you will understand the basic operating principles of common protective relays and how they are employed in protection systems.
➢ Recall the purpose of relay protection schemes
➢ Identify the eight types of transmission circuits subject to relay loadability
➢ Identify the five types of generation facilities subject to relay loadability
➢ Recall the evolution of relay design
➢ List the three major types of relay construction and explain how they differ
➢ Identify the conditions causing the basic operation of instantaneous relays
➢ Identify the strengths and limitations of instantaneous relays
➢ Identify the strengths and limitations of time delay relays
➢ Identify the strengths and limitations of differential relays
➢ Recall how directionality can be obtained in an AC power system
➢ Recall how impedance is used to detect faults on the electric system
➢ Identify why overlapping zone protection is needed when using impedance relays

350-03 Monitoring System Conditions
When you complete this lesson you will understand the purpose of PRC-002-2, and how system conditions are monitored through the application of per-unit measurements, AC polarity, and basic potential transformer and current transformer construction and operation.
➢ Identify settings established in R1 through R4 of PRC-002-2
➢ Recall how the per-unit scale differs from percentage comparisons
➢ Recall how phasors and vectors are related
➢ Identify phasor application in a three phase power system
➢ Recall the phase relationship between phase to neutral and phase to ground voltage measurements
➢ List the basic components of a transformer
➢ Calculate the secondary output of a transformer given input values and turns ratio
➢ Recall the difference between VTs, PTs, and CCVTs
➢ Recall the relationship between primary and secondary current as magnetic flux reaches saturation
➢ Recall how relays are connected to PTs and CTs and how this relates to burden
350-04 Disturbance Monitoring Equipment
When you complete this lesson, you will be able to explain why DME is required, identify and apply guidelines of applicable NERC standards, recognize types and applications of common DME, and conduct accurate DME data reporting.

➢ Identify the purpose of Disturbance Monitoring Equipment (DME)
➢ Recall the two universal requirements of DME installation
➢ Identify the common types of DME
➢ Recall NERC requirements for Disturbance Monitoring and Reporting
➢ Recall NERC requirements for DME installation and Data Reporting
➢ Recall the four types of data required for a three year archive
➢ Recognize DME application with the four DME application measurements
➢ Recall the considerations of disturbance recording and analysis

350-05 Line Protection
When you complete this lesson you will understand basic power system line relay loadability and how various protection methods are applied to isolate faults on these systems.

➢ Recall the purpose of Transmission Relay Loadability
➢ Identify the applicability of PRC-023-4 to functional entities
➢ Recall the process of coordinating protection between fuses and overcurrent protection relays
➢ Recall the difference between fuse saving and fuse blowing protection schemes
➢ Identify the strengths and weaknesses of using overcurrent protection relays
➢ Identify the strengths and weaknesses of using distance relays
➢ Recall how ground fault relay settings are different between distribution and transmission systems
➢ Recall the process by which mutual induction can cause false trips in adjacent lines
➢ Define overlapping zones of protection
➢ Identify methods of protection against voltage instability
➢ Recall the difference between manual and automatic load shedding

350-06 Transformer Protection
When you complete this lesson you will understand the basic construction and protection methods commonly used in transformer protection.

➢ Recall the basic construction of a common power transformer
➢ Identify the different types of transformer faults
➢ Identify the different types of pressure protection
➢ Recall the advantages and disadvantages of using fuses, circuit switchers, and circuit breakers for overcurrent protection
➢ Recall how ground fault protection is able to distinguish between an internal and external fault
➢ Recall the basic operation of differential protection
➢ Identify the different methods used to manage inrush current
➢ Identify the conditions required in order for reactor banks to perform similar to transformers
➢ Recall how capacitor banks detect and protect against severe imbalance
➢ Identify the limitations of differential protection with phase shifting transformers

350-07 Pilot Protection
When you complete this lesson you will understand the major forms of communications channels used by pilot protection, as well as the basic functions of the more common pilot protection schemes deployed in power system protection.

➢ Recall why pilot protection systems are needed
➢ Identify the strengths and weaknesses of the major communications channels
➢ Identify which communications mediums are capable of high bandwidth data transmission
➢ Identify the differences between permissive, blocking, and direct transfer trip schemes
➢ Recall how pilot protection both manipulates and makes use of time delays
➢ Define the difference between overreaching and under-reaching schemes
350-09 Bus Protection

When you complete this lesson you will understand the six basic substation bus configurations, as well as the various relaying systems used to protect them.

- Define the basic construction types for substations
- Identify the strengths and weaknesses of the six prominent bus configurations
- Define how a fault on a bus would impact each of the six different bus configurations
- Define how backup protection can be made to respond quicker to bus faults
- Define how fault bus protection can present a hazard to personnel
- Define how CT saturation causes issues with basic differential protection
- Define how high impedance relaying mitigates CT saturation effects
- Define how linear couplers completely eliminate saturation issues

350-10 Generator Protection

When you complete this lesson you should understand generator protection schemes and NERC standards as they apply to generator protection methods and requirements.

- Identify common internal faults of generation units
- Identify reportable systems conditions of PRC-019-2
- Recall external system conditions on generation units
- Define the term Composite Protection System
- Recall applications of Composite Protection Systems
- Recall the purpose of UFLS programs
- Recall generator relay settings and loadability
- Identify common protective relay loadability schemes
- Recall the conditions of a Remedial Action Schemes

350-11 Protection System Misoperation

When you complete this lesson, you will be able to define the term Misoperation, and identify conditions registering as such.

- Identify the two aspects of protection system design
- Recall the process of developing and implementing a Corrective Action Plan (CAP)
- Identify evidence required to prove compliance with CAP procedures
- Define Responsible Entity compliance with PRC-004-5(i)
- Recall the timelines for identifying the cause of a Misoperation for compliance with PRC-004-5(i)
- Identify the facilities subject to regulation of PRC-005-6
- Define Functional Entity compliance with PRC-005-6

350-12 Protection Systems Maintenance Programs

When you complete this lesson, you will be able to identify protection system terminology and assets and comply with applicable NERC standards.

- Define basic terminology associated with protection system maintenance programs
- Recall critical considerations of Protections Systems Maintenance
- Recall the fundamentals of Protection Systems Maintenance Programs
- Identify and discuss the three types of Protection System Maintenance Programs
- Identify and discuss common Protection System Maintenance practices

375 Resource and Demand Balancing

375-01 Real Power Balancing Control Performance

When you complete this lesson, you will be able to identify the fundamentals of generation and load balance, Area Control Error (ACE) and comply with the regulations of BAL-001-2.

- Identify the fundamentals of generation and load balancing
- Identify the fundamentals of ACE
- Identify the purpose of BAL-001-2
- Describe ACE and its components
- Describe CPS1 and its components
- Describe BAAL and its components

375-02 Disturbance Control Performance

When you complete this lesson you will understand the requirements for recovery from a disturbance, what is deemed a Reportable Disturbance and how Contingency Reserves play a role in disturbance recovery.

- Recall the purpose of the Disturbance Control Standard
- Define common terms used in Disturbance Control Performance
- Identify the defining characteristic of a Reportable Disturbance
- Recall the requirements of NERC’s Disturbance Control Standard
- Identify the prevalent types of NERC’s Contingency Reserves
- Examine three case studies related to Disturbance Control Performance
375-03 Frequency Response and Bias

When you complete this lesson you will understand the requirements necessary for a Balancing Authority to be able to calculate Area Control Error and to have Automatic Generation Control that will be able to dispatch Regulating Reserves as needed.

➢ Describe the basics of Frequency Control
➢ Describe normal and abnormal Frequency Deviations
➢ Identify terminology related to frequency response activities
➢ Describe the four requirements of BAL-003-1.1
➢ Identify the elements of BAL-003-1.1 Attachment A
➢ Describe the basics of frequency deviation
➢ Describe the process of frequency deviation response

375-05 Automatic Generation Control

When you complete this lesson you will understand the requirements necessary for a Balancing Authority to be able to calculate Area Control Error and to have Automatic Generation Control that will be able to dispatch Regulating Reserves as needed.

➢ Recall the difference between primary and secondary controls
➢ Recall how Automatic Generation Control (AGC) systems operate in an isolated power system setting
➢ Identify the three AGC system control modes
➢ Identify the role of AGC systems in Balancing Authority operations
➢ Recall the requirements of NERCs Balancing Authority Control standard

376 Communications

376-01 Bulk Power System Communication Basics

When you complete this lesson, you will understand the three levels of BPS communication as they relate to the system operator.

➢ Describe the basics of BPS communication
➢ Explain the importance of fiber optic network configuration
➢ Define Interpersonal Communication and Alternative Interpersonal Communication
➢ Explain how the 11 requirements of NERC Standard COM-001-2 apply to NERC system operator positions
➢ Describe how the 11 requirements of NERC Standard COM-001-2 apply to non-system operator positions
➢ Explain communication maintenance testing schedules and requirements
➢ Explain the migration to NASPI

376-02 Bulk Power System Communications and Coordination

When you complete this lesson, you will be able to communicate clearly and concisely according to documented protocols using three-part communication and the phonetic alphabet.

➢ Identify the four principles of interpersonal communication
➢ Recall the development of interpersonal communications
➢ Recognize the importance of Operating Instructions to the BES
➢ Recall a general description of three-part communication
➢ Recognize the letter-word combinations in the phonetic alphabet
➢ Recall the phonetic alphabet when relaying information
➢ Recall the requirements of the current NERC Operating Personnel Communications Protocol Standard
➢ Conduct simulation exercises for three-part communication
➢ Demonstrate three-part communication when relaying Operating Instructions

377 Critical Infrastructure Protection

377-01 CIP Personnel Responsibilities

Upon completion of this course, you should understand Critical Infrastructure Protection (CIP) training and planning requirements, and the applicable NERC CIP standards as they apply to maintaining the stability of the BES.

➢ Identify the responsible entities and facilities affected by CIP-004-6 and CIP-008-5
➢ List the five classes of applicable systems
➢ Recognize the relationship between documented processes, programs, and plans
➢ Identify the required documented processes associated with security awareness programs
➢ Identify the content required for training programs listed in CIP-004-6 R1 through R5
➢ Identify the content and frequency of implementation required for a Cyber Security Incident response plan
➢ Identify reporting requirements associated with the Cyber Security Incident response plan
377-02 CIP Perimeters and Configurations
Upon completion of this course, you should understand the safeguards for BES Cyber Systems as outlined in CIP-005-5 and CIP-010-2.

➢ Identify and define important CIP terminology
➢ Identify the applicable systems regarding ESPs and EAPs
➢ Recognize how dial-up connectivity is managed to maintain cyber security
➢ Recognize what interactive remote access management means and what requirements are defined in CIP-005-5
➢ Identify the components of a baseline configuration and the change management requirements
➢ List how to perform configuration monitoring and vulnerability assessments in accordance with CIP-010-2

377-03 Controls and Management
When you complete this lesson, you will be able to adhere to NERC compliance measures, identify specific information required by NERC CIP standards, and ensure the protection of critical cyber assets and devices.

➢ Identify the purpose of security management control policies
➢ Identify topics and strategies of policy implementation
➢ Identify management and compliance controls
➢ Identify roles responsible for administrative control
➢ Recognize the process of authority delegation
➢ Recognize the process of identifying critical cyber assets
➢ Identify critical control measures of CIP standards
➢ Identify concerns associated with compliance to high and medium impact requirements
➢ Identify audit recommendations and assistance tips for compliance with high and medium impact requirements
➢ Identify concerns associated with low impact assets

377-04 CIP Related BES Recovery Plans
Upon completion of this lesson, you will be able to categorize BES Cyber Systems according to CIP-002-5.1a requirements and implement a Recovery Plan meeting the requirements of CIP-009-6.

➢ Define BES Cyber System Categorization
➢ Recall the requirements of CIP-002-5.1a
➢ Identify the criteria used to label a high impact BES Cyber System
➢ Identify the criteria used to label a medium impact BES Cyber System
➢ Identify the criteria used to label a low impact BES Cyber System
➢ Recognize the applicability of BES System Categorization
➢ Define what a Recovery Plan is as outlined in CIP-009-6
➢ Recall the specifications for developed recovery plans
➢ Identify how to effectively implement and test a recovery plan
➢ Recall how to communicate the development of and changes to a recovery plan

377-05 CIP Physical Security
When you complete this lesson, you will be able to comply with the requirements of NERC standards regarding CIP Physical Security measures.

➢ Identify the Functional Entities tasked with physical security
➢ Recall the purpose of CIP-006-6 and CIP-014-2
➢ Identify how aggregate weighted value is determined
➢ Identify the goal of the BCS Physical Security Program
➢ Identify the difference between PACS and EACMS
➢ Identify three categories of physical access control
➢ Identify BCS physical security areas of concern
➢ Identify common physical threats to transmission assets
➢ Recognize applicability and security components of CIP-014-2
➢ Identify evidence that supports technical studies and analysis
➢ Identify considerations of Transmission asset physical security

378 Emergency Operations Planning
378-01 Emergency Policies and Procedures
When you complete this lesson, you will be able to determine the actions, processes, and procedures instituted by different levels of NERC system operators to improve emergency response during widespread electric system disruptions.

➢ Define the purpose of emergency policies and procedures
➢ Recall the roles and responsibilities of NERC system operators
➢ Recall the three standard electrical emergency stages
➢ Identify the common procedures for each of the emergency stages
➢ List procedures and actions common to blackout policymaking
➢ Recall the development and evaluation process of an electrical grid emergency plan

378-02 Capacity and Energy Emergencies
When you complete this lesson you will understand the responsibilities and expected actions to be taken during a capacity and energy emergency.

➢ Explain the four levels of Energy Emergency Alerts
➢ List the actions a Balancing Authority is expected to take in an energy emergency
➢ Describe the role that the Reliability Coordinator plays during an energy emergency
➢ Explain the expected actions by the Balancing Authority to return its ACE to zero
381 Interconnection Reliability Operations and Coordination

381-05 Reliability Coordination — Planning and Operations

When you complete this lesson, you will be able to identify the different aspects of BPS planning and operation and enact them in your facility to support stable system operations.

- Identify basic concept of Bulk Power System (BPS) Planning for Reliability
- Identify the fundamental elements associated with a NERC directed Operating Plan
- Identify System Reliability Characteristics and Guidelines for Bulk Power System Planning
- Identify Demand and Load Forecasting information and procedures
- Identify methods of addressing demand uncertainty

381-06 Coordinating Entities and Duties

When you complete this lesson, you will be able to identify the authority, plans, agreements, and responsibilities of NERC Functional Entities. Additionally, you will be able to define the roles of Generator Operators (GO), Transmission Service Providers (TSP), Purchasing-Selling Entities (PSE), and other major reliability entities.

- Identify the purpose of IRO-001-1.1
- List the eight entities active in coordinating and conducting power transactions
- Identify the nine requirements of a Reliability Coordinator (RC) during transactions
- Identify common responsibilities of the four NERC system operator classes
- Explain the difference between the three levels of Non-Compliance in standard IRO-001-1.1

386 Transmission Operations

386-01 Reliability Responsibilities and Authorities

When you complete this lesson you will understand the responsibility and authority granted to various entities under system emergencies so the reliability of the Interconnect can be maintained.

- Describe the hierarchy of who can issue and who must follow reliability directives
- Understand the exceptions under which a reliability directive does not need to be followed
- Explain what must be done if a reliability directive is not followed
- Describe the expectations for providing emergency assistance
- Explain the process of removing a Bulk Electric System facility from service which adversely impacts other entities
- Understand the responsibility and authorities bestowed upon the Transmission Operator

387 System Operations

387-01 Energy Production and Transfers

When you complete this lesson, you will be able to identify the elements associated with the production and transfer of energy in power systems.

- Identify the fundamentals of energy production and transfer
- Describe the factors of division of load between generators
- Describe how power systems are operated in parallel

387-02 Transmission Operations

When you complete this lesson, you will be able to understand the fundamentals and basic control strategies of transmission systems.

- Identify the basic functions and limitations of a transmission system in a power grid
- Identify common transmission line voltages and components
- Describe how reactive power affects the transmission system
- Describe basic Bulk Electrical System Load characteristics and categories
- Describe the basic practice of power flow control on a transmission system

387-03 Economic Power System Operations

When you complete this lesson, you will be able to recognize the system conditions contributing to or negatively impacting stable operations and inefficient generation unit loading.

- Identify the differences between fixed and variable costs
- Describe the efficient operation of modern generating units
- Describe economic generator loading
- Describe the effects of varying fuel costs
- Describe economic factors associated with the following types of generation:
  - Nuclear
  - Geothermal
  - Solar and Wind
- Describe losses on a transmission system
- Describe the economic interchange of power

387-04 Power System Control Elements

When you complete this lesson, you will be able to demonstrate an understanding of the elements required to control Power Systems within defined parameters.

- Identify common power system control parameters
- Describe Frequency Control
- Describe Automatic Generation Control
- Describe the basic concept of interconnected operation
- Identify common types of Tie-Line operation
- Describe Tie-Line Bias
- Identify the elements of Area Control Error (ACE)
- Describe Accumulated Frequency Error
387-05 Interconnected Energy Accounting
When you complete this lesson, you will be able to identify the basic concepts associated with accounting for energy transferred between Power Systems.

- Identify the purpose of energy accounting
- Identify common metering arrangements
- Identify how Power Flow is measured
- Identify fundamentals of Interchange Negotiations
- Identify fundamentals of Interconnected Energy Accounting
- Identify fundamentals of Inadvertent Energy accounting

387-07 Supervisory Control and Data Acquisition Systems (SCADA)
When you complete this lesson, you will be able to identify the basic control and communication functions performed by Master Units and Remote Terminal Units of Supervisory Control and Data Acquisition systems.

- Identify fundamental concepts of SCADA applications in a Bulk Electrical System setting
- Identify fundamentals of control and supervision functions performed by SCADA Master Units and Remote Terminal Units
- Identify methods of communication between SCADA Master Units and Remote Terminal Units
- Select basic operations performed by SCADA Master Units
- Select basic operations performed by SCADA Remote Terminal Units
- Identify how SCADA systems perform operations logging functions
- Identify common supporting applications performed by SCADA systems in a Bulk Electrical System setting

387-10 Power System Restoration
When you complete this lesson, you will be able to identify the basic concepts associated with power system restoration such as terms and critical issues.

- Identify fundamental concepts of power system restoration
- Identify common causes of system blackouts and separations
- Identify critical power system restoration issues
- Identify specific considerations of transmission system restoration

388 Active and Reactive Power

388-01 Active and Reactive Power Fundamentals
When you complete this lesson, you will be able to identify fundamental concepts of active and reactive power, angle relationships, and the factors affecting power flow values.

- Identify the fundamental concepts of active, reactive, and complex power
- Identify the relationship between the different angles affecting a power system
- Identify how a synchroscope is used to determine angle magnitude
- Identify the elements used in active and reactive power transfer equations
- Identify the major factors affecting active power flow
- Identify the major factors affecting reactive power flow

388-02 Active and Reactive Power Limits and Flows
When you complete this lesson, you will be able to determine both active and reactive power flow values, as well as differentiate between voltage, stability, and thermal limits.

- Recognize fundamental concepts of AC power flow
- Identify how resistance and reactance are affected by line characteristics of an electrical circuit
- Calculate the value and flow direction of real power
- Calculate the value and flow direction of reactive power
- Recall the flow direction of real and reactive power given bus conditions
- Identify the three categories of power transfer limits
- Recognize which of the three power transfer limits is the most restrictive in a given scenario
- Determine distribution factors on a mock power system
When you complete this lesson, you will be able to discuss basic electron theory and explain how the interaction between electrons and protons of atoms creates electrical energy. You will also be able to identify the factors that affect the movement of electrons, and explain how these factors are measured.

- Define electricity, current, voltage, and resistance
- Describe the structure of an atom
- Explain how voltage is produced
- Explain the term magnetic field

401-02 Magnetism and Electromagnetism Explained

When you complete this lesson, you will be able to describe the basic principles of magnetism.

- Describe the interactions between current, magnetic fields and stationary or moving conductors
- Describe the right-hand rules for conductors, electromagnets, and generators
- Describe the left-hand rule for motors

401-03 Ohm’s and Kirchhoff’s Laws Relating to DC Circuits

When you complete this lesson, you will be able to describe Ohm’s law, the basic formula for finding power (in watts), and Kirchhoff’s first and second laws as they relate to DC circuits.

- Explain Ohm’s as it relates to DC circuits
- Describe the formula for determining power in a DC circuit
- Explain Kirchhoff’s current law using a DC circuit example
- Explain Kirchhoff’s voltage law using a DC circuit example

Kirchhoff’s First Law

401-04 Evaluating Series and Parallel DC Circuit Performance

When you complete this lesson, you will be able to describe how current, voltage, resistance, and power flow through series and parallel DC circuits. You will also be able to calculate values of current, voltage, resistance, and power flow in DC series and parallel circuits. Finally, you will be able to explain some techniques for evaluating DC circuit performance.

- Explain the manner current flows through DC series and parallel circuits
- Describe the method of determining voltage in DC series and parallel circuits
- Explain calculating resistance in DC series circuits
- Describe the calculations of power in DC series and parallel circuits
- Explain some techniques for evaluating DC circuit performance
402 Alternating Current (AC)

402-01 Introduction to Alternating Current (AC)

When you complete this lesson, you will be able to explain the differences between AC power and DC power, define terminology relating to graphing AC power, and explain what is meant by effective values of AC power. You will also be able to describe the common production of AC power and define terminology regarding the characteristics of AC power.

➢ Explain the difference between AC power and DC power
➢ Define terminology relating to graphing AC power
➢ Explain what is meant by effective values of AC power
➢ Describe the common production of AC power
➢ Define terms regarding some characteristics of AC power

402-02 Ohm’s and Kirchhoff’s Laws Involving AC Circuits

When you complete this lesson, you will be able to describe Ohm’s law and Kirchhoff’s current and voltage laws as they relate to AC circuits. You will also be able to calculate power in a resistive AC circuit.

➢ Describe Ohm’s law as it relates to AC circuits
➢ Describe Kirchhoff’s current law using an AC circuit example
➢ Describe Kirchhoff’s voltage law using an AC circuit example
➢ Apply Ohm’s law to determine power in a resistive AC circuit

402-03 Inductance in AC Circuits

When you complete this lesson, you will be able to understand and calculate values of inductance and find the total amount of inductive reactance in a circuit.

➢ Describe the principle of induction
➢ Define the three factors needed for electromagnetic induction
➢ Define inductance
➢ Determine the total inductance of a circuit
➢ Describe inductive reactance and what is needed to calculate its value in the circuit

402-04 Capacitance in AC Circuits

When you complete this lesson, you will understand how capacitance reacts in an AC circuit, be able to calculate total values, and understand calculations for capacitive reactance.

➢ Describe the properties of a capacitor and an electrostatic field
➢ Describe how a capacitor charges and discharges
➢ Describe how a capacitor opposes the voltage in a circuit
➢ Identify the values of capacitance
➢ Describe capacitance in series and in parallel
➢ Demonstrate the calculation of capacitive reactance

402-05 Impedance in AC Circuits

When you complete this lesson, you will be able to determine the total impedance of an AC circuit and apply Ohm’s law to find other unknown values.

