

# 2009 Industrial Maintenance Skills Course Library



**360training.com**

# Table of Contents

|   |           |   |           |
|---|-----------|---|-----------|
| <b>100 - Safety and Soft Skills</b>                                   | <b>1</b>  | <b>500 - Power Generation and Alternate Energy Operations</b>         | <b>28</b> |
| 101 Personal Protective Equipment                                     |           | 501 Power Generation  |           |
| 102 Worksite Safety   |           | 505 Turbine Auxiliaries System and Control                            |           |
| 103 First Aid   |           | 507 Generator and Auxiliary Systems and Control                       |           |
| 104 Fire Prevention   |           | 511 Combustion Turbine Fundamentals                                   |           |
| 105 Lockout/Tagout  |           | 521 Combustion Air and Flue Gas System                                |           |
| 106 Confined Space Safety   |           | 523 Boiler Fuel Systems   |           |
| 107 Electrical Safety   |           | 531 Hydrocarbon Fired Boilers   |           |
| 108 Materials Handling  |           | 533 Boiler Firing Controls and Components                             |           |
| 109 Rigging Safety  |           | 535 Fundamental Aspects of Emission Controls                          |           |
| 110 Scaffolding Safety  |           | 551 Circulating Water System  |           |
| 111 Aerial Devices Safety   |           | 553 Condensate and Feedwater Systems                                  |           |
| 112 Crane Operations Safety   |           | 555 Boiler Feed Pumps   |           |
| 113 Forklift Safety   |           | 557 Boiler Water and Steam Systems                                    |           |
| 114 Fall Protection   |           | 559 Water Treatment   |           |
| 116 Compressed Gas Cylinder Safety                                    |           | 561 Unit Start-up and Shutdown  |           |
| 117