➢ Describe a phasor diagram
➢ Demonstrate the use of Ohm’s law to calculate for unknowns in an AC circuit
➢ Define impedance
➢ Identify the steps to find impedance in a resistive-inductive series AC circuit
➢ Identify the steps to find impedance in a resistive-capacitive series AC circuit
➢ Identify the different steps needed to find impedance in a parallel AC circuit of resistance and reactance

402-06 AC Power

When you complete this lesson, you will be able to calculate for unknown values in a power triangle and calculate power factor.

➢ Describe the trigonometric functions for right triangles
➢ Identify the differences between real, apparent, and reactive power
➢ Describe power factor
➢ Explain power factor correction
➢ Describe power in a purely resistive AC circuit
➢ Describe power in a capacitive or inductive circuit
➢ Apply power value calculation
402-07 Fundamentals of Three-Phase AC

When you complete this lesson, you will be able to identify the construction of an AC circuit, calculate the circuits' capacity value, and conduct power factor corrections in AC circuits.

- Describe the differences between three-phase and single-phase voltages
- Describe the characteristics of delta and wye connections
- Calculate current and voltage for delta connected circuits
- Calculate current and voltage for wye connected circuits
- Describe the purpose of power factor
- Calculate capacitance needed to make a power factor correction

405 Power Quality

405-01 Power Quality

When you complete this lesson, you will be able to discuss the nature of power supplied to electrical equipment and list circumstances that affect its quality.

- Define “power quality”
- List some wiring methods that will minimize harmonic frequencies
- Identify a cause of voltage sag
- List some means of protection against voltage spikes
- Describe unbalance in a three-phase four-wire system

405-02 Harmonics

When you complete this lesson, you will be able to describe problems that may arise in electrical systems due to harmonics. In addition, you will be able to identify the benefit of equipment with minimal harmonic distortion and discuss the wiring methods used to minimize the effects of harmonics.

- Discuss the increase of harmonics in electrical equipment and systems
- Describe harmonic frequency and explain how harmonic frequencies are caused
- Identify the difference between linear and non-linear loads
- Describe how motors react to harmonic currents
- Explain harmonic current reactions in transformers
- Describe problems harmonics cause in power systems
- Discuss total harmonic distortion and list ways to minimize harmonic distortion

405-03 High-voltage AC

When you complete this lesson, you will be able to identify the values of high and ultra-high-voltage systems, common system components, and high and ultra-high specific measurement and testing considerations.

- Describe the basic concepts of high-voltage electricity
- Identify the common components used in high-voltage power systems
- Describe the basics of high-voltage measurement
- Describe common high-voltage testing procedures

409 Industrial Motors

409-01 AC Induction Motors

When you complete this lesson, you will be able to describe the design and function of several different types of AC induction motors.

- Identify two main categories of AC induction motors
- List the basic components of an AC induction motor and their functions
- Discuss the operating characteristics of single-phase, AC induction motors
- Compare the design and function of the following pairs of motors:
  - A single-phase AC induction motor and a three-phase AC induction motor
  - A standard three-phase motor and a wound rotor three-phase motor
  - A standard squirrel cage, three-phase induction motor and a three-phase, wound rotor AC induction motor

409-02 AC Generators

When you complete this lesson, you will understand how an AC generator produces an AC voltage.

- List the components of a generator
- Describe a rotating field generator
- Identify the purpose of an exciter
- Explain the process of electromagnetic induction
- Describe the sine wave that is formed when a conductor is rotated through a magnetic field
- Identify the difference between a single-phase voltage sine wave and a three-phase voltage sine wave
- Explain the relationship between frequency and speed in an AC generator
- Explain how to increase voltage produced in a conductor

409-03 AC Induction Motor Theory

When you complete this lesson, you will be able to describe how an electric AC induction motor uses the principles of magnetism and magnetic fields to convert electrical energy into mechanical energy.
409-04 Troubleshooting AC Induction Motors

When you complete this lesson, you will be able to discuss effective troubleshooting procedures for AC induction motors. You will also be able to state various problems related to motor installation, maintenance, and repair.

- Describe five primary steps to take when troubleshooting motors
- Identify the information found on the motor nameplate
- Describe conditions that can cause a motor to trip or fail to start
- Describe the steps for testing motor insulation and the continuity of winding coils

409-05 AC Induction Motor Maintenance

When you complete this lesson, you will be able to describe general electric motor maintenance and inspection activities.

- List the common causes of motor failure
- Identify some items to check when visually inspecting an electric motor
- List conditions to watch for when maintaining electric motors
- Discuss the value of checking and monitoring motor operating temperatures
- Describe the difference between sleeve bearings and rolling element bearings
- Describe how lubrication differs between sealed bearings and open face bearings
- List some common causes of vibration
- Discuss the value of monitoring voltage

409-06 Overhauling Induction Motors

When you complete this lesson, you will be able to describe and properly execute each of the steps necessary to the induction motor overhaul process.

- List preliminary steps taken before starting any motor disassembly
- Explain how to disconnect the motor leads
- Describe the various steps of motor disassembly and inspection
- Identify tests that may be conducted on the rotor and stator
- Explain how to reassemble the motor and prepare it for service

409-07 Generator System Heat Protection

When you complete this lesson, you will be able to discuss industry standard heat reduction methods for industrial AC power generation, including hydrogen cooling systems and their associated equipment.

- Explain why a hydrogen cooling system is a preferred option for operating with AC power generators
- List three properties of hydrogen which make it the efficient gas to use for industrial generator cooling purposes
- Describe how a generator is purged of hydrogen gas using carbon dioxide gas
- Identify hydrogen monitoring systems commonly found in power generation facilities
- Discuss why a seal oil system is required for a hydrogen-cooled generator
- Identify the parts of a stator cooling system commonly found in power generation facilities
- Define the term isolated-phase bus and discuss steps to cool it

409-08 Generator Overhaul

When you complete this lesson, you will be able to discuss the steps taken in shutting down the generator, preparing a generator for maintenance, and considerations when conducting the overhaul inspection.

- Describe preparations for generator shutdown that ensure safe working conditions
- Discuss why some systems need to continue to operate after generator shutdown
- Explain the process of purging the hydrogen from the generator
- Describe stator component inspection
- Describe rotor component inspection
- Identify some of the electrical testing conducted on the generator

409-09 DC Motors and Generators

When you complete this lesson, you will understand how DC generators and motors convert energy from one form to another. In addition, you will be able to describe basic DC generator and motor winding configurations, and identify uses of each type.

- Outline the process of DC voltage generation
- Describe the windings and connections associated with a DC generator
- Describe the windings and connections associated with a DC motor
- Explain how various types of DC generators operate
- Discuss DC motor theory
- Identify and describe various types of DC motors
409-10 Maintenance of Direct Current Motors and Generators

When you complete this lesson, you will be able to describe the basic components of a DC motor and a DC generator, and be prepared to conduct basic maintenance and inspections of each.

➢ Identify the windings and connections of a DC generator using generator drawings
➢ Identify the windings and connections of a DC motor using motor drawings
➢ Explain some problems commonly found with brushes and commutators
➢ Describe the basics of commutator and brush maintenance for DC generators and motors
➢ Identify items to be checked as part of regular maintenance and inspections

411 Motor Control and Protection

411-01 Introduction to Motor Controls

When you complete this lesson, you will be able to draw a simple motor control circuit and describe relative ladder logic.

➢ Identify symbols used in control circuits and describe the functions they represent
➢ Describe input and output devices and identify where they are placed in the circuit
➢ Describe the function of a manual control circuit
➢ Explain the difference between a semiautomatic and an automatic circuit
➢ Describe the path of flow through a motor control circuit drawing

411-02 Motor Protection and Faults

When you complete this lesson, you will be able to explain the difference between internal and external motor faults. In addition, you will be able to select the proper overcurrent and short circuit protection devices for motor branch circuits.

➢ Explain demands affecting motor branch circuits
➢ Identify the major parts of a motor branch circuit
➢ Identify characteristics of NEMA motor classifications
➢ Explain the effects of voltage and frequency deviation
➢ Identify common faults and diagnosis of AC devices

411-03 Motor Control Troubleshooting

When you complete this lesson, you will understand the basics of troubleshooting motor control circuits.

➢ Describe the steps for effective troubleshooting
➢ Discuss how breaking down complex circuits to simple ones assists in isolating problems
➢ Describe how to use wiring diagrams and schematics to locate problems in a circuit

411-04 Motor Control Centers

When you complete this lesson, you will be able to explain the function of MCCs, common components of an MCC, and the difference between common classifications and their associated wiring schemes.

➢ Identify the principles of motor controls
➢ Identify common motor control power supplies
➢ Explain the need for circuit protection
➢ Identify common circuit protection devices
➢ Identify common components used in motor control centers
➢ Identify common National Electrical Manufacturers Association (NEMA) wiring classes and types

413 AC Drives

413-01 AC Drives Overview

Upon completion of this lesson, you will understand the basic designs, purposes, and applications for AC drive devices.

➢ Describe a typical AC drive and explain its operation
➢ Discuss the fundamental concept of reducing motor speed
➢ Identify the two main parts of an AC drive
➢ Describe the functions of each of the following components:
  ○ Rectifier assembly
  ○ Inverter
  ○ Controls
415 Transformers

415-01 Transformer Basics

When you complete this lesson, you will be able to explain magnetism and electromagnetism and to explain the basic principles of electrical voltage transformation.

➢ Explain the force of magnetism
➢ Describe the molecular domains of ferromagnetic metals
➢ Describe the reaction between like and unlike magnetic fields
➢ Describe magnetic flux
➢ Define electromagnetism
➢ Explain the changes of field strength in an electromagnetic coil
➢ Define permeability
➢ Explain the left hand rule for coils
➢ Describe the magnetic measurements of Weber, magnetic flux density, Tesla, magnetomotive force, field intensity, and reluctance
➢ Describe the line voltage and the load connections to the transformer
➢ Describe the property of inductance
➢ Describe electromagnetic induction
➢ Describe mutual induction
➢ Describe Lenz’s law and self-induction
➢ Describe the turns ratio between the primary and secondary windings
➢ Define volts per turn
➢ Explain the use of coil taps in a transformer
➢ Explain transformer losses from copper loss
➢ Describe transformer losses from eddy currents
➢ Describe hysteresis losses
➢ Define flux loss
➢ Describe mutual inductance or the coefficient of coupling

415-02 Transformer Design and Components

When you complete this lesson, you will be able to visually identify the type of core construction in a transformer, describe types of transformer cooling, temperature limits, and external devices of the transformer.

➢ Describe the basics of core construction
➢ Describe the design of a core-type transformer
➢ Describe the design of a shell-type transformer
➢ Describe a toroidal core transformer
➢ Describe the cause of coil movement
➢ Describe types of transformer cooling
➢ Describe the type of coolant used to cool transformers
➢ Identify the temperature limits of a transformer
➢ Explain the need for an explosion vent
➢ Describe the purpose of a gas relay
➢ Explain the purpose of the bushings
➢ Describe the purpose of a level gauge
➢ Explain the necessity of a thermometer
➢ Explain the purpose of the transformer nameplate
➢ Explain transformer power ratings
➢ Explain the effect of sound levels of a transformer and their role in selecting a transformer

415-03 Transformer Connections

When you complete this lesson, you will be able to identify and explain how to make the most common types of connections for single-phase and three-phase transformers. You will be able to calculate the value of phase voltage and current, as well as line voltage and current.

➢ Explain how a dual-voltage, single-phase transformer is wound and connected
➢ Identify the primary and secondary transformer lead marking
➢ Describe the relationship between each phase of three-phase voltage
➢ Discuss three-phase, delta-connected line and:
  o Phase voltage
  o Phase current
➢ Discuss three-phase, wye-connected line and:
  o Phase voltage
  o Phase current
➢ Explain the function of the Y-point in a wye-connected transformer
➢ Describe an open-delta connection and discuss the amount of current it can provide
➢ Identify a scenario where a delta-wye connection may be used

415-04 Special Transformers

When you complete this lesson, you will be able to identify the various types of special transformers and describe how they are used.

➢ Describe the use of a reactor in a circuit
➢ Identify the circumstances when you would use a choke in a circuit
➢ Explain why an isolation transformer is used to supply power to a variable speed drive
➢ Describe the windings in an auto-transformer
➢ Compare the purposes of buck-boost transformers, potential transformers, and current transformers
➢ Identify a scenario where a control transformer is needed
➢ Identify an application that requires a K-Factor transformer
416 Batteries, Battery Chargers, and UPS

416-01 Battery Basics
When you complete this lesson, you will understand the overall design and function of today's batteries. In addition, you will be able to identify maintenance practices you can perform to keep them ready for service.

➢ Identify the parts of a voltaic cell
➢ Explain the distinction between a cell and a battery
➢ Describe the electrochemical action associated with cells and batteries
➢ Compare the discharge and charge processes
➢ Identify ways to increase battery voltage and capacity
➢ Define amp-hours
➢ Explain the main difference between a primary and a secondary cell
➢ Describe how specific gravity affects cell voltage
➢ Discuss types of battery charging methods
➢ List safety precautions needed when testing or working with batteries

416-02 Electrical Backup Systems
When you complete this lesson, you will be able to distinguish between types of backup systems and choose the type that fits your application.

➢ Discuss variations in the need for a backup power system
➢ Identify sources of backup power
➢ Recognize components of battery backup systems
➢ Compare the configurations and features of various backup electrical systems

416-03 Uninterruptible Power Supplies (UPS)
When you complete this lesson, you will be able to identify common power problems that create a need for backup power systems, how UPS systems vary in characteristics, and how each is applicable to particular situations.

➢ Identify common power problems negated by UPS systems
➢ Describe common UPS types and their characteristics
➢ Identify issues affecting UPS battery life
➢ Describe the purpose of UPS functionality software
➢ Describe common UPS applications

417 Switchgear Maintenance

417-01 Switchgear
When you complete this lesson, you will be able to describe the function and operation of switchgear. You will be able to identify the equipment that makes up a switchgear system and describe the purpose of protection relays.

➢ Describe what switchgear is and explain how it is used
➢ Identify types of switchgear by voltage
➢ Describe the use and purpose of the following:
  o Breakers and switches
  o Generator breaker
  o Electrical bus
  o Switchgear relays
➢ Describe the type of indication and communication employed by switchgear relays

417-02 Low Voltage Breakers
When you complete this lesson, you will understand the purpose and use of low voltage circuit breakers in electrical circuits.

➢ Describe the function of low voltage breakers
➢ Describe low voltage, molded case breakers and low voltage, large frame breakers; identify their differences
➢ Explain how to connect a large frame breaker
➢ Define the low voltage breaker voltage category
➢ Describe how an arc is formed and extinguished
➢ Explain why breakers trip and describe breaker closing and tripping devices

417-03 Medium and High Voltage Switchgear
When you complete this lesson, you will be able to identify the technical details associated with construction and operation of high and medium voltage switchgears.

➢ Identify the basic theory and design of medium voltage switchgear
➢ Identify the basic theory and design of high voltage switchgear
➢ Describe the function and interrupting mediums of High Voltage and Medium Voltage operating mechanisms
➢ Identify common switching considerations
➢ Identify modern Medium Voltage switchgear applications

417-04 General Switchgear Maintenance
When you complete this lesson, you will be able to identify and perform the common tasks and tests related to modern switchgear.

➢ Identify general circuit breaker maintenance tasks
➢ Identify tasks associated with standard operating mechanism maintenance
➢ Identify tasks associated with hydraulic and pneumatic operating mechanism maintenance
➢ Describe the three common electrical tests conducted on large circuit breakers
418-02 Overcurrent Protection, Fuses, and Breakers

When you complete this lesson, you will be able to identify types of fuses and breakers used in electrical distribution systems and explain how they work.

- Compare single element and dual element fuses
- Explain the difference between an overload and a short circuit
- Identify one main difference between a fuse and a breaker
- Describe how current limiting fuses and breakers can limit the fault current
- Discuss selective coordination for fuses and breakers

418-03 Protection Relays

When you complete this lesson, you will be able to identify protection relay elements on an electrical drawing according to their ANSI (American National Standards Institute) standard device numbers. In addition, you will be able to describe basic relay operations and compare the accuracy and options provided by commonly used relays.

- Describe the operating principles behind protective relays
- Identify the essential requirements of relay protection
- List the ANSI standard device-function numbers that identify relays
- Describe the two types of electromechanical relays
- Discuss the benefits of solid-state relays

418-04 Generator, Transformer, and Motor Protection

When you complete this lesson, you will understand the principles of operation governing ground fault protection, phase-to-phase short circuit, time overcurrent protection, and motor overload protection.

- Describe types of ground circuit connections for a generator
- Compare the current flow for various types of generator ground connections
- Describe the function of a differential current relay
- Discuss the number of relays needed for three-phase, differential overcurrent protection
- Identify resources that specify the level of overload protection that should be used for a motor
- Describe how to choose overload protection for a three-phase motor

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417-05 Breaker Specific Maintenance

When you complete this lesson, you will be able to complete breaker specific maintenance tasks in order to maximize breaker life and maintain system stability.

- Identify shared maintenance tasks associated with air-magnetic and vacuum breakers
- Identify specific maintenance tasks related to air-magnetic circuit breakers
- Identify specific maintenance tasks related to vacuum circuit breakers
- Identify specific maintenance tasks related to oil circuit breakers
- Identify specific maintenance tasks related to gas-blast circuit breakers
- Identify specific maintenance tasks related to air-blast circuit breakers

417-06 Circuit Breaker Time-Travel Characteristics and Testing

When you complete this lesson, you will be able to identify the purpose and principles of circuit breaker time-travel testing and explain the processes associated with conducting the three types of time-travel testing.

- Identify the purpose of time-travel testing
- Identify the principles of time-travel testing
- Identify the characteristics of circuit breaker time
- Identify the characteristics of circuit breaker travel
- Identify equipment used in circuit breaker time-travel testing
- Compare operating processes of drop bar, light beam and digital timer/analyzer recorders

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418 Electrical Protection and Grounding

418-01 Electrical Faults and Current Ratings

When you complete this lesson, you will be able to explain causes and types of electrical overcurrent, and identify how to protect circuits from overcurrents and faults.

- Describe an electrical overcurrent condition
- Describe an electrical fault with excessively high current flow
- Identify the difference between an electrical circuit overload condition and a short circuit condition
- Name two good conductors of electricity
- List some of the factors that determine the current rating of a conductor
- Explain how devices are used to protect from overcurrent and faults
- Describe ground faults that can occur from various grounding connections
418-05 Grounding and Bonding

When you complete this lesson, you will be able to describe how grounding systems are used to ground electrical systems and equipment.

➢ Identify the purpose of grounding electrical systems and equipment
➢ Define the following terms as they relate to grounding:
  o Ground
  o Grounded conductor
  o System
  o Equipment
  o Ground fault
➢ Distinguish between the three common types of grounding systems
➢ Discuss the concepts of system grounding and equipment grounding
➢ Describe how to apply the proper grounding methods for various applications

419 Motor Operated Valves

419-01 MOV (Motor Operated Valve) Application and Construction

When you complete this lesson, you will be able to describe typical components, uses, and operations of motor operated valve actuators.

➢ List the advantages of using an MOV
➢ Describe the operation of a typical MOV
➢ Discuss typical scenarios in which MOV use would be beneficial
➢ Describe the components of actuators and explain the differences between the Limitorque® 00/000 and 0-3

419-02 MOV Disassembly and Inspection, Part 1

When you complete this lesson, you will be able to explain how to disassemble, inspect, and reassemble a Limitorque® SMB-00/000 MOV actuator.

➢ List the tools and equipment required for MOV inspection and disassembly
➢ Describe the things and conditions you look for during inspection
➢ Describe techniques that help prevent component damage during disassembly and reassembly
➢ Walk through the steps to disassemble a Limitorque® SMB-00/00 MOV, inspect its components, and reassemble it

419-03 MOV Disassembly and Inspection, Part 2

When you complete this lesson, you will be able to describe the reassembly techniques applied to the SMB-00/000 Limitorque® MOV.

➢ List the tools and equipment required for MOV reassembly
➢ Provide a detailed description of the reassembly steps employed with each of the following SMB-00/000 components:
  o Declutch shaft and fork
  o Drive sleeve
  o Worm shaft
  o Worm and spring pack
  o Spring cartridge cap
  o Declutch lever
  o Handwheel assembly
  o Tripper lever
  o Torque switch
  o Limit switch

419-04 Limit Switch Adjustment

When you complete this lesson, you will be able to explain the process of adjusting the limit switch for a Limitorque® actuator.

➢ Walk through the basic, step-by-step process of adjusting a Limitorque® actuator limit switch
➢ Explain how to determine whether or not the switch needs adjustment
➢ Discuss why it is important to note the direction of rotation of the intermittent gear shafts while the valve is being repositioned

421 Wiring Installation

421-01 Wire and Cable Management

When you complete this lesson, you will be able to determine how to properly use conduit and cable trays to ensure the necessary neat and workmanlike appearance required by the NEC.

➢ Describe the use of the following:
  o Cable trays
  o Junction boxes
  o Wire ducts
➢ Explain the importance of using a marking and numbering system
421-02 Terminating and Connecting Wires in a Control Panel

When you complete this lesson, you will be able to explain the basic steps to wire a control panel.

➢ List some conditions that affect selection of components
➢ Discuss the function of a truth table
➢ Describe how to use wiring duct
➢ Explain the purpose of din rail
➢ Describe selector switches and identify how they are used in a control panel
➢ Describe the value of numbering and color coding in control panels

421-03 Making Connections in a Junction Box

When you complete this lesson, you will be able to explain how to make connections and terminations in a junction box using several systems.

➢ Define an electrical junction and explain its purpose
➢ Describe how to perform the following activities:
  o Use a wire nut connector
  o Terminate wires using a terminal strip
  o Form wire in a junction box

421-04 Installing Conduit and Pulling Wire

Upon completing this lesson, you will be able to describe the major types of electrical conduit and the basics of installing and pulling wire through electrical conduit.

➢ Identify the five major types of conduit
➢ Explain the difference between each type of conduit
➢ Describe the process of cutting, bending, and fitting each type of conduit
➢ Discuss the methods of installing electrical conduit
➢ Explain the various methods of pulling wire through conduit

423-01 Introduction to Medium Voltage Cable

When you complete this lesson, you will be able to identify the components of medium voltage cable and why each is needed.

➢ Relate the difference in “pressure” between low voltage and medium voltage
➢ Describe corona
➢ Describe partial discharge
➢ Describe conductor stranding
➢ Identify the strand shielding
➢ Describe conductor insulation
➢ Describe insulation stranding

423-02 Medium Voltage Splices and Terminations

When you complete this lesson, you will know the steps needed to splice and terminate medium voltage power cable.

➢ Explain why a splice may be needed
➢ Describe the first step in cable preparation
➢ Describe the layers that need to be removed to prepare for a splice
➢ Describe the steps in re-shielding and re-insulation
➢ Describe the steps in preparing for cable termination
➢ Explain what is needed for a Class One termination
➢ Explain where stress control is needed in the termination

425 Troubleshooting Electrical Circuits

425-01 Troubleshooting AC Circuits

When you complete this lesson, you will be able to outline the logical steps used for troubleshooting AC motor control circuits.

➢ Discuss the general sequence of steps employed when troubleshooting
➢ List some potential questions to ask operations personnel
➢ Identify possible visual indications of a fault
➢ Explain actions taken to determine probable cause
➢ Discuss how safety rules and procedures fit into the troubleshooting process
➢ Describe testing performed with the power off
➢ Describe testing performed with the power on
425-02 Troubleshooting DC Circuits

When you complete this lesson, you will be able to outline the logical steps used to troubleshoot DC circuits.

➢ Discuss the general sequence of steps employed when troubleshooting DC circuits
➢ List some potential sources of information about a circuit
➢ Discuss how safety rules and procedures fit into the troubleshooting process
➢ Describe how methodical testing can isolate probable cause of the problem
➢ Use Ohm’s Law to calculate unknown values in a voltage divider circuit
➢ Describe how to use a multimeter to troubleshoot a DC breaker control malfunction

427 Freeze Protection

427-01 Electrical Freeze Protection
Components and Application

When you complete this lesson, you will be able to identify the fundamentals of heat-tracing and the methods used in its practice, as well as describe the types of electrical heat-tracing and their internal and external maintenance concerns.

➢ Describe the principles and purpose of heat-tracing systems
➢ Identify common heat-tracing methods
➢ Compare prominent heat-tracing methods
➢ Identify types of electrical heat-trace cabling and their characteristics
➢ Describe safety and temperature control
➢ Describe electrical heat-trace maintenance methods for exterior faults
➢ Describe electrical heat-trace maintenance methods for interior faults
When you complete this lesson, you will be able to describe how energy from fossil and renewable fuels is captured and converted into electrical energy. In addition, you will be able to discuss efficiency and the role it plays in energy conversions.

- Define energy
- Describe the difference between renewable and non-renewable energy sources
- Describe the difference between potential energy and kinetic energy
- Describe the three basic energy conversions taking place in a fossil fuel-fired power plant
- Identify benefits and desirable features of fossil fuel-fired units
- Define efficiency
- Describe losses and efficiency related to fossil fuel-fired power plants

501-02 Steam Turbine Basics

When you complete this lesson, you will be able to describe the basic operation of a typical power plant’s steam turbine and identify the functions of its critical components.

- Describe the role of the steam turbine in power plant operations
- Describe the basic design of turbine rotor bearings
- Identify the purpose of the stationary blades
- Identify the function of the main steam stop valves
- Describe the purpose of the steam chest and control valves
- Identify the primary function of the turbine lube oil system
- Describe the role of the emergency lube oil pump

501-03 Combustion System Component Overview

When you complete this lesson, you will be able to describe the equipment used to prepare and control natural gas, fuel oil, and coal as it is burned in the boiler. In addition, you will be able to identify some advantages and disadvantages of using each type of fuel in a power plant.

- Describe the basic components used in a combustion system that uses natural gas
- Identify advantages and disadvantages of using natural gas as the primary fuel source for the boiler
- Describe the basic components used in a combustion system that uses fuel oil
- Identify advantages and disadvantages of using fuel oil as the primary fuel source for the boiler
- Describe the basic components used in a combustion system that uses coal
- Identify advantages and disadvantages of using coal as the primary fuel source for the boiler
501-04 Boiler Water and Steam Cycle Overview

When you complete this lesson, you will be able to describe where boiler water comes from and how it enters and flows through a boiler. In addition, you will be able to explain the basic flow path the steam follows from the boiler to the steam turbine.

➢ Explain the purpose of a hotwell
➢ Describe the role low pressure condensate heaters and high pressure feedwater heaters play in the boiler water cycle
➢ Explain the purpose of a deaerator
➢ Describe the basic design of a water tube boiler
➢ Explain the purpose of a steam drum
➢ Explain the purpose of the primary superheater and secondary superheater

501-05 Generator Overview

When you complete this lesson, you will be able to describe the relationship between electrical usage and generator output. In addition, you will be able to explain the basic principles of producing electricity using an electromagnet.

➢ Define the term megawatt/hour
➢ Describe how electricity usage is measured in a typical household
➢ Describe how power system load continually changes
➢ Describe the purpose of the electromagnet in a generator
➢ Describe the purpose of the generator stator
➢ Describe what is meant by 3-phase power
➢ Describe the impact of generator size on power oscillations
➢ Describe the role of an exciter

505 Turbine Auxiliaries System and Control

505-01 Steam Turbine Design

When you complete this lesson, you will be able to describe the basic components comprising a typical steam turbine and explain the purpose of each. In addition, you will be able to trace the steam flow path through a typical steam turbine.

➢ Describe the energy conversion taking place in a steam turbine
➢ Explain the difference between impulse and reaction blading, and identify where each is found in a steam turbine
➢ Discuss the design characteristics of a steam turbine casing
➢ Explain the difference between thrust bearings and journal bearings, and identify where each is found in a typical steam turbine
➢ Recall the steam flow path through a high, intermediate, and low-pressure turbine

505-02 Steam Turbine Control and Operation

When you complete this lesson, you will be able describe the basic operation of the valves that control the speed and operation of a typical steam turbine.

➢ Identify the purpose of the main steam stop valves
➢ Identify how main steam stop valves affect a unit’s operation in Bulk Electric System (BES) emergency operations
➢ Identify how turbine speed control affects a unit’s ability to support normal, contingency, and emergency BES operations
➢ Identify the purpose of the turbine governor and control valves
➢ Identify the difference between reheating, reheat and intercept valves
➢ Identify how turbine valves are manipulated by Automatic Generation Control (AGC) systems using Area Control Error (ACE) data
➢ Recognize what happens during a turbine trip
➢ Recall the basic operation of a flyweight governor control system
➢ Identify the difference between full arc admission and partial arc admission
➢ Identify common steam turbine ramp rates
➢ Identify steam turbine viability as an option in normal, contingency and emergency operations

505-03 Steam Turbine Auxiliaries

When you complete this lesson, you will be able to describe the design and function of components found in a typical turbine lube oil system and gland steam seal system.

➢ Identify the two primary purposes of the main turbine lube oil system
➢ Describe the location and operation of the main lube oil pump and its relationship to the booster oil pump
➢ Explain the purpose of the turning gear
➢ Describe the operation of the gland steam seal system
➢ Discuss operator role in the operation of a steam turbine

505-10 Steam Turbine Governor System

When you complete this lesson, you will be able to identify the components and function of a typical turbine governor system.

➢ Identify facts pertaining to governor history
➢ Recognize governor system components
➢ Identify components associated with normal operations
➢ Identify components associated with shutdown operations
➢ Recall actions related to normal system operation
507 Generator and Auxiliary Systems and Control

507-01 Generator and Auxiliary Systems’ Functions

When you complete this lesson, you will be able to describe the functions performed by the generator and its auxiliary components.

➢ Define real power, reactive power, and the power factor
➢ Identify the function of the rotor
➢ Recall the importance of cooling particularly during load pickup
➢ List advantages of hydrogen cooling and identify auxiliaries associated with its use
➢ Recognize the design and function of the rotor winding assembly
➢ Identify the purpose of the shaft sealing systems

507-02 Generator and Auxiliary Systems’ Flow Paths and Major Components

When you complete this lesson, you will be able to identify the flow paths associated with the major components that support generator operation.

➢ Describe the following seal oil system components and systems and identify their place in the flow path:
  o Hydrogen seal oil supply
  o Air side of the seal oil system
  o Deoiling/detraining tank
  o Seal oil return
  o Hydrogen supply system
➢ Explain the process to purge hydrogen from the generator and identify the purpose of doing so

507-03 Generator Construction and Process Control

When you complete this lesson, you will be able to describe generator construction and explain some of the principles behind generator operation and process control.

➢ Identify the difference between induction and synchronous types of three-phase generators
➢ Recall the construction of a three-phase, two pole DC generator
➢ Recall how a sinusoidal waveform illustrates the number of amps produced over a given time
➢ Recall the operation of a synchroscope
➢ Identify the parameters to be controlled when placing the generator on the electrical grid

507-04 Generator and Auxiliary Systems’ Start-up

When you complete this lesson, you will be able to describe the steps to start-up the generator and establish it on the electrical grid.

➢ Explain how to place the hydrogen seal oil unit in service
➢ Describe the purging and gassing of the turbine
➢ Identify pre-start checks for generator start-up
➢ Describe operator responsibilities during the process of rolling on the turbine

507-05 Generator and Auxiliary Systems’ Normal Operations

When you complete this lesson, you will be able to describe tasks performed during normal operations of the generator and auxiliary systems.

➢ List checks conducted during normal operations of the generator
➢ Describe the system and process that removes moisture from hydrogen
➢ Explain operator responsibilities during normal operation of the seal oil system

507-06 Generator and Auxiliary Systems’ Shutdown

When you complete this lesson, you will be able to describe your role during shutdown of the generator and its auxiliary components.

➢ Explain the steps followed when shutting down each of the following:
  o Generator
  o Seal oil system
  o Cooling water system
➢ Identify the importance of putting the turbine on turning gear when it is taken off-line
➢ Identify the conditions under which it is appropriate to shut down the cooling water system
511 Combustion Turbine Fundamentals

511-01 Gas Turbine Fundamentals and Configuration of Generating Facilities
When you complete this lesson, you will be able to discuss the basic design of a simple cycle power plant and the function and operation of its fundamental piece of equipment, the combustion turbine.
- Recall the basic layout of a simple cycle and combined cycle generation facilities
- Explain the Brayton Cycle and supporting principles as they relate to the basic operation of a gas turbine compressor
- List the components of a typical combustion turbine package and discuss the function of each
- Explain the basics of the fuel system
- Describe the purpose of the lube oil system
- Recognize the importance of temperature monitoring and identify heat’s potential for system damage

511-02 Introduction to the GE LM Series Gas Turbine
When you complete this lesson, you will be able to describe the basic components that comprise GE’s LM series of gas turbine. In addition, you will be able to explain the basic compressed air and hot gas flow paths through each type of LM gas turbine.
- Define gas turbine
- Identify the four LM series gas turbines that comprise the GE medium sized gas turbine fleet
- Recall the basic design of an axial flow compressor
- Explain the basic purpose of a combustor
- Identify two basic power turbine designs

511-03 Introduction to GE Frame Series Gas Turbines
When you complete this lesson, you will be able to discuss the motivation behind the development of the F-series of gas turbine. In addition, you will be able to describe the Frame 7 gas turbine’s basic components and general operation.
- Recall the driving factor for the creation of F-series gas turbine technology
- Identify the primary differences between the Frame 7 gas turbine and its predecessors
- Describe the basic components and flow paths through the Frame 7 gas turbine
- Explain the purpose of the inlet air guide vanes
- Recall the relationship between turbine output energy and the compressor energy consumption
- Explain the purpose of a regenerator

511-04 Introduction to the Siemens V-Series Gas Turbine
When you complete this lesson, you will be able to describe the basic components comprising the Siemens Westinghouse V-series gas turbines. In addition, you will be able to identify the basic compressed air and hot gas flow paths through the V94.3 gas turbine.
- Explain the overall function of a gas turbine
- Describe the basic design of an axial flow compressor
- Identify the primary purpose of a combustion chamber
- Identify the purpose of a turbine

511-05 Heavy Duty Gas Turbines – Major Components and Support Systems
When you complete this lesson, you will be able to discuss the motivation behind the development of the heavy duty gas turbine. In addition, you will be able to describe the gas turbine’s basic components and general operation.
- Discuss factors that drove the creation of the heavy duty gas turbine technology
- Describe the basic compressed air and hot gas flow paths through the turbine
- Explain the purpose of the inlet air guide vanes
- Discuss the relationship between turbine output energy and the compressor energy consumption
- Explain the purpose of a regenerator
- Describe the fuel delivery system for a heavy duty gas turbine and its flow paths
- Describe the lube oil system for a heavy duty gas turbine and how it functions

511-07 Aero-derivative Gas Turbines – Major Components and Support Systems
When you complete this lesson, you will be able to discuss the motivation behind the development of the aero-derivative gas turbine. In addition, you will be able to describe the gas turbine’s major components and support systems.
- Define an aero-derivative gas turbine
- Describe how an aero-derivative gas turbine is different from its heavy duty counterpart
- Discuss the basic design of the compressor section
- Explain the basic purpose of a combustor
- Describe the fuel delivery system for an aero-derivative gas turbine and its flow paths
- Describe the lube oil system for an aero-derivative gas turbine and how it functions
511-10 Fundamentals of Gas Turbine Operation and Routine Maintenance
When you complete this lesson, you will be familiar with several common procedures for operating and maintaining a combustion turbine (CT) as well as some conditions that require emergency procedures.

➢ Describe pre-start up maintenance/inspection, and windmilling parameters
➢ Describe the basic startup process for a combustion turbine (CT)
➢ Describe the basics of swapping fuel types, and the risks involved
➢ Explain how the environment affects the CT (high and low temperature, barometric pressure, etc.)
➢ Identify emergency procedures and the conditions in which they would be implemented
➢ Explain the purpose of a water wash
➢ Explain what a load commutated inverter is and how it communicates with the exciter to start a combustion turbine

511-11 Gas turbine Control Schemes
When you complete this lesson, you will be able to identify common control schemes, gas turbine compressor startup and shutdown operations, and exhaust control on both simple cycle and combined cycle exhausts.

➢ Identify critical operating parameters
➢ Recall the flame detection and protection systems
➢ Identify simple cycle exhaust control measures
➢ Identify combined cycle exhaust control components
➢ Identify startup sequence steps
➢ Identify shutdown sequence steps

511-12 Gas Turbine Fuel and Combustion Systems
When you complete this lesson, you will be able to identify common fuel and combustion system components and their functions.

➢ Identify types of fuels used in gas turbine compressors
➢ Recall gaseous fuel system components and operations
➢ Describe fuel oil skid system components and operations
➢ Identify components on the fuel oil forwarding skid
➢ Recall facts pertaining to combustion section designs

511-13 Gas Turbine Lube Oil and Control Oil Systems
When you complete this lesson, you will be able to identify common lube oil system components and operations as well as control oil system components and operations.

➢ Identify lube oil system components
➢ Recall lube oil system operation
➢ Select control oil system components
➢ Identify control oil system operation

511-14 Gas Turbine Air Systems
When you complete this lesson, you will be familiar with several subsystems of the air system of the gas turbine compressor.

➢ Identify the major components of the gas turbine air inlet system
➢ Identify the function of air inlet components
➢ Describe the construction air inlet filters
➢ Recall advantages of a self-cleaning air filter
➢ Explain facts pertaining to the self-cleaning air filters
➢ Identify cooling and sealing air operations
➢ Describe simple cycle exhaust components
➢ Describe combined cycle exhaust components

511-15 Gas Turbine Water Wash and Drain Systems
When you complete this lesson, you will be familiar with several subsystems of the water and drain systems of the gas turbine compressor.

➢ Identify steam/water system components and operations
➢ Identify the turbine water wash system operations
➢ Describe case and exhaust drain functions

521 Combustion Air and Flue Gas System
521-01 Introduction to Combustion Air and Flue Gas Systems
When you complete this lesson, you will be able to describe how the overall combustion process works and demonstrate a working knowledge of the combustion air and flue gas systems.

➢ Describe the indications of incomplete combustion
➢ Define flash point
➢ Describe primary and secondary air and the fans associated with them
➢ Describe the following components of the flue gas system:
  ○ Air preheater
  ○ Dust collector
  ○ Soot blower
521-02 Combustion Air and Flue Gas Flow Paths and Components

When you complete this lesson, you will be able to trace the flow paths of typical power plant combustion air and flue gas systems. You will also be able to describe the operation of major components within those flow paths.

➢ Describe the individual flow paths of primary and secondary air
➢ Compare the relative temperatures of the reheat and superheat boiler sections
➢ Explain the use of forced and induced draft fans
➢ Describe the function of the following flue gas system components:
  o Air preheaters
  o Scrubbers
  o Expansion joints

521-03 Control Loops and Methods of Control

When you complete this lesson, you will be able to discuss how control loops and methods of control can safely direct operational events in a power plant.

➢ Demonstrate a fundamental understanding of logic diagrams
➢ Discuss the importance of interlocks and describe how they work
➢ Describe the operation of PID, closed loop methods of control

521-04 Combustion Air and Flue Gas System Start-up

When you complete this lesson, you will be able to describe the steps performed to put the boiler fan operation system into service.

➢ Identify the importance of establishing air flow in the boiler with the induced draft (ID) fan
➢ List verifications and tests to be completed prior to forced draft (FD) fan start-up
➢ Describe the steps to start the FD fan
➢ Describe preparations to ensure the ignitor air blowers are ready for service
➢ List typical permissives to be satisfied before purging the boiler
➢ Describe the steps to successfully purge the boiler
➢ Describe the steps to put preheater into service

521-05 Maintaining Fan Operations in Combustion Air and Flue Gas Systems

When you complete this lesson, you will be able to describe how to perform the checks and monitoring necessary to maintain operation of fans and their components.

➢ Identify the reasons for monitoring a fan’s current, bearing temperature, bearing vibration, and lubrication
➢ List four checks you should perform as part of air preheater maintenance
➢ Explain how leaks in the heat exchanger can affect fan performance
➢ Describe operational maintenance procedures involving ignitor air fans, scanners, excess air, and the boiler
➢ Discuss how to overcome the effects of abnormal conditions such as hunting, stalling, excess temperature, and vibration

521-06 Combustion Air and Flue Gas System Shutdown Process

When you complete this lesson, you will have an overall understanding of the shutdown process and general knowledge of an operator’s shutdown responsibilities.

➢ Walk through the steps for boiler shutdown, describing procedures related to each of these critical components:
  o Primary Air (PA) Fan
  o Induced Draft (ID) Fan
  o Forced Draft (FD) Fan
  o Air preheaters
➢ Explain how air flow and fuel flow are controlled during shutdown
➢ Define thermal shock and explain how to avoid it during shutdown

522 Coal Handling System

522-01 Coal Handling System

When you complete this lesson, you will be able to identify common coal handling processes. You will also be able to discuss the operation of essential pieces of equipment used at the plant site.

➢ Define key coal handling and processing equipment
➢ Discuss how coal handling equipment is used to deliver coal
➢ Describe the difference between coal crushers and pulverizers
➢ Explain the operating principle of coal pulverizers
➢ Explain the operating principle of coal crushers
523 Boiler Fuel Systems

523-01 Boiler Fuel System Function
When you complete this lesson, you will be able to describe the functions of the boiler fuel system and differentiate among types of boiler fuel systems.

➢ Explain the function of the boiler fuel system
➢ Describe various types of coal used in the fuel system
➢ Identify the conveyor, tripper, silo components, and path of a boiler feeder system
➢ Describe gravimetric feeder, its components, and its path
➢ Describe coal pulverizer components and path
➢ Explain the function of cyclone burner ports
➢ Identify and explain the tangentially fired boiler

523-02 Process and Methods of Control for the Boiler Fuel System
When you complete this lesson, you will be able to describe the digital control system that regulates and automates the components of the boiler fuel system to attain specific setpoints and meet desired production loads.

➢ Describe fuel flow to the boiler
➢ Explain functional logic systems
➢ Describe logic subsystems
➢ Explain the operations of the fuel system process control loops

523-03 Boiler Fuel System Start-up
When you complete this lesson, you will be able to apply standard procedures for initiating the boiler fuel system components during startup.

➢ Perform checks on the readiness of the seal air system, the pulverizers, and the feeders
➢ Perform checks on the oil and lubrication system of the boiler fuel supply system
➢ Apply startup procedures for the pulverizers
➢ Adhere to feeder start permissives

523-04 Normal Operation of the Boiler Fuel Systems
When you complete this lesson, you will be able to explain the normal operation of the components of the boiler fuel system.

➢ Assess normal operations of the pulverizers, including its seal air and lubrication components
➢ Describe and assess the normal operations of the silo and feeder systems
➢ Determine the primary and secondary air fans are operating properly during normal operations

523-05 Shutdown for the Boiler Fuel System
When you complete this lesson, you will be able to describe the controlled and emergency shutdown procedures for the feeders and pulverizers.

➢ Apply procedures for the controlled shutdown of the feeders and pulverizers
➢ Adhere to procedures for the emergency shutdown of the boiler fuel system
➢ Initiate the extinguishing procedure for a pulverizer fire

531 Hydrocarbon Fired Boilers

531-01 Combustion Theory
When you complete this lesson, you will be able to explain the different types of fossil fuels commonly used in an industrial setting, and explain some characteristics of the fuels. In addition, you will be able to describe the elements and conditions that must be present in order for the combustion of fuel to take place.

➢ Describe the basic chemical composition of fossil fuels
➢ Describe how the three elements of the fire triangle and a sustained chemical reaction release stored chemical energy from the fuel
➢ Define the following terms as they pertain to combustion:
  o Chemical energy
  o Hydrocarbon
➢ Describe the difference between flash point and fire point
➢ Describe three types of combustion

531-02 Basic Boiler Design
When you complete this lesson, you will be able to explain why different types of boilers are used for different processes. In addition, you will be able to describe the basic components that make up a firetube and watertube boiler and explain the circulation paths through each type of boiler.

➢ Describe the relationship between heating surface and boiler output
➢ Describe the difference between package boilers and field erected boilers
➢ Describe the differences between firetube boilers and watertube boilers and the applications in which they are used
➢ Describe the basic steam and feedwater flow paths through a horizontal-return tubular boiler
➢ Describe the basic components that make up a typical watertube boiler
531-03 Boiler Valves and Steam Fittings
When you complete this lesson, you will be able to identify the different types of valves, gauges, and steam traps used in the operation of a steam boiler. In addition, you will be able to explain how these steam fittings are used to safely operate a steam boiler.

➢ Identify five types of valves commonly associated with steam boiler operation
➢ Describe two types of gauge glasses used in boiler operation
➢ Explain the difference between a safety valve and a relief valve and discuss how they are used in steam boiler operation
➢ Describe the purpose of a pigtail siphon on a Bourdon tube pressure gauge
➢ Describe the purpose of steam traps in conjunction with steam boiler operation and identify the three basic categories of steam traps
➢ Describe the purpose of a feedwater regulator and explain how it is used in steam boiler operation

531-04 Boiler Fuel and Air Systems
When you complete this lesson, you will be able to identify the basic equipment found in high-pressure gas systems and fuel oil systems and describe the design and operation of fuel oil burners. In addition, you will be able to describe boiler draft and identify the different equipment used to control draft in a boiler.

➢ Identify the location of the furnace within the boiler and describe how fuel and air flow affect the firing rate of the boiler
➢ Describe the basic equipment found in high-pressure gas burner systems and explain their operation
➢ Describe the basic components found in a typical fuel oil system
➢ Describe three types of atomizing fuel oil burners and explain the operation of each type
➢ Define the following terms:
  o Draft
  o Forced draft
  o Induced draft
  o Balanced draft

531-05 Boiler Water and Steam Cycle
When you complete this lesson, you will be able to explain the basic components that make up a condensate and feedwater system and describe the flow path through those systems. In addition, you will be able to explain the difference between saturated steam and superheated steam and identify the factors that affect the quality of steam.

➢ Describe the following terms as they relate to heat transfer:
  o Radiation
  o Conduction
  o Convection
➢ Describe the difference between open feedwater and closed feedwater heaters and identify where each type of heater would be found in the condensate/feedwater system
➢ Explain the basic components found in a condensate system and the flow path through the system
➢ Explain the basic components found in a feedwater system and the flow path through the system
➢ Define the term Quality of Steam
➢ Describe the difference between saturated steam and superheated steam

531-06 Boiler Heat Recovery Systems
When you complete this lesson, you will be able to describe the equipment used to recover waste heat in a boiler. In addition, you will be able to describe the basic design and operation of a superheater, economizer, and air preheater.

➢ Describe three types of heat recovery equipment
➢ Explain the purpose of a convection superheater
➢ Explain the purpose of a radiant superheater
➢ Describe the purpose of an economizer and the location of the economizer in the boiler
➢ Explain the difference between a counter-flow economizer and parallel flow economizer
➢ Explain the purpose of an air preheater and describe the difference between tubular and regenerative air heaters

531-07 Scrubbers and Ash Removal Systems
When you complete this lesson, you will be able to identify the primary pollutants emitted from fossil-fired boilers. In addition, you will be able to explain the basic design and operation of baghouses, electrostatic precipitators, and scrubbers.

➢ Describe three harmful pollutants found in flue gas
➢ Describe the difference between bottom ash and fly ash
➢ Explain the basic equipment used to remove bottom ash from a boiler
➢ Explain the basic equipment used to remove fly ash from a boiler
➢ Explain the purpose of a baghouse and describe its basic operation
➢ Explain the purpose of an electrostatic precipitator and describe its basic operation
531-08 Boiler Operator Roles and Responsibilities

When you complete this lesson, you will be able to explain the work environment a boiler operator is subject to and describe the primary responsibilities of a boiler operator. In addition, you will be able to describe the basic rounds and routines an operator completes during their shift.

➢ Describe the typical boiler operator shift schedule
➢ Describe the general work environment boiler operators tend to work in
➢ Explain the basic rounds and routines that boiler operators make during a typical shift
➢ Describe some of the common tasks performed during boiler startup and shutdown

533 Boiler Firing Controls and Components

533-01 Fuel Combustion and Controls

When you complete this lesson, you will be able to understand the importance of complete combustion and describe the components used to make this possible. You will distinguish the different types of fuel controls used on a pulverized unit and a cyclone unit.

➢ Explain a combustion chamber
➢ Discuss the different types of fuels used
➢ Explain a pulverized coal firing process
➢ Explain a cyclone furnace
➢ Describe a fuel oil atomizer
➢ Describe an ignitor and its operation
➢ Explain the different types of oil guns

533-02 Boiler Burner Controls and Management

When you complete this lesson, you will be able to describe the different control types used, control hardware, and the effects of optimizing combustion. You will understand the system requirements for burner management, including flame monitoring techniques and scanning coal flames.

➢ Explain different combustion control types
➢ Discuss control hardware
➢ Explain combustion optimization
➢ Explain system requirements for burner management
➢ Describe flame-monitoring techniques

535 Fundamental Aspects of Emission Controls

535-01 Flue Gas Desulfurization System

When you complete this lesson, you will be able to describe the design and function of control systems that remove sulfur oxides and particulates from flue gas. In addition, you will be able to outline recovery systems, which extract and concentrate the sulfur oxides present in flue gas and convert them into usable by-products.

➢ Identify wastes contained in flue gases
➢ Discuss the basic design and function of a scrubber
➢ Identify the components of a typical wet scrubber and describe its operation
➢ Identify the components of a typical dry scrubber and describe its operation

535-02 Flue Gas Desulfurization System, Open Spray Design, Part 1

When you complete this lesson, you will be able to understand how the design of the open spray FGDS effectively reduces SO₂ and provides substantial flexibility in meeting SO₂ emissions requirements.

➢ Discuss the purpose and operating philosophy behind the FGDS
➢ Describe operation in both the fly ash and lime modes
➢ Explain the use of the absorber tower and reaction tank
➢ Identify the purpose of the spray recycle pumps
➢ Describe the dampers and ductwork
➢ Explain how each of the following features facilitate the meeting of emissions parameters:
  o Absorber bypass fraction
  o Number of absorbers in service
  o Number of spray levels in service
  o Fly ash and lime feed

535-03 Flue Gas Desulfurization System, Open Spray Design, Part 2

When you complete this lesson, you will have an understanding of the overall process of cleaning the SO₂ out of flue gas. In addition, you will have general knowledge of each of the systems used to accomplish this.

➢ Explain what happens to the scrubbing slurry
➢ Discuss the practice of reusing the slurry and identify how the pH is maintained for good scrubbing action
➢ Identify the function of the blowdown system
➢ Describe the pond return system
➢ Explain the operation of a lime system
➢ Identify how the fly ash is used
➢ Explain the operation of the scrubber inverters
535-04 Dry Scrubber Operation Lesson
When you complete this lesson, you will be able to describe dry scrubber design and function. In addition, you will be able to compare the results of different installations, and describe some subtle design and operational differences that are believed to account for the higher pollutant removal efficiencies.

- Explain basic dry scrubber design and operation
- Discuss designing for optimum operation
- Describe gas cooling and the reagent system
- Explain the baghouse material and design

535-05 Selective Catalytic Reduction (SCR) System
When you complete this lesson, you will be able to explain what SCR is and its importance, as well as identify the components that the SCR consists of.

- Describe the purpose of the SCR system
- Understand the chemistry of the SCR System
- Describe the components of the SCR system
- Describe the operation of the SCR system
- List the proper PPE required when using the SCR system

535-09 Introduction to Continuous Emission Monitoring Systems
When you complete this lesson, you will be familiar with the purpose, function, and major components of Continuous Emission Monitoring Systems.

- Identify the purposes of a Continuous Emission Monitoring System (CEMS)
- Distinguish what components are and are not part of the certified loop
- Identify the function of the gas fuel flow transmitters
- Identify the function of the megawatt transmitters
- Identify the function of the probe and sample system

535-10 Fundamentals of Using a CEMS
When you complete this lesson, you will be able to describe the basic steps for collecting Continuous Emission Monitoring System (CEMS) data readings, troubleshooting probe and sample systems, changing calibration gas bottles, and entering new data in the engineering workstation (EWS). You will also be able to describe the process for performing weekly, monthly, quarterly, semi-annual, and annual preventive maintenance (PM) procedures.

- Describe how to collect CEMS data readings
- Describe basic steps required for troubleshooting probe and sample systems
- Describe basic steps required to change calibration gas bottles and enter new data in the engineering workstation (EWS)
- Identify tasks to be performed weekly, monthly, quarterly, semi-annually, and annually for preventive maintenance (PM)

535-11 Calibration of CEMS Components
When you complete this lesson, you will be able to describe how components of the CEMS are calibrated to maintain accurate records of emissions.

- Recall fundamentals for calibrating stack flow monitors
- Recall fundamentals for calibrating Nitrogen Oxide (NOx) analyzers
- Recall fundamentals for calibrating Sulfur Dioxide (SO2) analyzers
- Recall fundamentals for calibrating Carbon Dioxide (CO2) analyzers
- Recall fundamentals for calibrating typical opacity monitors

551 Circulating Water System

551-01 Introduction to the Circulating Water System
When you complete this lesson, you will be able to describe the design and operation of a circulating water system.

- Discuss the function of circulating water system and its role in the operation of a power plant
- Describe typical components used in a circulating water system
- Identify the flow paths that bring circulating water into, through, and out of a typical power plant
- Describe system operation during:
  - Start-up
  - Normal use
  - Shutdown

551-02 Function of the Circulating Water System
When you complete this lesson, you will be able to describe the design and operation of a circulating water system.

- Identify the function of the circulating water system
- Discuss its contribution to efficient power plant operation
- Compare the use of water and air as cooling mediums
- Describe commonly used system designs and identify conditions appropriate for the use of each

551-03 Circulating Water System Components
When you complete this lesson, you will be able to describe the components that make up a circulating water system and explain their functions.

- Discuss common circulating water system designs
- Identify components of a once through type system and describe their features
- Identify components of a recirculating circulating water system and describe their features

551-04 Circulating Water System Start-up
When you complete this lesson, you will be able to explain the steps required to safely start the circulating water system.

- Describe preparation for starting the circulating water system
- List checks performed prior to startup
- Identify the steps completed during startup
- Discuss operators’ responsibilities during startup
- Describe the inspections and checks performed after startup
551-05 Circulating Water System Normal Operations

When you complete this lesson, you will be able to describe how to monitor and adjust the circulating water system during normal operations.

- List circulating water system operating parameters
- Describe how parameters are monitored, and explain how to make minor changes and adjustments
- Discuss circulating water system maintenance during normal operations
- Compare the roles of the field and control room operators, and discuss the importance of coordinating their activities
- Define cycle efficiency

551-06 Circulating Water System Shutdown

When you complete this lesson, you will be able to describe circulating water system shutdown procedures.

- Identify circumstances that prompt shutdown of the circulating water system
- Describe typical shutdown preparations
- List safety measures associated with shutdown
- Explain the steps to shut down the circulating water system

551-07 Circulating Water System Controls

When you complete this lesson, you will be able to describe typical instruments and control systems used within the circulating water system.

- Explain the importance of monitoring and managing the circulating water system
- Describe the use of the following instruments:
  - Level indicator
  - Differential pressure detector
  - Flow meter
  - Pressure meter
  - Temperature detector
- Describe the following automatic controls typically used in the circulating water system:
  - Intake structure instruments
  - Cooling tower instruments
  - Condenser instruments

551-08 Cooling Towers: Operating Principles and Designs

When you complete this lesson, you will be able to explain the operating principles of a cooling tower and identify and describe various cooling tower designs.

- Explain the operating principle of a cooling tower
- List and describe various types of natural draft cooling towers
- List and describe various types of mechanical draft cooling towers
- Describe different air flow path designs of cooling towers
- Describe cooling towers by shape characterization

551-09 Cooling Towers: Components

When you complete this lesson, you will be able to describe the basic structural, mechanical and electrical components used in the construction and operation of cooling towers.

- Identify and describe the following structural components of a cooling tower:
  - Cold water basin
  - Framework
  - Fan deck
  - Fan cylinders
  - Water distribution system
  - Fill
  - Drift eliminators
  - Casing
  - Louvers
- Identify and describe the following mechanical components of a cooling tower:
  - Fans
  - Speed reducers
  - Drive shafts
  - Valves
- Identify and describe the major electrical components of a cooling tower

551-10 Air Cooled Condensers

When you complete this lesson, you will be able to describe basic design principles, structural components, and operating considerations of industrial air cooled condensers.

You will also be able to describe the flow of water for condensation of steam in an A-frame air cooled condenser and discuss typical maintenance procedures for ACCs.

- Discuss the function of an air cooled condenser and its role in the operation of a power plant
- State the purpose for the A-frame design and finned tubes of commonly employed air cooled condensers
- Describe the standard structural components of an A-frame air cooled condenser
- Identify flow paths into and out of an A-frame air cooled condenser
- Discuss an air cooled condenser’s contribution to efficient power plant operation
- List common maintenance concerns for A-frame air cooled condensers utilizing finned tubes

553 Condensate and Feedwater Systems

553-01 Introduction to the Condensate System

When you complete this lesson, you will be able to explain the purpose and operation of all major components in the condensate system. In addition, you will be able to discuss the basic relationship between the condensate and feedwater systems.

- Describe the general function of the condenser
- Define condensate
- Identify the location and purpose of the hotwell
- Explain the basic operation of the condensate hotwell pumps
- Describe the overall design and function of low-pressure heaters
- Discuss the purpose of the gland steam seal condenser and its relationship to the condensate system
- Describe the purpose of a maintaining air ejector and a hogger
- Describe the function of a deaerator
553-02 Introduction to the Feedwater System

When you complete this lesson, you will be able to describe the basic purpose and operation of the major components typically found in a feedwater system. In addition, you will be able to further explain the relationship between the condensate and feedwater systems during boiler operation.

- Discuss the relationship between the deaerator storage tank and boiler feed pumps
- Describe the function of a typical boiler feed pump
- Explain the purpose and operation of the high-pressure heaters
- Discuss the relationship between the boiler economizer and the final feedwater temperature
- Describe the basic design and operation of a typical steam drum

553-03 Condensate and Feedwater Systems Operation

Upon completion of this lesson, you will be able to describe the basic procedures for the start-up and operation of the condensate and feedwater systems.

- Explain the five basic steps typically used to place the condensate system in service
- Discuss considerations taken into account when initially filling the deaerator storage tank
- Describe two methods used to fill the feedwater system
- List four common tasks completed when putting high and low-pressure heat exchangers in service
- Describe basic checks power plant operators routinely make on the condensate and feedwater systems

553-04 Condensate and Feedwater System Control

When you complete this lesson, you will be able to explain steam drum level control methods and discuss their overall relationship to condensate and feedwater flow. In addition, you will be able to describe different types of level measurement used in the condensate and feedwater systems.

- Explain how single element control responds to changes in drum level
- Explain how three element control responds to changes in feedwater flow, steam flow, and drum level
- Describe three types of level indication used in the condensate and feedwater systems
- Explain the basic procedure used in the event of a tube rupture in a high pressure feedwater heater

555 Boiler Feed Pumps

555-01 Boiler Feed Pump and Associated Auxiliary Equipment

When you complete this lesson, you will be able to describe the design and function of a typical boiler feed pump.

- Discuss the purpose and importance of a boiler feed pump
- Describe the boiler feed pump design and operation
- Describe the associated auxiliary equipment
- Explain the use of different drive units

555-02 Boiler Feed Pump Flow Path and Major Components

When you complete this lesson, you will be able to identify the feedwater flow path and describe how various components contribute to its progress.

- Describe the condensate flow to the suction side of the boiler feed pump
- Explain the transition of condensate to “feedwater” and identify where it takes place
- Identify the feedwater’s path after boiler feed pump discharge
- Define what is meant by a “closed loop” system
- Explain the role of the following:
  - Hotwell
  - Deaerator
  - Feedwater heaters
  - Flow control valve
  - Economizer
  - Steam drum

555-03 Boiler Feed Pump Water Supply and Control Systems

When you complete this lesson, you will be able to discuss the value of maintaining proper water levels in the hotwell, deaerator, and steam drum. You will also be able to describe how built-in controls help maintain a balanced system.

- Explain how the condensate and feedwater sides of the process loop are tied together
- Describe the operation of the deaerator level controllers
- Identify the permissives for the boiler feed pump operation
- Describe the function of flow control elements
- Describe the steam drum level gage indicators
- Explain the purpose of the boiler master controller

555-04 Boiler Feed Pump Start-up

When you complete this lesson, you will be able to explain the proper steps to place a boiler feed pump in service.

- Explain the importance of ensuring all conditions and sign-off requirements are met before start-up begins
- Discuss normal start-up of a motor-driven boiler feed pump and describe components associated with this pump
- Discuss normal start-up of a steam-driven boiler feed pump and describe components associated with this pump
- Compare the process of placing a single pump in service to placing two pumps in service
- Identify what permissives will hold out the pump from starting and discuss appropriate responses
- Explain the role of a control room operator in starting the boiler feed pump
555-05 Boiler Feed Pump Daily Operations

When you complete this lesson, you will be able to describe routine tests associated with the boiler feed pump and explain the importance of performing them regularly. You will also be able to explain what steps may be taken in response to test results.

➢ Describe the routine inspections performed daily on the boiler feed pump
➢ Identify tests performed on the boiler feed pump and explain their importance
➢ Discuss the steps an operator may take in the event of a boiler feed pump trip
➢ Describe the procedure to shut down a boiler feed pump under normal conditions

557 Boiler Water and Steam Systems

557-01 Function of Boiler Water and Steam Systems

When you complete this lesson, you will be able to describe the function of the boiler water and the steam systems. You will also be able to distinguish between forced and natural circulation boilers.

➢ Examine boiler water systems
➢ Define boiler steam systems
➢ Distinguish forced circulation boilers from natural circulation boilers

557-02 Flow Paths and Components of the Boiler Water and Steam Systems

When you complete this lesson, you will be able to identify the major components of boiler water and steam systems and explain their functions.

➢ Describe the flow path of the boiler water from the economizer to the boiler shroud and drum
➢ Explain the relationship of drum water and steam levels
➢ Describe the steam cycle through the primary superheater to the economizer
➢ Explain the purpose of the major components along the steam cycle
➢ Identify critical lines, valves, vents, drains, and controls along the main steam line
➢ Explain the relationship of cooling water to the condenser during peak load demands

557-03 Process Controls for Boiler Water and Steam Systems

When you complete this lesson, you will be able to describe the process and controls of the boiler water and steam systems.

➢ Describe the process controls for the boiler drum level
➢ Explain the relationship of steam flow, fuel, and air supplies and describe the controls that oversee this relationship
➢ Examine the methods of control for low water fuel cutoffs

557-04 Start-up Procedures for the Boiler Water and Steam Systems

When you complete this lesson, you will be able to identify and explain the general start-up procedures for a boiler's steam and water cycle.

➢ Examine the initial conditions
➢ Explain boiler feed pump operations
➢ Describe and perform start-up procedures

557-05 Normal Operation of the Boiler Water and Steam Systems

When you complete this lesson, you will be able to describe the normal operations of the water and steam cycle within a power generating unit, the relationship of components within the system, and the effect of adjustments made to those components that may affect the efficiency and safety of the plant's normal operation.

➢ Describe the relationship of system components to maintain boiler water levels
➢ Sequence the steps in the boiler water cycle
➢ Identify and explain the relationship of components within the boiler steam system
➢ Identify moisture erosion, its causes, and preventions

557-06 Shutdown of the Boiler Water and Steam Systems

When you complete this lesson, you will be able to identify and explain the shutdown process for the steam and water systems in the boiler.

➢ Identify and describe the shutdown process for the steam cycle
➢ Describe the shutdown process for the boiler water systems
➢ Identify the procedures for opening the boiler and preparing it for maintenance during shutdown

559 Water Treatment

559-01 Molecular Chemistry of Water

When you complete this lesson, you will be able to discuss which elements combine to form water and why they bond. You will also learn some basic history of water and its special characteristics.

➢ Discuss the history and importance of water
➢ Describe the atom's molecular structure and electromagnetic forces
➢ Review Dalton's Atomic Theory
➢ Describe the atomic makeup of a water molecule and how this applies to water chemistry
➢ List some of the unique characteristics of water
559-02 Elements and the Periodic Table of Elements

When you complete this lesson, you will understand how elements are named, grouped, and listed on the periodic table.

- Discuss the history of the periodic table of elements
- Describe the role elements play in chemistry
- Explain the importance of an element's atomic weight, atomic number, and symbol
- Discuss how electrons in the outer shell of an atom relate to chemical reactions and bonding
- Describe the organizational pattern of the periodic table of elements and list classifications of elements

559-03 Chemical Compounds

When you have completed this lesson, you will be able to identify individual compounds and describe their creation, reactions, and bonds. You will also be able to demonstrate a working knowledge of solutions.

- Discuss the chemical makeup of compounds and explain how they differ from mixtures
- Describe the chemical bonding process and identify different types of bonds
- List the four types of chemical reactions
- Demonstrate how to write chemical equations and formulas
- Describe solutions, solubility, and saturation; discuss the role each plays in the treatment of water

559-04 Corrosion Causes and Effects

When you complete this lesson, you will be able to identify the causes and effects of the various types of corrosion found throughout the water and steam systems in an industrial facility.

- Define corrosion and discuss its causes
- Explain how corrosion relates to erosion
- Identify major types of corrosion and describe how each can affect industrial plant systems
- Relate hydrogen and hydroxyl ions to acids and bases, and discuss roles each can play in corrosion
- List factors that affect the corrosion process in a boiler

559-05 Corrosion Control in Steam Production

When you complete this lesson, you will be able to describe how corrosion affects various systems within a steam production facility and explain how to detect common failures caused by excessive corrosion. In addition, you'll be able to identify causes and discuss means employed to control corrosion.

- Identify types of water treatment programs and discuss their goals
- Describe the cause and effect of corrosion in the following:
  - Pre-boiler or feedwater system
  - Boiler system
  - Condensate system
- Explain the steps facilities take to control or eliminate corrosion in the water and steam path
- Explain how corrosion can be minimized by identifying condenser tube leaks through chemical analysis of steam plant water
- Describe how boiler chemistry control can reduce the adverse effects of condenser tube leaks

559-06 Steam Chemistry Control Guidelines

When you complete this lesson, you will be able to describe the importance of steam purity and chemistry to the steam turbine. In addition, you will be able to identify how water and steam chemistry are monitored and controlled.

- Define steam purity and describe factors that affect it
- Explain the mechanics of steam drum carryover and identify its impact on the steam system
- Discuss steam turbine deposition and types of corrosion
- Examine the critical control guidelines for water treatment
- Describe the best areas for sampling

559-07 Industrial Water Treatment Systems

When you complete this lesson, you will be able to describe the water pretreatment and treatment process, as it may exist in a typical industrial plant. In addition, you will be able to discuss chemical cleaning options for boilers and turbines.

- Describe how the source of raw water impacts which treatment systems and procedures are required
- Follow the flow from the source through the water treatment system
- Describe the systems and components used in the following pre-treatment operations:
  - Clarification
  - Filtration
  - Demineralization
- List chemicals commonly used in water treatment and identify their purpose
- Discuss chemical cleaning options and explain how they impact the boiler and turbine efficiency
559-08 Introduction to Desalination
When you complete this lesson, you will be able to define desalination and discuss its importance to society. You will also be able to describe membrane and thermal technologies used for the desalination process, as well as the purpose of pre- and post-treatment systems.

➢ Define desalination
➢ Describe the process of solar distillation
➢ State the main differences between membrane and thermal desalination technologies
➢ Discuss the following primary methods of desalination:
  o Reverse osmosis
  o Electrodiagnosis
  o Multi-stage flash
  o Multi-effect distillation
➢ State the purpose of pre- and post-treatment systems as they pertain to desalination technologies

559-09 Desalination: Pre- and Post-treatment of Water
When you complete this lesson, you will be able to discuss industry standard pre- and post-treatment applications for desalinated water. You will also be able to discuss concerns associated with bringing seawater into a desalination system for processing, and describe specific pre- and post-treatment applications common to processing water through reverse osmosis and thermal distillation desalination systems.

➢ Explain why seawater is harmful to desalination systems
➢ Define potable water and identify the international agency responsible for setting quality standards for potable water
➢ State two factors that drive the pretreatment and post-treatment applications employed at a desalination facility
➢ Discuss the process and importance of the chlorination -dechlorination-chlorination application required at reverse osmosis facilities
➢ List standard pre- and post-treatment applications discussed in this lesson and describe the general purpose of each
➢ State and example of when post-treatment of water is NOT required

559-10 Reverse Osmosis
When you complete this lesson, you will be able to discuss the scientific principles on which reverse osmosis (RO) technology is based and explain the primary function of a reverse osmosis desalination system. You will also be able to identify the key components of a typical reverse osmosis system, with an emphasis on membrane technology, and describe the importance of permeate recovery percentage.

➢ State the main purpose of reverse osmosis technology
➢ Discuss the scientific principles of osmosis and osmotic pressure
➢ State the purpose of high pressure pumps in a reverse osmosis system
➢ Identify the main components of a spiral wound reverse osmosis membrane
➢ Describe the construction of spiral wound membranes and discuss how they separate permeate and concentrate from feedwater
➢ Describe the construction and purpose of a reverse osmosis vessel
➢ Discuss the flow of saline water through a reverse osmosis system from intake to collection
➢ Discuss the purpose of energy recovery systems used in a reverse osmosis desalination system
➢ Describe the purpose of reverse osmosis pre- and post-treatment applications
➢ Calculate permeate recovery percentage and describe factors that can affect this percentage

559-11 Thermal Desalination Technologies
When you complete this lesson, you will be able to discuss the principles on which thermal desalination technologies are based and explain the importance waste heat or steam plays in multiple effect distillation (MED) and multi-stage flash (MSF) systems. You will also be able to discuss the key components of MED and MSF systems, including the function of evaporators, condensers, demisters, and brine heaters. And you will be able to distinguish between multi-stage flash and multiple effect distillation technologies by comparing the differences between them.

➢ Define distillate and distillation
➢ Discuss how freshwater is created through the process of evaporation and condensation
➢ Describe how an industrial thermal desalination facility can be an economic option for freshwater production by utilizing waste heat and processing source water through multiple stages
➢ Explain the functions of the heat exchanger tube bundles and brine pool in a multiple effect distillation system
➢ Explain the functions of the brine heater, brine pool, and demister in a multi-stage flash distillation system
➢ Describe the flow of water from intake to collection in a multiple effect distillation (MED) system using terminology from this lesson, including:
  o Evaporator
  o Effect
  o Condensation
  o Vapor
  o Condenser
➢ Describe the flow of water from intake to collection in a multi-stage flash (MSF) system using terminology from this lesson, including:
  o Stage
  o Brine heater
  o Demister
  o Condenser
560 Plant Electrical Systems

560-01 Main Transformers

When you complete this lesson, you will be able to describe the overall design and function of a main station transformer. In addition, you will be able to discuss systems and inspections related to transformer protection.

➢ Explain the purpose of a main station transformer
➢ List major components of a main transformer and identify their individual functions
➢ Describe the use of protective devices associated with the main transformer
➢ Discuss some safety considerations when working around a main station transformer
➢ Produce a checklist for operators performing a routine inspection

560-02 Station Service System

When you complete this lesson, you will be able to describe the general design and operation of a station service system.

➢ Describe the function of a station service system
➢ Identify major station service components
➢ List tasks performed during a routine station service inspection
➢ Explain the relationship between the essential service system and the station service system
➢ Identify essential station service components
➢ List tasks performed during routine essential service system inspections

560-03 Fuses and Circuit Breakers

When you complete this lesson, you will be able to explain the design and function of commonly used fuses and circuit breakers, and how to test and protect them.

➢ Identify some applications that employ fuses
➢ Compare the operation of plug fuses to cartridge fuses
➢ Discuss factors to consider before replacing a fuse
➢ Explain the general function of a circuit breaker
➢ Identify three methods of extinguishing an arc in an air circuit breaker
➢ Lists commonly used types of circuit breakers and compare their operation

560-04 Protective Relays and Instrument Transformers

When you complete this lesson, you will be able to describe the design and function of various types of protective relays and instrument transformers used to protect electrical circuits and equipment.

➢ Identify the principles behind the operation of protective relays
➢ Identify different types of protective relays
➢ Identify protective relay operating indicators
➢ Identify the principles behind the operation of instrument transformers
➢ Compare the uses of potential transformers and current transformers

560-05 Equipment Disconnects and Grounding

When you complete this lesson, you will be able to describe the design and function of disconnects used to isolate electrical circuits. You will also be able to explain some methods of grounding plant equipment.

➢ Explain the purpose and operation of disconnects
➢ List various types of disconnects and describe their use
➢ Explain the purpose of grounding
➢ Describe various grounding techniques
➢ Identify advantages of neutral grounding
➢ Discuss safety precautions taken when working with disconnects and grounding

561 Unit Start-up and Shutdown

561-01 Preparing for Power Plant Start-ups

When you complete this lesson, you will be able to describe the basic checks that must be performed on plant equipment, including the boiler, turbine, and generator, prior to a power plant startup.

➢ Recognize the role an electrical dispatcher plays in preparing for a power plant startup
➢ Recall the purpose of determining appropriate ramp rates for starting up the boiler and turbine
➢ List the four basic categories of pre-startup checks on each of the following:
  - Boiler
  - Steam turbine
  - Generator

561-02 Power Plant Start-up Procedures

When you complete this lesson, you will be able to describe the basic concepts and typical tasks associated with putting a fossil fuel-fired power plant online.

➢ Describe the basic steps associated with the following tasks:
  - Filling the condensate/feedwater system
  - Firing a steam boiler
  - Rolling a steam turbine
  - Synchronizing a generator to the electrical grid
  - Increasing load
➢ Explain the purpose of turbine preheating
561-03 Preparing for Power Plant Shutdown
When you complete this lesson, you will be able to describe the basic tasks that must be performed on plant equipment prior to a power plant shutdown.

- List and define the three classifications of power plant shutdowns
- Discuss the purpose of blowing soot and removing ash from the boiler
- Discuss coal system preparations completed prior to a scheduled shutdown
- Explain what four conditions must simultaneously exist while reducing the firing rate on a boiler
- Describe each of the basic tasks associated with ramping-down a turbine/generator

561-04 Power Plant Shutdown Procedures
When you complete this lesson, you will be able to describe the basic steps associated with taking a fossil fuel fired power plant off-line. In addition, you will be able to explain how operators prepare a power plant for an annual outage.

- Describe the common sequence of steps to remove a pulverizer from service for an extended period of time
- Describe the basic steps followed to take each of the following out of service:
  - Scrubber
  - Steam turbine
  - Generator
- Explain how a power plant is prepared for an annual outage

563 Efficiency, Reliability, and Environmentally Sensitive Operations

563-01 Basic Power Plant Efficiency
When you complete this lesson, you will be able to explain the relationship between energy, work and efficiency. Heat rate, the term used to express power plant efficiency will be part of your vocabulary. You will be able to explain how the boiler, turbine cycle, and generator comprise plant heat rate. You will be able to explain how heat rate is affected by key plant parameters known as performance parameters. Finally, you will be able to explain the roles of operations, maintenance, engineering, and plant management in the plant heat rate program.

- Explain the relationship between energy, work, and efficiency
- Describe the relationship between gross heat rate, net unit heat rate, and design heat rate
- Describe typical efficiencies of the three main parts of a power plant: the boiler, turbine cycle, and generator; and the role they play in overall plant efficiency.
- Explain how heat rate is affected by key plant parameters known as performance parameters
- Explain the roles of operations, maintenance, engineering, and plant management in the plant heat rate program

563-02 Water and Steam: Terms and Principles
When you complete this lesson, you will be able to explain the relationship between energy, temperature, and the phases of water. You will also be able to describe the concept and importance of latent heat, the heat associated with phase changes of water without a temperature change. Given the weights of both steam and liquid water in a vessel, you will be able to calculate quality and moisture content. You will be able to explain the relationship of a subcooled liquid, saturated liquid, saturated steam, latent heat of vaporization, and superheated steam on a provided temperature/enthalpy diagram.

- Explain the relationship between energy, heat, and phase changes of water
- Define terms associated with water as heat is added and removed. For example:
  - Subcooled liquid
  - Saturated liquid
  - Saturated steam
  - Quality
  - Moisture content
  - Superheated steam
- Explain the relationship between operating boiler pressure and the ability of the boiler to utilize natural circulation
- Describe the concept of the critical point, supercritical fluid, and the benefits of operating at such high pressure

563-03 Heat Transfer Principles
When you complete this lesson, you will be able to state the primary parameter that causes heat transfer. You will be able to explain the three types of heat transfer and the characteristics of them. You will also be able to describe conditions and problems that negatively affect proper heat transfer. Finally, you will be able to determine heat transfer rate given operating parameters in heat transfer equipment.

- Define heat transfer
- State the parameter that causes heat transfer
- Explain the three forms of heat transfer
- List problems that can hinder proper heat transfer in equipment designed to transfer heat
- Given operating parameters in heat transfer equipment, calculate the rate of heat transfer

563-04 Laws and Principles of Thermodynamics
When you complete this lesson, you will be able to explain thermodynamics. You will also be able to describe thermodynamic terms in your own words. You will also be able to explain the relationship of thermodynamic principles to plant efficiency.
Define thermodynamics in your own words
Explain the thermodynamic properties of steam and water as they pertain to a power plant
Describe the thermodynamic laws in your own words
Given appropriate parameter values, plot basic power plant processes on either a temperature/enthalpy or enthalpy/entropy chart
Explain what happens to related thermodynamic parameters through common power processes and equipment

563-05 Performance Parameters
When you complete this lesson, you will be able to list several key operating parameters that affect efficiency. You will also be able to describe in your own words problems that can prevent key operating parameters from being operated at optimum level. You will be able to calculate the approximate extra fuel cost associated with operating a key performance parameter off design value.
- Describe net unit heat rate in your own words
- List several key operating parameters that affect net unit heat rate
- Describe in your own words problems that can prevent key operating parameters from being operated at optimum level
- Given industry average data, calculate the approximate effect on net unit heat rate when a key operating parameter is operated off the design value
- Given appropriate supporting data, calculate the approximate extra fuel cost associated with operating a key performance parameter off of design value

563-06 Balancing Efficiency, Availability, Capability and Flexibility
When you complete this lesson, you will be able to explain efficiency, capability, flexibility, and availability in your own words. You will be able to describe the concept of economic dispatch. You will also be able to discuss running and shutdown reserves and the reasons they are important.
- Explain the concepts of economic dispatch
- List the two reserve categories. Explain their importance
- Discuss Power Plant unit efficiency especially concerning how it fits into economic dispatch
- Explain the importance of maintaining power plant unit capability as high as feasible
- List and discuss the components of power plant unit flexibility especially concerning their importance in economic dispatch
- Discuss the importance of power plant units being available when needed

563-07 Instrumentation and Controls
When you complete this lesson, you will be able to explain the basic operation of a boiler-following instrumentation and control system. You will be able to describe the effects when actual parameter values are different than what is indicated. You will also be able to explain common responses to instrumentation and control problems.
- Explain the basic operation of a boiler-following instrumentation and control system
- Describe the effects on efficiency and/or availability when actual parameter values are different than what is indicated
- List common systems and parameters controlled by generating unit instrumentation and control systems
- In your own words, describe how a control system responds when it receives an erroneous signal from an instrument such a thermocouple
- Explain common operator responses to instrumentation and control problems

563-08 Boiler Efficiency
When you complete this lesson, you will be able to describe boiler efficiency and explain how it is determined. You will be able to discuss the major factors that can cause an increase or decrease in boiler efficiency.
- Identify parameters that influence boiler efficiency and describe their effect
- Discuss problems that can reduce proper heat transfer in boiler components
- Explain what is meant by the term “boiler envelope”
- Explain the input/output method of determining boiler efficiency and list the associated inputs and outputs
- Explain the heat loss method of determining boiler efficiency and list the associated losses
- List the main boiler components and describe problems that can decrease their efficiency

563-09 Boiler Reliability
When you complete this lesson, you will be able to explain the importance of maintaining proper boiler parameters. You will also be able to identify several things that can decrease a boiler’s reliability.
- Describe why controlling steam temperatures and pressure, drum level, and flow are vital to maintaining boiler reliability
- Identify the effects of flow, level, and heat-up/cool down rates on boiler reliability
- Explain how operating outside established chemistry parameters can quickly reduce a boiler’s reliability
- Describe key operational steps to help protect boilers during start-up and shutdown
- List common permissives that must be met before a fire can be ignited in a boiler
- Explain how tube leaks can affect boiler reliability
563-10 Turbine Efficiency
When you complete this lesson, you will be able to explain how to calculate turbine efficiency. You will also be able to describe how parameters, components, and problems can affect turbine efficiency.
➢ Explain the two methods of calculating turbine efficiency
➢ Describe how each of the following affects turbine efficiency:
  o Chemical deposits and internal erosion
  o Internal and external seal leakage
  o Variations in steam temperature and pressure
  o Backpressure
  o Attemperation spray flow
  o Extraction steam flow
➢ Explain how control valves can be the source of a loss that is typically attributed to the turbine

563-11 Condenser Efficiency
When you complete this lesson, you will be able to explain how to evaluate and maintain condenser efficiency.
➢ Identify the roles of key parameters associated with condenser efficiency
➢ Describe the main energy flows into and out of the condenser
➢ Explain how to calculate condenser efficiency
➢ Identify the terms of the general heat transfer equation as it applies to a condenser
➢ Use a condenser performance curve and condenser operating parameters to determine if condenser efficiency is satisfactory
➢ Use condenser pump selection curves and condenser operating parameters to determine the optimal number of circulation water pumps
➢ Explain the relationship between back pressure, turbine exhaust temperature, and condenser problems

563-12 Condenser Operation and Reliability
When you complete this lesson, you will be able to describe methods of troubleshooting condensers and identify symptoms of several problems that can negatively affect condenser reliability. You will also be able to discuss methods ofremedying specific condenser problems and optimizing operational performance.
➢ Describe the symptoms of these problems that reduce the effective heat transfer area of an operating condenser:
  o Air in-leakage
  o Problems with air removal equipment
  o High hotwell levels
  o Improperly vented waterboxes
  o Blocked or plugged tubes
➢ Describe the symptoms of these problems that reduce the heat transfer coefficient of a condenser:
  o Scaling
  o Micro-fouling
  o Dirt, debris, and sludge
  o Oxidation and rust
➢ Describe the symptoms of these problems that increase average circulating water temperature of an operating condenser:
  o Overloading
  o Insufficient circulating water flow
  o High circulating water inlet temperature
➢ Given a condenser pump selection curves and condenser operating parameters, determine the optimum number of circulation water pumps to run

563-13 Feedwater Heater Operation and Efficiency
When you complete this lesson, you will be able to describe feedwater heater operations and discuss problems that affect performance.
➢ Describe the normal operations of a feedwater heater
➢ Identify problems commonly associated with feedwater heaters and describe how they affect unit efficiency and reliability
➢ Discuss the following methods of evaluating feedwater heater performance.
  o Feedwater heater temperature rise
  o Drain Cooler Approach (DCA)
  o Terminal Temperature Difference (TTD)
563-14 Pump Efficiency and Reliability

When you complete this lesson, you will be able to describe commonly used pumps and discuss their maintenance.

➢ Describe the two major classifications of pumps and discuss their primary applications
➢ Define the following terms associated with pump operation:
  o Capacity
  o Head
  o Power
  o Efficiency
➢ Describe basic operating and maintenance techniques used to keep pumps operating efficiently and reliably
➢ Define net positive suction head (NPSH) and describe the relationship between available and required NPSH
➢ Given pump curves associated with a given pump, determine associated operating parameters for various pump operating capacities
➢ List and explain the pump laws

563-15 Environmentally Sensitive Operations

When you complete this lesson, you will be able to discuss a power plant’s potential environmental impacts and describe methods to minimize them.

➢ Explain the relationship between power plant unit efficiency and environmental impact
➢ List some categories of environmental impact associated with power plants
➢ Discuss the negative and positive effects of greenhouse gases
➢ Identify the environmental effects of improper boiler combustion
➢ Define the following terms as they apply to boiler combustion:
  o Greenhouse gases
  o Incomplete combustion
  o NOx
➢ Describe methods of removing environmentally unfriendly substances from boiler flue gas

565 Plant Control System

565-01 Distributed Control System Fundamentals

When you complete this lesson, you will be able to describe the design and function of a typical distributed control system (DCS).

➢ Describe the functions of a typical distributed control system (DCS)
➢ List and briefly describe the main components or elements of a DCS
➢ Explain the use of a remote control panel in the DCS
➢ Discuss communications mediums available for use in DCS; list advantages and disadvantages of each choice
➢ Describe the purpose of a central control facility (control room) associated with a DCS
➢ Describe the functions of the human machine interface (HMI)
➢ Discuss the reasons for different levels of authority on various HMI stations
➢ Identify the functions of control, interface, and database software associated with DCS

565-02 Distributed Control System Components

When you complete this lesson, you will be able to list the components associated with a common distributed control system (DCS) and describe their functions.

➢ List and briefly describe plant instrumentation used to collect system parameter and equipment data to be used in a DCS
➢ Describe the general design and function of the following DCS components:
  o Instrumentation
  o Transmitters and input/output modules
  o Processors
  o Multiplexers
  o Electrical/computer busses
  o Human-machine interface
  o Control devices/actuators
➢ Discuss the flow of information through the DCS and describe how that information is used to monitor and control power plant systems, parameters, and equipment

565-03 Using Distributed Control System Diagrams

When you complete this lesson, you will be able to describe the basic symbols and parts of a logic diagram. You will also be able to explain how to use a DCS logic diagram as a troubleshooting tool.

➢ Identify basic logic symbols used in logic diagrams
➢ List the parts of a drawing title block
➢ Explain the purpose of a drawing legend
➢ Discuss permissives and interlocks associated with control systems
➢ Describe how a control loop maintains a parameter at its control setpoint
➢ Discuss the use of trip setpoints
➢ Describe how the feedback function in a control loop helps keep processes stable
➢ Describe trim and bias control logic features
➢ Discuss general troubleshooting steps and techniques
565-04 Power Plant Unit Control

When you complete this lesson, you will be able to describe the basic design and function of a boiler-following instrumentation and control system.

➢ Discuss the basic operation of a boiler-following distributive control system (DCS)
➢ Explain how changing power plant load affects steam temperature, pressure, and flow
➢ Discuss how the DCS maintains parameters at their designed values when unit load changes
➢ Discuss the relationship between the following:
  o Fuel flow and associated unit parameters
  o Fuel flow, furnace draft, air flow, and excess oxygen
  o Feedwater flow, steam flow, unit load, and boiler drum level
➢ Identify operator responsibilities in controlling key operating parameters, systems, and equipment during normal operation

567 Heat Rate Optimization

567-01 Understanding the Basic Properties of Water and Steam

When you complete this lesson, you will be able to describe the properties of water in its liquid, solid, and gaseous states. In addition, you will be able to explain how heat and pressure effect changes between these states.

➢ Define temperature
➢ Define heat
➢ Explain the difference between temperature and heat
➢ Define enthalpy
➢ Describe the relationship between the latent heat of fusion and changing the state of water from a solid to a liquid
➢ Describe the relationship between the latent heat of vaporization and changing the state of water from a liquid to a gas
➢ Discuss how pressure affects the boiling point of water

567-02 Saturated Steam Tables

When you complete this lesson, you will be able to explain the terms associated with the physical characteristics of water, saturated steam, and superheated steam. In addition, you will be able to interpret and discuss the information illustrated in steam tables.

➢ Define saturation temperature
➢ Explain what is meant by the term "saturated steam"
➢ Define saturation pressure
➢ Identify the critical point of water
➢ Explain the difference between enthalpy and entropy
➢ Define superheated steam
➢ Describe the two categories of saturated steam tables and discuss their use

567-03 Superheated Steam Tables

When you complete this lesson, you will be able to discuss the physical characteristics of superheated steam under various conditions. In addition, you will have the ability to interpret the information found in superheated steam tables and employ it in practical applications.

➢ Identify the kinds of information found in a superheated steam table
➢ Describe the information found on a Mollier diagram
➢ Discuss the relationship between the Btu in boiler fuels and the Btu in superheated steam
➢ Use a steam table to explain what is meant by “no distinguishable differences” at the critical point of water

581 Diesel Power Plant Operations

581-01 Diesel Engines for Power Generation

When you complete this lesson, you will be able to describe the design and operation of a diesel engine. In addition, you will be able to explain the importance of the diesel generator.

➢ Describe the theory behind the basic operation of a diesel engine
➢ Identify the major components of the diesel engine and explain the function of each
➢ Describe what happens during each of the following operating cycle events:
  o Intake
  o Compression
  o Injection
  o Combustion
  o Power
  o Exhaust
➢ Identify the difference between a two-stroke and four-stroke diesel engine
➢ Discuss the role of the diesel generator in our society

581-02 Diesel Engine Support Systems

When you complete this lesson, you will understand the operation and importance of the supporting systems that make the diesel engine run and operate efficiently.

➢ Describe the diesel engine cooling system
➢ Explain the importance and function of the lubrication system used in the diesel engine
➢ Describe how the fuel system stores, cleans, and delivers the fuel to the diesel engine
➢ List the components of the diesel engine’s air intake and exhaust systems and identify their functions
581-03 Diesel Powered Generation

When you complete this lesson, you will be able to describe applications for diesel powered generators and explain the effects they have on society and the environment.

➢ Describe where, and under what circumstances, diesel powered generation is used
➢ Identify benefits to society provided by a diesel powered generator
➢ Discuss the importance of installing and using diesel powered generators
➢ Describe the features of the most common type of generator and explain how it works

581-04 Diesel Power Plant Operations

When you complete this lesson, you will be able to describe basic diesel power plant operations.

➢ Explain how to prepare the unit for start-up
➢ Explain how to energize the station service supply
➢ Describe on-load operations monitoring
➢ Walk through a typical shutdown procedure

581-05 Diesel Plant Control Systems and Protective Devices

When you complete this lesson, you will be able to describe the design and function of a typical control panel and identify its primary components. You will also be able to explain the importance of the protective devices built into the system.

➢ Describe a typical control panel
➢ Explain the operation of some of the generator controls
➢ Describe a remote operation and explain how it works
➢ Identify some of the hazardous machine conditions
➢ Discuss protective devices and identify what they protect

581-06 Diesel Plant Routine Maintenance

When you complete this lesson, you will be able to describe routine diesel inspections and discuss their contribution to safe and efficient operations.

➢ Identify the standard timeframes associated with the routine inspections of diesel plant systems
➢ Explain how routine inspections affect outages and downtime
➢ Describe the maintenance performed on each of the following:
  o Prime mover
  o Generator and exciters
  o Switchgear

582 Combined Cycle Power Plant Operations

582-01 Combined Cycle Power Plants

When you complete this lesson, you will be able to describe the basic thermal cycles of a combined cycle power plant, including topping and bottoming cycles. You will also be able to list advantages and disadvantages of various combined cycle configurations and define common terminology associated with combined cycle operations.

➢ Explain the thermal cycles of combined cycle plant
➢ Describe a combined cycle plant “topping” cycle
➢ Describe a combined cycle plant “bottoming” cycle
➢ List advantages of a combustion turbine-water/steam combined cycle system
➢ Compare combined cycle plant efficiencies with the efficiencies of simple cycle plants
➢ Describe the way that simple cycle efficiencies can be increased
➢ Define cogeneration and IGCC
➢ Describe the effects of combustion air cooling and supplemental HRSG firing
➢ Explain the difference between a single shaft and multi-shaft combined cycle configurations
➢ Describe the use of single pressure and multi-pressure steam cycle designs

582-02 Combined Cycle Power Plant Components

When you complete this lesson, you will be able to identify and describe the major components of a combined cycle power plant.

➢ Describe the design and operating principles of a combustion turbine used in a combined cycle application
➢ Describe the design and operating principles of a heat recovery steam generator used in a combined cycle application
➢ Describe the design and operating principles of an electrical generator used in a combined cycle application
➢ Describe the purpose of a stack damper on combined cycle units
➢ Explain the use of supplementary firing in heat recovery steam generators
➢ Be able to explain the natural and forced circulation in the steam production process
➢ Explain the purpose of selective catalytic reduction and carbon monoxide catalyst systems in the operation of a combined cycle power plant
➢ Be able to explain the purpose of reheat steam
582-03 HRSG – Flow Path and Major Equipment

When you complete this lesson, you will be able to identify and describe the major components and flow paths of a HRSG.

➢ Recall the function of a HRSG
➢ Describe the purpose of the economizer in a HRSG
➢ Describe the purpose of the evaporator in a HRSG
➢ Describe the purpose of the steam drum in a HRSG
➢ Describe the purpose of the superheater in a HRSG
➢ Outline the flow path of the combustion gas through the HRSG
➢ Outline the flow path of the water/steam through the HRSG
➢ Explain the relationship of water flow vs steam flow

582-04 HRSG – Auxiliary Equipment and Systems

When you complete this lesson, you will be able to identify some auxiliary systems that may be found in a HRSG and recall their purpose and benefit to the unit.

➢ Recall the purpose of the following systems:
  o Supplementary firing
  o Bleed Air
  o Deaerator
  o Attemperator
  o Sampling
  o Dosing
  o Selective Catalytic Reduction (SCR)
  o CO catalyst
  o Nitrogen
➢ Identify the general location of the following systems:
  o Supplementary firing
  o Deaerator
  o Selective Catalytic Reduction (SCR)
  o CO catalyst
➢ Relate the operating conditions in which supplementary firing would be impactful
➢ Describe the mechanism by which deaerators fulfill their purpose
➢ List some qualities for which analyses are frequently performed in the steam/water cycle
➢ State why SCR systems and CO catalyst systems have been put in place
➢ Relate what operating conditions a nitrogen system would be used in

582-05 HRSG - Basic Operating Concerns and Conditions

When you complete this lesson, you will be able to describe the steps to startup and shutdown the HRSG, and the steps to confirm it is operating normally. Additionally, conditions that may cause concern during operation will be covered.

➢ Explain important steps during startup, shutdown, and normal operations
➢ Explain the need for maintaining steam flow during the startup process
➢ State why the operating environment of the HRSG is important
➢ Describe why the use of vents and drains ensures steam quality
➢ Identify what shutdown conditions would modify the shutdown procedure
➢ Recall why and how pressure and temperature affect the life expectancy of the HRSG
➢ Explain how pressure is created during the steam production process
➢ Explain how pressure and temperature are controlled in the steam systems
➢ Define cycling
➢ Identify what components are most susceptible to failure when cycling
➢ Explain and define:
  o Stress corrosion cracking
  o Fatigue corrosion cracking
  o Thermal fatigue
  o Creep

582-06 Combined Cycle Steam and Feedwater Operating Principles

When you complete this lesson, you will be able to describe the feedwater and steam flowpaths in a typical combined cycle power plant. You will also be able to explain the HRSG design principles governing plant operation.

➢ Describe the system flow path of a basic single-pressure cycle
➢ Describe the function of the following components of a HRSG:
  o Economizer
  o Evaporator
  o Superheater
➢ Explain the concept of a pinch point
➢ Describe the system flow path of a dual-pressure (HP and LP) cycle
➢ Describe the system flow path of a triple-pressure (HP, IP, and LP) cycle
➢ Explain the purpose of a pegging steam line
➢ Describe the system flow path of a triple-pressure cycle with reheat
➢ Explain the operation of a HRSG feedwater pump
➢ Describe the function of a steam attemperator

582-07 Combined Cycle Condensate and Circulating Water Systems

When you complete this lesson, you will be able to explain the flow paths of the condensate and circulating water systems and describe their major components. You will also be able to explain the design principles governing the operation of these systems.
Describe the purpose of the Condensate System in a combined cycle plant

Explain the operation of a Water-Cooled Condenser

Explain the operation of an Air-Cooled Condenser

Describe the purpose of a steam jet air ejector, vacuum pump, and hogger

Describe the function of a deaerator

Describe the common deaerator arrangements used in combined cycle power plants

Explain the difference between a once-through and a closed-circuit circulating water system

Describe the purpose of a cooling tower in a combined cycle circulating water system

582-08 Combined Cycle Auxiliary Systems

When you complete this lesson, you will be able to describe the function and operation of the auxiliary components and systems found in a typical combined cycle power plant.

Describe the function of the Closed Cooling Water System

List the typical heat loads cooled by the auxiliary cooling water system

Explain the reason for maintaining chemistry control of boiler water

Describe the common methods of HRSG chemistry control, including the following:
  o All volatile treatment
  o Phosphate treatment
  o Caustic treatment

List the common parameters monitored by the water treatment, sampling, and analysis systems

582-10 Steam Turbines in a Combined Cycle Plant

When you complete this lesson, you will be able to describe the basic components of a steam turbine and explain their purpose in relation to a combined cycle power plant. In addition, you will be able to identify common turbine auxiliaries and describe basic steam turbine operations.

Describe the energy conversions that take place between the HRSG and steam turbine

Recall the steam flow path through a high, intermediate, and low-pressure turbine

Identify the purpose of the following steam turbine valves:
  o main steam stop valves
  o turbine governor and control valves
  o reheat and intercept valves

Identify the difference between full arc admission and partial arc admission

583 Hydroelectric Power Plant Operations

583-01 The Hydroelectric Role in the Power System

When you complete this lesson, you will be able to explain the advantages of hydroelectric power and describe the significant contributions of hydroelectric energy to the environment and economy.

Identify hydroelectric contributions

Examine the roles of hydroelectric power within the power system

Review specific advantages of hydroelectricity

583-02 Hydroelectric Power Stations

When you complete this lesson, you will be able to identify the major components in a hydroelectric power station. You will also examine the operations of hydroelectric power stations, describe variations among them, and explain the components common to each hydropower generating station.

Describe a variety of hydroelectric plant construction designs

Define the principles of hydropower operations

Explain the purpose of various hydropower plant components

583-03 Water Management

When you complete this lesson, you will be able to identify the various issues of water management and their impacts on hydroelectric power generation.

Explain the importance of inflow forecasting when determining the efficient production of hydroelectric power

Describe environmental considerations when constructing hydroelectric generating stations

Examine water management policies

583-04 Hydroelectric Generators

When you complete this lesson, you will be able to identify and describe the operations of the hydroelectric power generator and the component of the lower unit.

Examine the design characteristics of the penstock, scroll case, and suction tube

Describe the wicket gate operations

Characterize a number of turbine types and their uses

Describe guide and thrust bearings

Identify stators and generator supports

Explain generator operations
583-05 Generator Monitoring and Control
When you complete this lesson, you will be able to describe the monitoring and controlling of the generator in hydroelectric generating stations by identifying the various components of the turbine and generator and explaining their functions.

➢ Explain the operating principles of the turbine generator and their components
➢ Explain the use of hydraulic forces to control the speed and frequency of a hydroelectric turbine generator
➢ Identify hydraulic governor components
➢ Describe the operations of a hydraulic governor

583-06 Hydroelectric Plant Auxiliaries
When you complete this lesson, you will be able to identify the auxiliary systems inside a hydroelectric power plant.

➢ Explain the fire protection system used in a hydroelectric plant
➢ Describe the construction and purpose of the packing box
➢ Explain the operation and purpose of the cooling water system
➢ Describe the operation of the service air system of a hydroelectric plant

583-07 Operating Electrical Equipment in a Hydroelectric Plant
When you complete this lesson, you will be able to identify the standard procedures for operating electrical equipment in a hydroelectric plant, including lockout/tagout procedures, start-up, and shutdown procedures.

➢ Identify pre-start procedures for electrical equipment within the hydroelectric plant
➢ Examine precautions and procedures for operating electrical equipment, including lockout/tagout procedures
➢ Identify the process for the hydroelectric plant’s system start-up and removal from service

583-08 Mechanical Governor
When you complete this lesson, you will be able to identify components of the mechanical governor and be able to describe its operations.

➢ Identify major governor components
➢ Explain governor operations

583-09 Electric Governor
When you complete this lesson, you will be able to identify the evolution of the electric governor, components, functions, and governor operations.

➢ Recall electric governor evolution
➢ Identify electric governor components
➢ Recall electric governor functions
➢ Identify electric governor operations

584-01 Introduction to Biomass Power Plants
When you complete this lesson, you will be able to define biomass and list common biomass fuels used in the production of electricity. You will also be able to describe biomass storage, fuel handling equipment and various configurations of biomass boilers.

➢ Define biomass
➢ List common sources of biomass fuels
➢ List advantages of biomass fuels over coal
➢ Describe fuel handling and storage equipment used in biomass power plant applications
➢ Describe the various boiler designs used in biomass plants

584-02 Biomass and Waste to Energy Power Plants
When you complete this lesson, you will be able to explain the difference between mass burn and refuse derived fuel waste to energy plants. You will be able to describe the types of fuel and the fuel processing that takes place in these facilities. You will be able to describe the combustion systems utilized in these facilities.

➢ Define Municipal Solid Waste (MSW)
➢ Define Refuse Derived Waste (RDF)
➢ Compare mass to flow RDF waste to energy facilities
➢ List undesirable components in MSW
➢ Describe the major components in the waste handling system of a waste to energy facility
➢ Describe the major components in the combustion system of a waste to energy facility

585-01 Basic Wind Turbine Design
When you complete this lesson, you will be able to explain how a wind turbine harnesses the kinetic energy in wind and converts it into useful mechanical energy. In addition, you will be able to identify the principle components that comprise a typical, modern wind turbine.

➢ Define wind
➢ Discuss some factors that affect wind
➢ Identify two classifications of wind turbines
➢ Describe the components that typically comprise the drive train on a wind turbine
➢ Describe the basic wind turbine design currently used in the production of electricity
585-02 Wind Farm Development
When you complete this lesson, you will be able to discuss the factors that must be considered when identifying a possible location for a wind farm.
➢ Discuss five key considerations taken into account when initially selecting a site for a wind farm
➢ Describe three categories of wind farms
➢ Discuss the information that may be included in a detailed wind resource study
➢ Explain how the wind resource study impacts the location of the wind farm
➢ Describe “wake” as it relates to wind turbine operation

585-03 Horizontal Wind Turbine Design and Operation
When you complete this lesson, you will be able to explain how wind flowing over the blades causes the turbine rotor to turn. In addition, you will be able to describe the operation of wind turbine components and discuss how wind turbines are controlled.
➢ Describe five key components common to horizontal wind turbines
➢ Identify the two most common types of blades
➢ Discuss the type of generator most commonly used in wind turbines
➢ Describe how pitch-controlled blades control wind turbine speed
➢ Explain the purpose of the yaw mechanism

585-04 Wind Energy Production
When you complete this lesson, you will be able to discuss the relationship between the size of a wind farm and its corresponding capacity factor. In addition, you will be able to explain how wind energy impacts traditional energy markets.
➢ Define capacity factor
➢ Compare the capacity factor of a traditional coal-fired power plant to that of a modern wind farm
➢ Describe how the costs of construction and operation for a traditional fossil-fired power plant compare to those of a new, large scale wind farm
➢ Discuss how the cost of wind energy has become more competitive over the years

586 Reciprocating Engine Power Plants
586-01 Introduction to Reciprocating Engine Power Plants
When you complete this lesson, you will be able to explain the operation of a reciprocating engine and describe the common configurations in which it can be used in power generation facilities.
➢ Define reciprocating engine
➢ Describe the basic operation of a reciprocating engine
➢ Explain the role of reciprocating engines in large-scale power generation
➢ Describe the typical layout of a stand-alone reciprocating engine power plant
➢ Explain why reciprocating engines are incorporated into existing power plants
➢ Describe the use of cogeneration in a reciprocating engine power plant

586-03 Fundamentals of Reciprocating Engine Design
When you complete this lesson, you will be able to describe the major types of reciprocating engines and their fuel sources. You will also be able to describe the function of the major components of a reciprocating engine as applied to power generation.
➢ Describe the operation of liquid fuel-ignited and spark-ignited (Otto Cycle) reciprocating engines
➢ Describe the operation of a compression-ignited (Diesel Cycle) reciprocating engine
➢ List the types of fuels commonly used in reciprocating engines
➢ Describe common reciprocating engine fuel systems, including the following components:
  ○ Fuel pumps
  ○ Gas rams
  ○ Fuel rack
➢ Explain the operation of a dual-fuel (DF) reciprocating engine
➢ Describe the function of the following reciprocating engine components:
  ○ Turbocharger
  ○ Compressed Air Systems
  ○ Cooling Water Pumps
  ○ Lube Oil Pumps
586-05 Reciprocating Engine Auxiliary Systems
When you complete this lesson, you will be able to explain the operation of the major systems commonly found in a reciprocating engine power plant and describe their major components.

➢ Explain the operation of the fuel systems for liquid and gas-fueled reciprocating engines
➢ Describe the major components of a typical reciprocating engine lube oil system
➢ Explain the function of compressed air systems in a reciprocating engine power plant
➢ Describe the operation of the high-temperature (HT) and low-temperature (LT) cooling water circuits
➢ Explain the purpose of the charge air and exhaust gas system
➢ Describe the function of a steam generating system as it relates to a reciprocating engine power plant

586-06 Reciprocating Engine Electrical and Control Systems
When you complete this lesson, you will be able to explain the electrical control modes used to maintain engine speed and the control systems used for starting, stopping, and maintaining safe engine operation.

➢ Describe how automatic and manual control modes affect generator operations
➢ Explain the speed droop mode of engine control
➢ Explain the isochronous mode of engine control
➢ Explain the kW control mode of engine control
➢ Describe the engine starting circuit permissive logic
➢ List the conditions which may result in an automatic engine shutdown/auto-start
➢ List the conditions which may result in an engine load reduction

586-07 Reciprocating Engine Operations
When you complete this lesson, you will be able to describe the steps to startup and shutdown a reciprocating engine, and the steps to confirm it is operating normally. Additionally, some special operating conditions will be covered.

➢ Explain the pre-startup checks performed as part of the reciprocating engine startup process
➢ Describe the importance of slow-turning a reciprocating engine
➢ Describe the conditions monitored during normal reciprocating engine operation
➢ Explain the adverse effects of low-load operation on a reciprocating engine
➢ Describe the methods of performing a reciprocating engine shutdown
➢ Describe the conditions required to maintain a reciprocating engine in standby

586-09 Generator Control in Reciprocating Engine Power Plants
When you complete this lesson, you will be able to explain generator operation modes and the methods used to control generator output voltage. You will also be able to describe ways the automatic generator control system regulates loading and protects against faults on the generator output.

➢ Describe the following generator voltage regulator control modes:
  ○ Power factor
  ○ Voltage droop
  ○ Voltage droop compensation
➢ Explain voltage droop in relation to a generator excitation control system
➢ List the conditions that must be met before the generator can be synchronized with the grid
➢ List the conditions which may result in a generator breaker trip

586-11 Reciprocating Engine General Inspection
When you complete this lesson, you will be able to identify the general inspection requirements, the components involved, and how to remove them for further inspection and overhaul.

➢ Identify the cost benefits of performing preventive maintenance
➢ Define general inspection in relation to reciprocating engine maintenance
➢ Recall engine components removed for a general inspection
➢ Describe maintenance procedures for removing components during a general inspection

587 Nuclear Energy

587-01 Nuclear Power Principles and Designs
When you complete this lesson, you will be able to explain the basic theory and operation of a nuclear power plant. You will also be able to explain the basic process of nuclear fission and describe various nuclear reactor designs.

➢ Describe the type of fuel used in nuclear power plants
➢ Explain the purpose of control rods in nuclear reactors
➢ Describe the use of coolants in nuclear reactors
➢ Explain the use of moderators used in nuclear reactors
➢ Explain the process of nuclear fission
➢ Describe the basic design of a pressurized water reactor
➢ Describe the basic design of a boiling water reactor
➢ Describe the basic design of heavy water reactors
➢ Describe the basic design of gas cooled reactors
➢ Describe the basic design of liquid metal fast breeder reactors
➢ Describe the basic design of pressure tube graphite reactors
587-02 **PWR and BWR Operation and Design**

When you complete this lesson, you will be able to describe and explain the operating principles and design of the two major types of nuclear power plants.

- Explain the basic operation of a Pressurized Water Reactor (PWR) nuclear power plant
- Describe the containment structure of a PWR nuclear power plant
- Describe the reactor pressure vessel of a PWR nuclear power plant
- Explain the operation of the recirculation pumps in a PWR nuclear power plant.
- Explain the function of the pressurizer in a PWR nuclear power plant
- Explain the function of the steam generators in a PWR nuclear power plant
- Describe the basic operation of a Boiling Water Reactor (BWR) nuclear power plant
- Describe the pressure vessel of a BWR
- Explain the function and operation of the recirculation jet pumps of a BWR
- Describe the fuel rods used in PWRs and BWRs
- Explain how the reactivity is controlled in PWRs and BWRs

589 **Solar Energy**

**589-01 Introduction to Solar Energy**

When you complete this lesson, you will be able to explain the benefits of solar power generation and how solar power can be used to augment power generation from fossil fuels. You will also be able to describe the most common methods of solar power generation in use today.

- Describe the benefits of solar power production
- List common ways solar energy can be used to augment traditional fossil fuel generation
- Explain how energy storage systems are used to overcome deficiencies in solar power production
- Describe how a photovoltaic solar plant produces and delivers power to the grid
- Describe how a thermal solar plant produces and supplies steam for use in electrical power generation

589-03 **Solar Energy - Photovoltaic**

When you complete this lesson, you will be able to explain the purpose of a photovoltaic cell and describe how they can be arranged to form arrays suitable for power generation. You will also be able to describe the common components required to support power generation from photovoltaic systems.

- Describe the basic construction and operation of a photovoltaic cell
- Define photovoltaic effect as it relates production of photovoltaic cells
- Explain Maximum Power Point (MPP) and how voltage, current, and power output are related in a photovoltaic cell
- Explain how photovoltaic cells are arranged to form modules, panels, and arrays
- Understand the function of the following equipment related to photovoltaic solar installations:
  - Batteries
  - Inverters
  - Charge controllers
  - Peak-power trackers
  - Mounting hardware
- Describe and give examples of the following types of photovoltaic applications:
  - Direct coupled
  - Stand-alone
  - Grid-connected
  - Hybrid-connected

589-05 **Solar Energy – Thermal Applications**

When you complete this lesson, you will be able to explain how concentrated solar power can be used to generate electricity. You will also be able to describe the function and operation of the components that make up a functioning solar thermal power generating system.

- Explain Concentrated Solar Power (CSP) and how it is converted to electrical energy
- Describe a Rankine cycle power plant in relation to CSP
- Explain the function of the major components in a CSP power plant:
  - Solar collector
  - Heat transfer medium
  - Thermal energy storage
  - Boiler
- Turbine generator
- Describe the following types of solar collectors:
  - Power tower
  - Parabolic trough
- Describe the components and explain the operation of a parabolic trough concentrated solar power system
- Compare stand-alone and integrated solar combined cycle (ISCC) plant designs
603 Process Control Variables

603-01 Instrumentation and Control Overview

When you complete this lesson, you will be able to describe the basic operating principles behind the instrumentation and control common to your unit. You will also be able to identify various instrumentation components and discuss the ways instrumentation systems collect and transmit information.

➢ Discuss the importance of instrumentation and control
➢ Define the following common plant process variables:
  o Pressure
  o Temperature
  o Flow
  o Level
  o Analytical
➢ Describe basic function of process instrumentation
➢ Explain the relationship between common process variables
➢ Define terms associated with process instrumentation:
  o Differential (delta \( \Delta \))
  o Local control
  o Remote control
  o Control loop
  o Electronic
  o Pneumatic
  o Analog
  o Digital

603-02 Principles of Temperature

When you complete this lesson, you will understand the concepts of temperature and heat transfer and be able to convert between common temperature scales.

➢ Define heat and temperature and explain the difference between them
➢ Recognize different temperature scales and list their basic units of measurement
➢ Convert between common temperature scales
➢ Describe how heat transfer can change the temperature or other physical properties of a substance
➢ Describe the following methods of heat transfer:
  o Conduction
  o Convection
  o Radiation

603-03 Principles of Pressure

When you complete this lesson, you will understand pressure and how it is measured. You will be able to apply conversion formulas to convert readings from one standard pressure scale to another.

➢ Define pressure and list the basic units of pressure measurement
➢ Discuss the formula used to calculate pressure (\( P = \frac{F}{A} \))
➢ List the factors and conditions that affect pressure
➢ Explain how Boyle’s Law and the combined gas law relate to pressure
➢ Recognize common pressure measurement scales and demonstrate your ability to calculate conversion between them
603-04 Principles of Level
When you complete this lesson, you will be able to explain the concept of level and describe how it is measured.
➢ Define level
➢ Explain the difference between continuous and single-point level detection
➢ List the basic units of level measurement
➢ Define the following terms associated with level measurement:
  o Innage
  o Ullage (outage)
  o Level
  o Interface
  o Meniscus
  o Buoyancy

603-05 Principles of Flow
When you complete this lesson, you will be able to describe the principles of fluid flow and understand how these principles provide multiple means for measuring flow rate in the process industry.
➢ Define flow rate
➢ Discuss the difference between volumetric and mass flow rate and list the common units used for measuring each
➢ Describe the common types of flow measuring devices used in industrial processes
➢ Using the concept of flow profiles, explain laminar and turbulent flow including a discussion of Reynolds Numbers
➢ Explain how flow rate is affected by the following fluid properties:
  o Pressure
  o Density
  o Viscosity
➢ Describe how detector position and flow disturbances can affect the accuracy of flow rate measurements

603-06 Temperature Instruments
When you complete this lesson, you will be able to identify various temperature measuring and sensing devices, and describe their operation.
➢ Describe and give examples of the following types of temperature measuring devices:
  o Thermal Expansion Thermometers
  o Electrical Thermometers
  o Infrared Radiation Thermometers
➢ Explain the operation of a resistance temperature detector (RTD) and bridge circuit
➢ Describe how to properly connect a 2-wire or 3-wire RTD to a temperature transmitter
➢ Explain thermocouple compensation and the effect of wires and junctions on accurate temperature measurement
➢ Describe distance-to-size ratio in an infrared radiation thermometer
➢ Explain emissivity in relation to an infrared radiation thermometer

603-07 Pressure Measuring Devices
When you complete this lesson, you will be able to identify and describe the operation of various pressure sensing and measurement devices.
➢ Describe the difference between absolute, gauge, vacuum, and differential pressure
➢ Describe and explain the operation of liquid column manometers, including the following types:
  o U-tube
  o Well
  o Inclined tube
➢ Describe and explain the operation of elastic pressure sensors, including the following types:
  o Bourdon tube
  o Bellows
  o Diaphragm
➢ Explain in detail the construction and operation of a Bourdon tube pressure gauge
➢ Describe the purpose of a pressure switch, pressure transducer, and a d/p cell

603-08 Level Measuring Devices
When you complete this lesson, you will be able to identify various level sensing and measurement devices, and describe their basic operation.
➢ Describe the basic types of level measurements, including point and continuous level methods
➢ Explain the operation of the following types of direct measuring level instruments:
  o Weighted tape gauge
  o Sight glass
  o Reflex gauge glass
  o Float
➢ Explain the operation of the following types of indirect measuring level instruments:
  o Pressure detector
  o Bubbler
  o Displacer
  o Capacitance probe
  o Ultrasonic/radiation sensor
  o Weight sensor
603-09 Flow Measuring Devices

When you complete this lesson, you will be able to identify and describe the basic operation of various direct and indirect flow measurement devices.

➢ Describe the following types of flow measuring devices, or flowmeters:
  o Mass flowmeters
  o Velocity based flowmeters
  o Variable area flowmeters
  o Pressure based flowmeters
➢ Explain how a Coriolis flowmeter and a thermal flowmeter determine mass flowrate
➢ Describe the operation of the following velocity based flowmeters:
  o Turbine flowmeter
  o Vortex flowmeter
  o Magnetic flowmeter
  o Ultrasonic flowmeter
  o Optical flowmeter
➢ Explain how a rotameter uses variable flow area to determine flowrate
➢ Explain how differential pressure can indirectly indicate flowrate
➢ Describe the following methods for producing a differential pressure that are commonly used in flow measuring instruments:
  o Orifice plates
  o Venturi tubes
  o Flow nozzles
  o Pitot tubes
➢ Describe the difference between and give examples of concentric and non-concentric orifice plates

603-15 Weight Measuring Devices

When you complete this lesson, you will be able to describe various weight measuring devices used in industrial applications and explain their operating principles.

➢ Identify the two types of balance scales
➢ Describe platform scales
➢ Describe stretched and compressed spring scales
➢ Explain the operation of electronic, hydraulic, and pneumatic load cells
➢ Explain the operation of linear variable differential transformers
➢ Describe batch and belt scales, including continuous weigh feeders and nuclear scales

605 Test Equipment

605-01 Multimeter

When you complete this lesson, you will understand the basics of a digital multimeter and volt-ohm-meter and how to properly use a multimeter.

➢ Describe the multimeter’s function and operation
➢ Discuss multimeter specifications
➢ Identify the symbols on a multimeter
➢ Discuss the tool’s range and resolution.
➢ Demonstrate how to safely use a multimeter to make measurements

605-02 Oscilloscopes

When you complete this lesson, you will understand how to use the controls of an oscilloscope for the purpose of measuring electrical signals. You will also be able to set an oscilloscope to measure voltage, frequency, time, and phase shift.

➢ State what values are represented on the x and y axes of the display
➢ Name the general components of an oscilloscope needed to display a waveform
➢ Recall the differences between analog and digital oscilloscopes
➢ Identify waveform types and examples of equipment that produce those waveforms
➢ Describe how to use the basic controls of an oscilloscope
➢ Express how to take simple measurements for voltage, period, amplitude, frequency, and phase shift
605-03 Power Supplies
When you complete this lesson, you will be able to identify the main sections of a DC power supply and describe the types of regulation and regulators. You will also understand how a linear regulator works and be able to troubleshoot power supply problems.
➢ Explain the function of the sections of a DC power supply
➢ Describe a block diagram of a DC power supply
➢ Explain the difference between line regulation and load regulation
➢ Recognize the difference between linear and switching power supplies
➢ Discuss how to setup and use a power supply
➢ Explain the process for troubleshooting power supplies

605-04 Signal Generators
When you complete this lesson, you will understand the basic controls and operations of a signal generator. You will be able to use the device to generate basic waveforms for troubleshooting.
➢ Describe how signal generators work
➢ Identify types of electrical waveforms
➢ Describe waveform parameters
➢ Discuss operation of basic signal generator controls
➢ Demonstrate how to use a signal generator to generate simple waveforms

605-05 Temperature and Loop Calibrators
When you complete this lesson, you will understand the basic function and operation of temperature calibration equipment and loop calibrators. Explain the difference between contact and non-contact sensors
➢ Explain how temperature sources and simulators are used to perform thermocouple and RTD calibration
➢ Describe the common types of temperature sources used for calibrating temperature instruments:
  o Dry Well (Block)
  o Liquid and Fluidized-Sand Bath
  o Thermoelectric
➢ Describe the operation of a blackbody calibrator
➢ Describe the function and common features of a loop calibrator
➢ Explain the three basic modes of operation of a 4-20 mA loop calibrator:
  o Measuring Current
  o Sourcing Current
➢ Simulating a Transmitter

605-06 Manometers
Upon completion of this lesson you will be able to describe a manometer and explain how the most common types of manometers are used to measure pressure.
➢ Define manometer and describe how it differs from other pressure measuring devices
➢ Describe the purpose of a manometer and list its common uses
➢ Explain the terms parallax and meniscus in relation to using a manometer to obtain a pressure reading
➢ Describe the construction and operation of common types of manometers, including the U-tube, well, and inclined tube manometer
➢ Explain the factors which can affect the accuracy of a manometer

605-07 Pressure and Vacuum Calibrators
When you complete this lesson, you will understand how various types of pressure and vacuum calibrators operate and how to use them.
➢ Explain the purpose of a pressure and vacuum calibrator
➢ Describe a deadweight calibrator and its uses
➢ Explain the operation of a variator
➢ Understand the uses of an aspirator bulb
➢ Explain when to use a hand pump
➢ Describe pneumatic calibrators and when they are used

605-08 Megohmmeter
When you complete this lesson, you will be able to use a megohmmeter to safely take a reading of the resistance of wire insulation.
➢ Recall the purpose of insulation
➢ List the modes of deterioration of insulation
➢ Identify the purpose of a megohmmeter
➢ Describe the types of megohmmeters
➢ List the components of a megohmmeter
➢ Describe how to conduct a spot test
607 Analyzers

607-01 Analytical Instruments
When you complete this lesson, you will be able to correctly identify analytical variables and explain the processes for measuring them. You will be able to explain analysis and describe the basic operation of direct and indirect analysis measurement devices.

➢ Identify the units of measurement for analytical variables
➢ Describe basic operation of analytical measurement devices
➢ Recognize the general purpose of analytical measurement
➢ Define terms associated with analytical:
  - Measurement
  - Analyzer
  - Concentration
  - Conductivity
  - Moisture
  - pH
  - Humidity
  - Dew point

607-02 Introduction to Analytical Testing
When you complete this lesson, you will be able to identify and describe the function of several key analyzers commonly found in industrial facilities.

➢ Explain the use of analyzers in an industrial facility
➢ Identify and describe the operation of the following commonly used analyzers:
  - Hydrometer
  - Vibrating u-tube density analyzer
  - Nuclear radiation density analyzer
  - Slurry density analyzer
  - Hydrostatic pressure density analyzer
  - Falling piston viscosity analyzer
  - Rotating spindle viscosity analyzer
  - Rheometer

609 Calibration and Troubleshooting

609-01 Calibration Overview, Part 1
When you complete this lesson, you will be able to explain calibration and describe basic calibration methods and equipment. Discuss the three-point and five-point methods of calibration.

➢ Discuss the three-point and five-point methods of calibration
➢ Identify pneumatic and electronic calibration equipment
➢ Discuss calibrating procedures for electronic and pneumatic calibration equipment
➢ Define:
  - Calibration
  - Noisy signal
  - I/P transducer
  - Zero
  - Span (range)
  - Live zero

609-02 Calibration Overview, Part 2
Upon completion of this lesson, you will be able to explain methods used to calibrate transducers, control valve positioners, and smart instruments.

➢ Discuss common methods of calibration
➢ Explain how to calibrate transducers and transmitters
➢ Describe smart instruments and common troubleshooting methods
➢ Discuss the steps to calibrate controllers and control valve positioners
➢ Define:
  - Smart instruments
  - Impulse leg

609-03 Introduction to Troubleshooting
When you complete this lesson, you will be able to describe basic troubleshooting techniques for temperature, pressure, level, and flow equipment in the plant.

➢ List available resources that will help you troubleshoot a problem
➢ Describe the best way to read a gauge.
➢ Define:
  - Linearity
  - Hysteresis
  - Repeatability
  - Accuracy versus precision
  - Parallax

609-04 Instrument Troubleshooting
When you complete this lesson, you will be able to explain the basic steps used in instrument troubleshooting.

➢ Identify common causes of instrument malfunctions
➢ Discuss the value of troubleshooting, and outline the steps employed in successful troubleshooting
➢ Identify common sensors, and discuss the malfunctions often associated with each of them
➢ List the basic steps for troubleshooting an instrument on a control loop
611-01 P&ID Basics
When you complete this lesson, you will have the skills necessary to read a P&ID. You will be able to identify symbols and function labels, as well as describe how the components are related.

- Define P&ID and discuss its importance to the facility
- Identify who uses the P&ID
- List the types of information typically found on a P&ID and describe where each of the following is located on the drawing:
  - Title block
  - Main drawing
  - Line schedules
  - Equipment descriptions
  - Issue descriptions
  - Notes
  - Zone numbers
- Describe a master sheet and identify commonly used symbols
- Identify instruments, control loops, line designations, and piping on the P&ID
- Trace the course of a process from beginning to end

611-02 Reading a P&ID
When you complete this lesson, you will be able to use a P&ID to identify instrumentation, common equipment, and symbols used in your area. You will also be able to describe how components are related.

- Identify symbols for selected vessels, compressors, heat exchangers, valves, and pumps
- Identify instrument symbols
- Describe how the instruments in control loops are named on a P&ID
- Identify piping and determine information about a pipeline including:
  - Material in the line
  - Size of the pipe
  - Line number
- Recognize the different types of lines including pneumatic, hydraulic, electric, and signal lines

611-03 Electrical Drawings
When you complete this lesson, you will be able to identify the different types of electrical drawings and describe how each is used. You will also be able to identify and describe the common elements and symbols that make up electrical drawings. Describe the purpose of an electrical drawing

- Explain the purpose of an electrical drawing
- Describe the title block, revision block, reference block, and legend block
- Identify symbols commonly used in electrical drawings
- Explain why device numbers are used in electrical drawings

611-04 Logic Diagrams
When you complete this lesson, you will be able to state the important features of a logic diagram and identify the most common types of logic gates and how each is used. You will also be able to identify the common symbols and components on a logic diagram and explain their relationship to each other.

- Explain the purpose of a logic diagram
- Describe the title block, revision block, reference block, legend block, and grid coordinates
- Identify the common symbols associated with logic diagrams
- Describe the principles of logic gates and identify common logic gate types
- Define the following terms:
  - Logic gates
  - Boolean logic
  - Ladder logic
  - Truth tables

611-05 Industrial Print Reading Overview
When you complete this lesson, you will be able to describe the different types of drawings used by site employees to design, repair, and maintain equipment in the facility. In addition, you will have the skills necessary to determine which type of drawing should be used to acquire the specific information directing a specific project.

- Explain the purpose drawings and schematics serve in an industrial setting
- Describe seven categories most industrial drawings fall under
- Discuss the purpose of a civil drawing
- Describe two types of construction drawings commonly used in industrial facilities when new buildings or large equipment are constructed
- Describe the use of mechanical drawings by facility mechanics as part of their jobs
- Explain the purpose of electrical diagrams
613 Automated Control

613-01 Introduction to Automated Control
When you complete this lesson, you will be able to discuss the basic design and function of automated control loops.
➢ Describe the main elements employed in an automated control loop
➢ Explain the difference between open and closed control loops
➢ Define the following terms as they relate to an automated control system:
  o Process variable
  o Control variable
  o Final control element

613-02 Pneumatic Control Systems
When you complete this lesson, you will be able to describe the design and function of typical pneumatic control systems used in industrial facilities.
➢ Identify pneumatic control system components
➢ Explain pneumatic signal transmission ranges
➢ Describe a typical pneumatic control room layout
➢ Identify advantages and disadvantages of pneumatic control systems

613-03 Introduction to Switches
When you complete this lesson, you will be able to identify common types of electrical switching devices, and describe the principles of their operation.
➢ Explain the purpose of an electrical switch
➢ Identify the various types of electrical switches
➢ Describe variations and operating principles of throw and pole switches
➢ Explain difference between mercury and reed relay switches
➢ Describe the operation of mercury, reed relay, float, pressure, limit, flow, pushbutton, selector, and drum switches
➢ Describe the operation of joysticks
➢ Identify the operating principles of interlock switches
➢ Explain the purpose and operation of safety switches

615 Signal Transmission and Conversion

615-01 Signal Transmission
When you complete this lesson, you will be able to provide a general overview of how mechanical, analog, digital, pneumatic, electrical, fiber optic, and wireless systems are used to transmit signals in industrial control loops.
You will also be able to convert measured values into corresponding transmission values, and transmitted values back into measured values.
➢ Compare analog and digital signal transmission
➢ Describe the operation of pneumatic signal transmission systems
➢ Identify several varieties of electric signal transmission systems
➢ Describe the following types of signal transmission:
  o Mechanical
  o Optical
  o Wireless
➢ Explain how to convert between measured values and transmitted values

615-02 Basic Principles of Industrial Transmitters
When you complete this lesson, you will be able to describe the basic function and operation of pneumatic and electric transmitters. You will also understand the formula relating transmitter outputs to inputs.
➢ Explain the need for transmission of process signals in industrial facilities
➢ Describe the basic operation of each of the following:
  o Pneumatic transmitters
  o Electrical transmitters
  o Variable inductance transmitters
➢ Calculate transmitter outputs from a given input

615-03 Smart Transmitters
When you complete this lesson, you will be able to describe the basic design, operation, and features of smart transmitters. You will also understand additional functionality available through the use of intelligent transmitters.
➢ Describe the basic operation of a smart transmitter
➢ List some advantages of smart transmitters
➢ List some disadvantages of smart transmitters
➢ Discuss the additional capabilities supplied by intelligent transmitters
615-04 Transducers
When you complete this lesson, you will be able to discuss the function of a transducer and describe types of conversions transducers perform. You will also be able to explain the operating principles behind the most common types of transducers.
- List various types of transducers and identify their function
- Describe I/P transducer operating mechanics
- Describe P/I transducer operating mechanics
- Discuss the basic principle behind capacitive pressure transducer operation
- Define stress and strain; explain how their relationship is used in a variable resistance sensor
- Discuss the basic operating principle behind variable frequency sensor operation
- Identify the purpose of A/D (analog to digital) and D/A (digital to analog) converters

617 Controllers and Final Control
617-01 Controller Control Modes
When you complete this lesson, you will be able to describe the design and function of the four main control modes used by industrial controllers.
- Describe each of the following controller modes:
  - On-off control mode
  - Proportional control mode
  - Integral, or reset, control mode
  - Derivative, or rate, control mode
- Explain how each mode works to keep a process at its desired value or setpoint

617-02 Operation of Automatic-Manual Transfer Stations
When you complete this lesson, you will be able to describe the basic design, function, and use of an automatic-manual transfer station.
- Identify the purpose and describe the operation of an automatic-manual transfer station
- Describe the function of the transfer switch
- Describe what is meant by transfer balancing
- Explain how to transfer control from manual to automatic
- Explain how to transfer control from automatic to manual

617-03 Final Control Elements
When you complete this lesson, you will be able to describe the basic design and function of various types of final control elements used in control loops in industrial facilities.
- Describe a final control element
- Explain how control valves and their actuators are used as final control elements
- Identify types of dampers used as final control elements
- Describe common variable speed drives that may be used as final control elements
- Explain how modulating power controllers are used as final control elements

619 Electronics Fundamentals
619-01 Introduction to Industrial Electronics
When you complete this lesson, you will be able to describe the construction and operation of basic electronic components. You will also be able to explain common troubleshooting techniques used in electronic circuits.
- Explain how semiconductor materials are used to construct electronic components
- Describe the operation of a P-N junction in an electronic component
- Explain the effect of bias voltage on current flow through a P-N junction
- Explain the operation of the following electronic components:
  - Diode
  - Transistor
  - Thyristor
- Describe the purpose of a rectifier
- Describe the following types of thyristors:
  - Silicon Controlled Rectifiers (SCR)
  - Triacs
- Explain the common techniques used in troubleshooting electronic circuits

619-07 Digital Electronics and Microprocessors
When you complete this lesson, you will be able to explain how digital signals differ from analog signals. You will also be able to describe the operation of many common types of digital components and circuits, including microprocessors.
- Explain the difference between digital and analog signals
- Describe logic levels in a digital circuit
- For the standard logic gates that make up a digital circuit:
  - Determine the output for any combination of input
  - Identify the proper schematic symbol
- Determine the output of a digital circuit based on given inputs
- Explain the function of a J-K flip-flop circuit
- Describe the purpose of a microprocessor in an industrial control system
- Explain the purpose of a microprocessor program
- Describe the components found in a basic microprocessor-based system
621 Programmable Logic Controllers

621-01 Introduction to Programmable Logic Controllers (PLC)

When you complete this lesson, you will be able to describe the design and function of the major components of a PLC. In addition, you will be able to convert numbers from decimal to binary, binary coded decimal, and hexadecimal.

➢ Describe the purpose of each of the major PLC components
➢ Discuss basic PLC operation
➢ Describe the internal structure of the CPU
➢ Describe the internal architecture of a typical PLC
➢ Identify typical input and output devices
➢ Discuss the function of the I/O (input/output) modules
➢ Identify types of signals used by PLC and discuss how they are handled
➢ Define ladder logic and explain its use
➢ Discuss how binary, octal, and hexadecimal numbering systems are used in PLC programming

621-02 Input/Output (I/O) Processing

When you complete this lesson, you will be able to discuss I/O error checking and its impact on communications and function. In addition, you will be able to identify the various types and structure of PLC memory and describe how memory interacts with the peripheral I/O.

➢ Describe various error checking methods
➢ Compare volatile and nonvolatile memory and provide example types of each
➢ Describe data table structure within the CPU memory
➢ Discuss the addressing of the I/O modules
➢ Describe memory maps and their function
➢ Describe I/O module structure

621-03 Inputs and Outputs

When you complete this lesson, you will be able to describe the design and function of I/O (input/output) interfaces and the equipment used to produce and communicate I/O data.

➢ List some types of discrete I/O (input/output) interfaces
➢ Describe AC/DC and DC/AC conversion in I/O modules
➢ Discuss DC sinking and sourcing
➢ Describe the use of transistor-transistor logic (TTL)
➢ Discuss register/BCD modules and multiplexing
➢ List some types of analog input devices
➢ Describe the use of A/D and D/A converters
➢ Identify the functions of transducers in input field devices
➢ Discuss single-ended and differential configurations

621-04 PLC (Programmable Logic Controllers) Programming Instructions, Part 1

When you complete this lesson, you will be able to describe the functions of the programming instructions most commonly used in PLC programming.

➢ Identify two types of ladder logic
➢ List commonly used Boolean logic functions
➢ Discuss the use of individual instructions and function blocks in ladder logic
➢ Describe the following types of instructions:
  ○ Ladder relay instructions
  ○ Timer instructions
  ○ Counter instructions
  ○ Program/flow instructions
  ○ Arithmetic instructions

621-05 PLC (Programmable Logic Controllers) Programming Instructions, Part 2

When you complete this lesson, you will be able to describe the functions of the programming instructions most commonly used in PLC programming.

➢ Discuss the use of individual instructions and function blocks in ladder logic
➢ Describe the following types of instructions:
  ○ Data manipulation instructions
  ○ Data transfer instructions
  ○ Special function instructions
  ○ Network communication instructions

621-06 PLC (Programmable Logic Controllers) Networks

When you complete this lesson, you will have a basic understanding of LAN architecture and topology, communication network access, and transmission media.

➢ Discuss LAN architecture as it applies to industrial networks
➢ Compare the structures of star, common bus, and ring topology, and identify advantages and disadvantages of each configuration
➢ Discuss how error detection is accomplished in the various network topologies
➢ Describe common methods of network access used in PLC systems
➢ Describe different types of transfer medium and identify their pros and cons
➢ Define throughput and describe its impact on system response
621-07 PLC Network Protocols

When you complete this lesson, you will have a basic understanding of common PLC network protocols.

- Explain the ISO/OSI seven-layer model
- Discuss a Fieldbus, industrial network and identify its attributes
- Discuss a PROFIBUS (Process Fieldbus) industrial network and identify its attributes
- Discuss a DeviceNet industrial network and identify its attributes

670 Principles of HVAC and Refrigeration

670-01 Air Conditioning Fundamentals

When you complete this lesson, you will understand the basic refrigeration cycle and how it applies to air conditioning.

- Describe how heat is transferred from one fluid to another
- List the common types of refrigerant used in air conditioning applications
- Explain the purpose of the compressor, condenser, metering device, and evaporator
- Describe the four steps of the basic refrigeration cycle

670-02 Ductless Air Conditioning

When you complete this lesson, you will understand the various types of ductless air conditioners and how the components function, including basic maintenance.

- Describe the different types of ductless air conditioners
- Explain the purpose of each major component in a ductless air conditioning system
- Demonstrate an understanding of how each component's operation relates to the basic refrigeration cycle
- Describe the basic preventive maintenance procedures performed on a ductless air conditioner
- Explain the common problems that can occur with an air conditioning system and how they may be corrected

670-03 Introduction to Industrial and Commercial Refrigeration

When you complete this lesson, you will understand the purpose and function of industrial and commercial refrigeration, how heat transfer and the refrigeration cycle drive the process, and the types of components and refrigerants that may be used in units of this type.

- Define the purpose of refrigeration
- Identify the types of industries that use refrigeration
- Describe the fundamentals of heat transfer
- Describe the four steps of the basic refrigeration cycle
- Explain the purpose of the compressor, condenser, metering device, and evaporator
- Recall the purpose of using different refrigerants in different industrial and commercial operating conditions

670-05 Refrigerant System Troubleshooting

When you complete this lesson, you will understand how to systematically troubleshoot and diagnose refrigerant systems based on their universal application of the refrigeration cycle. You will also be familiar with industry standard diagnostic and testing tools for these systems.

- Identify various types of tools and testing instruments necessary for refrigerant system troubleshooting
- State three or more safety precautions to adhere to when troubleshooting refrigerant systems
- Follow a logical, step-by-step approach to troubleshooting refrigerant systems
- Describe the most common causes of refrigerant system malfunctions as discussed in this lesson
- Identify indicators for airflow, refrigerant, compressor, mechanical, and electrical failures in the system

670-06 Chiller Design and Maintenance

When you complete this lesson, you will know the purpose of an industrial HVAC chiller and understand how its main components work together to remove heat from the system’s refrigerant, allowing the HVAC circuit to provide cool air to the facility.

You will also understand how heat exhausted from the chiller can be captured and reused as energy elsewhere at the facility, and you will be familiar with general maintenance recommendations which help keep the chiller operating at peak performance.

- Explain the role of a chiller in an HVAC circuit
- State specific conditions under which a water-cooled chiller would be better employed than an air-cooled chiller
- Sketch the flow paths of chilled water, refrigerant, and cooling water through a water-cooled chiller’s main components; include the following:
  o Evaporator
  o Compressor
  o Condenser
  o Metering Device
  o Cooling tower
- Give examples of two or more industry standard maintenance operations for industrial chillers and describe the purpose of each
- Summarize the rationale of capturing heat exhausted by a chiller
When you complete this lesson, you will understand the important role ducting plays in the HVAC system’s ability to provide maximum airflow. You will also be able to identify common HVAC airflow issues related to poorly implemented ducting.

➢ State the three functions of an HVAC system and briefly discuss each
➢ Describe the difference between HVAC ducting and HVAC equipment in relation to airflow
➢ Discuss three reasons sheet metal ductwork provides superior airflow over flexible ducting; include the topics of installation, mold, and maintenance
➢ Describe a hybrid duct system and state why flex ducting is often used at the end of the run
➢ List industry standard ducting components and describe the role each plays in the ducting system
➢ State the main differences between smoke dampers and fire dampers
➢ Describe three commonly reported HVAC related issues which are caused by reduced airflow

670-15 District Energy Basics

When you complete this lesson, you will be able to define district energy and provide examples of the types of situations where district energy could be a solution. You will also be able to recall some advantages and disadvantages of the technology.

➢ Define district energy
➢ Identify examples in which district energy is a viable solution
➢ Recall the advantages and disadvantages of district heating/cooling
Process Systems and Operations

700 – Process Systems and Operations

701 Petroleum Refining

701-01 Introduction to Petroleum Refining

When you complete this lesson, you will be able to identify and briefly describe various refining processes that take place in a typical petroleum refinery.

➢ Explain what is meant by crude oil
➢ Describe the purpose of each of the following processes:
  o Crude oil desalting
  o Atmospheric distillation
  o Vacuum distillation
  o Catalytic reforming
  o Cracking
  o Alkylation
  o Isomerization
  o Polymerization
➢ Discuss refinery treating processes
➢ Identify the function of a gas plant
➢ Explain the importance of refinery blending operations
➢ List substances often stored in the refinery tank farm

701-02 Basic Petroleum Chemistry

When you complete this lesson, you will be able to discuss the molecular structure, physical properties, naming conventions, and commercial uses of several common hydrocarbons.

➢ Compare the definitions of petroleum and crude oil
➢ Relate the physical states of hydrocarbons to their carbon content
➢ Discuss how covalent bonds are formed between hydrogen and carbon
➢ Explain the use of base names, prefixes, and suffixes to label hydrocarbons
➢ Describe and compare the structure of the following hydrocarbon families:
  o Paraffins
  o Napthenes
  o Aromatics
  o Olefins
  o Alkynes
➢ Identify correlations between physical properties of a hydrocarbon and the hydrocarbon’s molecular structure
➢ List some contaminants commonly found in crude oil and explain their adverse effects on oil refining

701-03 OSHA’s Process Safety Management Standard

When you complete this lesson, you will be able to identify the main components and explain the objectives of the OSHA Process Safety Management (PSM) standard.

➢ Discuss the purpose of the PSM standard
➢ Describe the type of process safety information required under the PSM standard
➢ List the points included in a process hazard analysis
➢ Identify the types of operating procedures that fall under the PSM standard requirements
➢ Discuss the training requirements under PSM standard
➢ Describe how the PSM standard relates to contractors
➢ Identify what is included in a PSM pre-start-up safety review
➢ Describe requirements to comply with PSM mechanical integrity standards
➢ Explain what is meant by management of change procedures under PSM
➢ Describe PSM incident investigation and emergency planning and response provisions
➢ Discuss PSM compliance audit requirements
701-04 History of Refining
When you complete this lesson, you will be able to provide a general overview of the evolution of crude oil processing from 1846 until the present day.
➢ Explain how and why kerosene replaced whale oil
➢ Discuss causes of the emergence of the gasoline market
➢ Describe how the CAA Amendments of 1970 affected refining processes
➢ Identify some effects of oil industry deregulation
➢ Discuss the effects of the vapor pressure regulations of 1989 and 1992
➢ Describe how the CAA Amendments of 1990 affected refining processes

707 Process Heaters
707-01 Features and Operation of Process Heaters
When you complete this lesson, you will be able to describe the features and operation of process heaters.
➢ Describe the features of process heaters.
➢ Explain the operation of process heaters

709 Process Tanks
709-01 Features and Uses of Process Tanks
When you complete this lesson, you will be able to describe the main features and uses of process tanks.
➢ Explain the main features of process tanks
➢ Describe the uses of process tanks
➢ Define the following terms:
  o Level alarm
  o Pressure alarm
  o Relief valve
  o Rupture disk
  o Manway
  o Sightglass cleanout system
  o Feed tank agitator
  o Baffles
  o Surge tank
  o Blowdown tank

711 Distillation
711-01 Introduction to Distillation
When you complete this lesson, you will be able to describe the theory of distillation and the configuration of a distillation column and its components.
➢ Correlate the distillation principle with separating hydrocarbon components of crude oil
➢ Recognize types of distillation
➢ Describe the equipment associated with fractional distillation

711-02 Operation of a Distillation Column
When you complete this lesson, you will be able to describe the start-up, normal operation, and shutdown of a distillation column.
➢ Important factors to monitor during normal operation of a distillation column
➢ Define the following terms:
  o Feedpoint
  o Flash
  o Rectification
  o Stripping
➢ Describe the steps of the startup of a distillation column
➢ Recognize the steps of the shutdown of a distillation column

713 Process Separators
713-01 Introduction to Process Separators
When you complete this lesson, you will be able to identify common types of process separators and their components. You will also be able to describe the process separator’s operating principles.
➢ Describe major components of process separators
➢ Explain the function of the process separator sections
➢ Describe a two-phase separator
➢ Describe a three-phase separator

715 Process Reactors
715-01 Introduction to Process Reactors
When you complete this lesson, you will be able to describe chemical reactions, the features and operations of various types of reactors, and their application in the refining industry.
➢ Define the following types of reactions
  o endothermic
  o exothermic
  o homogeneous
  o heterogeneous
➢ Identify conditions affecting chemical reactions
➢ Describe the components of a process reactor
➢ Describe the types of process reactors
➢ Identify the common application for different reactors
717 Reforming and Synthesis

717-01 Introduction to Naphtha Reforming
When you complete this lesson, you will be able to explain how reforming relates to the operation of a refinery. You will also be able to identify reforming technologies, types of catalytic reformers, and how variables affect the process.

➢ Define conventional naphtha reforming
➢ Describe catalytic reforming technology
➢ Explain catalytic processes

719 Process Safety Systems

719-01 Safety Alarm Systems and Instrumentation
When you complete this lesson, you will be able to describe the design, operation and use of safety alarm systems and instrumentation.

➢ Describe alarm systems
➢ Describe shutdown systems
➢ Describe equipment protection devices

719-02 Overpressure Safety Systems
When you complete this lesson, you will be able to describe the design, operation, and use of overpressure safety systems.

➢ Explain causes of overpressure
➢ Describe pressure relief valve design and use
➢ Describe safety valve design and use
➢ Describe rupture disk design and use
➢ Describe flare design and use

721 Process Utilities Systems

721-01 Process Utilities Systems, Part 1
When you complete this lesson, you will be able to explain the function and design of plant water and air utility systems.

➢ Describe plant water supply systems and their functions
➢ Describe plant air supply systems and their functions

721-02 Process Utilities Systems, Part 2
When you complete this lesson, you will be able to explain the function and design of heat and fuel, refrigeration, and power supply utility systems, and how they are linked in order to meet energy demands from industrial processes.

➢ Describe heat and fuel supply utility systems and their functions
➢ Describe refrigeration utility systems and their functions
➢ Describe power supply utility systems and their functions

723 Process Product Movement and Storage

723-01 Process Product Movement and Shipment
When you complete this lesson, you will be able to describe efficiency considerations in facility design, types of product storage and transportation, and precautions taken when handling product.

➢ Describe different types of product storage
➢ Describe various types of product transporting
➢ Explain safe transporting and storage tactics

723-02 Tanks and Vessels Used for Storage
When you complete this lesson, you will be able to describe and explain various types of non-pressurized, pressurized, and refrigerated storage tanks and vessels. You will also be able to explain safety equipment associated with these tanks and vessels.

➢ Describe types of non-pressurized storage tanks
➢ Describe types of pressurized storage tanks
➢ Describe types of refrigerated storage tanks

725 Process Sampling and Testing

725-01 Sampling Principles and Methods
When you complete this lesson, you will be able to describe the importance of accurate sampling. You will also be able to explain several sampling types and systems. You will be able to describe correct sampling procedures.

➢ Explain the purposes of product sampling
➢ Describe continuous product sampling
➢ Describe spot product sampling
➢ Describe composite product sampling
➢ Explain open sampling systems
➢ Explain closed sampling systems
➢ Explain totally closed sampling systems
➢ Describe typical sampling procedures

725-02 Testing Principles and Procedures
When you complete this lesson, you will be able to describe how tests are used to ensure on-specification quality products. You will be able to explain common chemical and physical tests performed on products to ensure this quality.

➢ Explain distillation testing
➢ Explain specific gravity testing
➢ Explain API gravity testing
➢ Explain mass spectrometry testing
➢ Explain gas chromatograph testing
➢ Explain testing for vapor pressure
➢ Explain BS&W testing
➢ Explain testing for H2S and mercaptans
➢ Explain pH testing
➢ Explain conductivity testing
➢ Explain color testing
➢ Explain viscosity testing
➢ Explain cloud and pour point testing
➢ Explain flash and smoke point testing
800 – Industrial Machining and Welding

801 Precision Measurement

801-01 Intro to Measuring and Care of Measuring Tools
When you complete this lesson, you will be able to explain the need for measuring tools in machining and maintenance operations. You will also be able to describe some of the precautions to take to properly care for these tools.

- Explain the need for both coarse and precision measurements
- Describe the proper care of:
  - Simple calipers
  - Rigid rules, folding rules, and tape measures
  - Vernier calipers
  - Telescoping gauges and micrometers
  - Dial indicators and fixed gauges

801-02 Measuring Rules and Tapes
When you complete this lesson, you will be able to identify rigid rules, folding rules, depth rules, and tape measures; you will also be able to explain the correct procedures for taking accurate measurements with them.

- Identify a rigid rule and describe how to use it
- Identify a folding rule and describe how to use it
- Identify a depth rule and describe how to use it
- Explain the procedure for taking a measurement with a depth rule
- Identify a tape measure and explain how to use it

801-03 Micrometers
When you complete this lesson, you will be able to identify common micrometer types, identify their components, and correctly take readings using English, metric and Vernier micrometers.

- Identify common types of micrometers
- List the major components of micrometers
- Demonstrate how to take an accurate reading with an outside micrometer
- Explain how to properly read the scale on an English scale micrometer, a metric scale micrometer, and a Vernier micrometer
- Demonstrate how to take an accurate reading with an inside micrometer
- Demonstrate how to take an accurate reading with a depth micrometer

801-04 Fixed Gauges
When you complete this lesson, you will be able to describe the various types of fixed gauges commonly used by maintenance and machining technicians. You will also be able to explain the purpose of the various fixed gauges.

- Identify and describe the purpose of each of the following types of fixed gauges:
  - Go NoGo gauge
  - Plug gauge
  - Thickness gauge
  - Screw pitch gauge
  - Radius gauge
  - Small hole gauge
  - Wire and sheet metal gauges
When you complete this lesson, you will be able to identify common types of calipers used in machining and maintenance work, and explain how to properly use them.

- Identify each of the following types of calipers, and describe their operation and use:
  - Inside caliper
  - Outside caliper
  - Hermaphrodite caliper
  - Transfer and direct reading calipers
  - Slide calipers
  - Vernier calipers
  - Dial calipers
  - Digital calipers

801-06 Dial Indicators

When you complete this lesson, you will be able to list the major components of dial indicators and demonstrate how to use the instrument to take an accurate reading. You will also be able to describe how to use a dial indicator to measure the run out of a rotating part, and how to align two shafts using a dial indicator.

- List the main components of a dial indicator
- Explain how to properly read a dial indicator
- Describe how to measure run out
- Demonstrate how to align rotating components
- Describe various types of indicators

801-07 Telescoping Gauges

When you complete this lesson, you will be able to describe the function and proper use of a telescoping gauge, and explain its care.

- Explain the function of a telescoping gauge
- Identify the gauge’s components
- Describe the procedure for obtaining accurate measurements
- Explain the proper care of a telescoping gauge

803 Layout and Bench Work

803-01 Layout and Bench Work

When you complete this lesson, you will be able to identify the basic hand tools required and hand work methods used to manufacture replacement or repair parts used in various types of equipment.

- Describe tools and methods for workpiece layout, bluing, measuring, scribing lines, and marking hole centers
- Describe tools and methods for hand cutting material with a hacksaw, including hacksaw parts, blade types, cutting edge alloys, and tooth pitch
- Describe the different types of files and methods for filing and draw filing
- Describe the types of hand reamers and methods for precision sizing of holes, including the use of hand reamers, hand chucks, and drivers
- Describe the different types of deburring tools and techniques for the deburring of parts with hand tools
- Describe the various types of taps and dies and the proper hand use of taps and dies
- Describe tools for broaching and techniques for keyway broaching using an arbor press and broach set

803-02 Threading and Tapping

When you complete this lesson, you will be able to describe taps, dies, and die nuts. You will also be able to explain how they are used in threading operations.

- Describe the design and function of a tap
- Identify types of taps
- Explain the procedure for hand tapping
- Describe the design and function of a die
- Explain how to cut threads with a hand die
- Describe the design and function of a die nut
- Identify accessories used in machine threading

805 Vertical Milling Machine

805-01 Vertical Milling Machine

When you complete this lesson, you will be able to identify the basic control systems and machining methods used on a vertical milling machine and explain the basic operations necessary to manufacture replacement or repair parts used in various types of equipment.

- Identify the function of the vertical milling machine’s operational controls
- Explain how workpieces and cutting tools may be precision located through coordinate measuring
- Explain how to square a workpiece on a vertical milling machine
- Describe the use of the holding and clamping tools
- Explain how to determine suitable speeds and feeds for various:
  - Cutting tools
  - Operations
  - Workpiece materials
- Describe the use of each of the following cutting tools:
  - End mills
  - Woodruff cutters
  - Fly cutters
  - Precision boring heads
  - Counter-bores, spot facers, and chamfering tools
- Describe a method for cutting key seats and keyways
- Identify other machining processes possible on a vertical milling machine
807 Engine Lathe

807-01 Engine Lathe
When you complete this lesson, you will be able to identify engine lathe control systems and machining methods, and explain the basic methods to manufacture replacement or repair parts for various types of equipment.

➢ Describe basic engine lathe parts and operational controls
➢ Identify types of chucks and discuss procedures for installing and removing chucks and faceplates on cam-lock spindles
➢ Explain the operation and use of the four jaw chuck
➢ Describe tail stock parts and operations
➢ Describe the following types of cutting tools and discuss their uses:
  o Carbide and alloy turning tools and drills
  o Drill bits
  o Turning tools
  o Facing tools
  o Boring bars and tools
  o Threading and specialty tools
➢ Identify factors that determine suitable speeds and feeds for different cutting tools, operations, and work piece materials
➢ Describe the basic methods used for:
  o Turning operations
  o Shaft work
  o Thread cutting
  o Boring
  o Facing
➢ List other machining processes possible on an engine lathe

809 Surface Grinder

809-01 Surface Grinder
When you complete this lesson, you will be able to describe surface grinder control systems and explain basic machining methods required to manufacture replacement parts used in repair of various types of equipment.

➢ List surface grinder components and identify their functions
➢ Discuss techniques and components related to workpiece clamping
➢ Identify types of grinding wheels and compare their uses
➢ Explain the basic steps for dressing a grinding wheel and profile-shaping a grinding wheel
➢ Describe the two basic techniques for grinding a part
➢ Identify safety equipment and best practices for safe grinder operation
➢ Outline the technique for grinding a workpiece parallel and to a specific size

811 Pedestal Grinder

811-01 Pedestal Grinder
When you complete this lesson, you will be able to describe the design, function, and safe use of a pedestal grinder.

➢ Describe safety precautions taken when operating a pedestal grinder
➢ List the main pedestal grinder components and describe their functions
➢ Explain the procedure for replacing a grinding wheel on a pedestal grinder
➢ Explain how to dress a grinding wheel

813 Bandsaw

813-01 Band saw
When you complete this lesson, you will be able to describe the design and operation of a band saw. In addition, you will be able to explain how to use a band saw to produce various cuts.

➢ List the major components of a vertical band saw
➢ Describe different types of available band saw cutting blades
➢ Describe the procedures used to make straight, angle, external contour, and internal contour cuts

815 Drill Press

815-01 Drill Press
When you complete this lesson, you will be able to describe the design, function, and safe operation of a drill press and its major components and attachments.

➢ Explain safety precautions taken when operating a drill press
➢ Describe various drill press components and attachments
➢ List various types of drill presses and describe their operations
➢ Describe how cutting speeds and feed rates affect drill press operations

820 Rigging, Lifting, and Elevated Work Surfaces

820-01 Scaffold Erection and Components
When you complete this lesson, you will be able to describe the proper erecting sequence of scaffolding. You will be able to identify components used to build a scaffold and the different types of scaffolding used in many constructions projects.

➢ Explain an erecting sequence
➢ Describe the purpose of putlogs
➢ Explain the design of a rolling tower
➢ Explain the process to erect scaffold stair towers
➢ Describe the tube and clamp scaffold
➢ Explain the tube and clamp assembly
820-02 Rigging, Part 1
When you complete this lesson, you will be able to describe the design and identify the classifications of wire ropes. You will learn to install wire ropes properly and the importance of inspections and lubrication.

➢ Describe the design of wire rope
➢ Explain non-rotating ropes
➢ Describe the proper installation of rope
➢ Explain rope inspection
➢ Describe the proper lubrication of ropes

820-03 Rigging, Part 2
When you complete this lesson, you will be able to identify types of fiber ropes and the applications where they are best used. In addition, you will be able to describe techniques for care and use of ropes.

➢ Describe the features of various natural fiber ropes
➢ Describe the features of various synthetic fiber ropes
➢ Discuss proper care of natural fiber and synthetic fiber ropes
➢ Explain the importance of good rope inspections
➢ Describe proper rope splicing techniques
➢ Describe various knots, bends, and hitches
➢ Identify which knots should be used for common applications

820-04 Rigging, Part 3
When you complete this lesson, you will be able to describe the design and importance of several types of rigging hardware. In addition, you’ll be able to discuss appropriate applications for their use.

➢ Describe the features and uses of each of the following:
  o Chains
  o Drum assemblies
  o Sheaves
  o Hooks
  o Blocks
  o Slings
➢ Identify configurations associated with reeving
➢ Discuss the importance of inspections and other safety measures

820-05 Ladders
When you complete this lesson, you will be able to identify the design and function of several types of commonly used ladders. In addition, you will be able to describe proper care and safe use of ladders.

➢ List various types of rigid ladders and describe their use
➢ Explain the procedure for raising and handling a ladder
➢ Describe the factors that affect the service life of a fiberglass ladder
➢ Describe proper ladder handling, storage, transport, and maintenance
➢ Discuss how ladder selection, placement, and handling contribute to safe operation

820-06 Overhead Cranes
When you complete this lesson, you will be able to describe the design and function of various types of overhead cranes. In addition, you will understand the importance of responsibilities related to the operation, inspection, and maintenance of overhead cranes.

➢ Identify different types of overhead cranes and describe their uses
➢ Explain the mechanics of an overhead crane
➢ Discuss the responsibilities of managers, supervisors, and operators
➢ List crane components and describe their functions
➢ Explain the benefits of a good inspection and maintenance program

820-07 Aerial Lift Devices
When you complete this lesson, you will be able to describe the three main aerial lift designs and their components. You will also be able to use this knowledge to choose the design that best suits the work you are doing.

➢ Describe the design and use of boom lifts, scissor lifts, and vertical personnel lifts
➢ Identify some aerial lift features that provide convenience and facilitate efficient operation
➢ List the factors that influence your selection of an aerial lift for a specific application
➢ Explain the user’s responsibilities for aerial lift safety

841 Welding and Cutting for Maintenance
841-01 Safe Welding and Cutting Practices
When the lesson is complete, the user will be able to identify common welding hazards and describe how to use personal protective equipment (PPE), ventilation, and safety procedures to mitigate these hazards.

➢ List some common welding hazards
➢ Identify and describe proper PPE used in welding
➢ Discuss the use of ventilation to avoid welding fumes
➢ Describe safety practices employed under hot work conditions
➢ Describe safety practices employed under confined space entry conditions
➢ Identify safety considerations related to cutting operations
➢ Recall safety precautions required in oxyacetylene welding operations
➢ Identify safety precautions required in arc welding operations
➢ Discuss safe storage and handling of compressed gas cylinders
➢ Describe precautions taken to avoid electric shock when welding
841-02 Weldability of Metals
When you complete this lesson, you will be able to identify classifications of various metals and explain factors influencing their weldability.

➢ Describe the principles behind a metal’s weldability
➢ Discuss commonly used classifications of metals
➢ Identify factors and features that influence the weldability of each of the following:
  o Steel
  o Stainless steel
  o Cast iron
  o Aluminum
➢ List some adjustments you can make when lack of weldability is a problem
➢ Describe steel quenching and tempering processes

841-03 Shielded Metal Arc Welding (SMAW)
When you complete this lesson, you will be able to describe shielded metal arc welding (SMAW) and identify equipment, procedures, and methods used in successful SMAW operations.

➢ Describe the operating principles behind shielded metal arc welding (SMAW)
➢ List equipment commonly used in SMAW
➢ Explain how to strike and sustain a welding arc
➢ Explain how to control weld crater formation and overcome arc blow
➢ Describe various welding electrodes and their uses
➢ Discuss American Welding Society (AWS) symbol representation for electrodes
➢ Identify various welding positions commonly used in SMAW

841-04 Gas Metal Arc Welding (GMAW)
When you complete this lesson, you will be able to describe gas metal arc welding (GMAW) methods. In addition, you will be able to discuss the design and function of components used in the GMAW process.

➢ Explain the principles of operation behind gas metal arc welding (GMAW)
➢ Describe the design and function of each of the following components:
  o GMAW wire feeders
  o GMAW electrode wires
  o GMAW guns
➢ List the shielding gases that can be used during GMAW
➢ Explain how to start an arc when performing GMAW
➢ Describe the four main methods of metal transfer associated with GMAW

841-05 Tungsten Inert Gas (TIG) Welding
When you complete this lesson, you will be able to describe tungsten inert gas (TIG) welding methods. In addition, you will be able to discuss the design and function of components used in the process.

➢ Describe the principles of operation behind tungsten inert gas (TIG) welding
➢ Describe the design and function of each of the following components:
  o TIG welding torch
  o TIG electrodes
➢ Explain the purpose of the use of shielding gas
➢ Describe the use of TIG welding filler materials
➢ Explain how to start a TIG welding arc
➢ Discuss TIG welding positions
➢ Explain the process of hot wire welding
➢ Explain the process of pulsed TIG welding

841-06 Oxyacetylene Welding (OAW)
When you complete this lesson, you will be able to describe oxyacetylene welding (OAW) techniques. In addition, you will be able to discuss the design and function of components and apparatus used in the OAW process.

➢ Describe the principles behind oxyacetylene welding (OAW) operations
➢ Identify and describe commonly used OAW equipment
➢ Outline the procedure to light an oxyacetylene torch
➢ Explain how to adjust the flame on an oxyacetylene welding torch
➢ Describe the characteristics of an oxyacetylene flame
➢ Discuss oxyacetylene flame control
➢ Outline the procedure to shut off an oxyacetylene torch
➢ Describe OAW techniques
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Contact Us

Martech Media, Inc.
9595 Six Pines Drive
Suite 6305
The Woodlands, TX 77380
1-281-465-0625
contactus@martechmedia.com
www.martechmedia.com

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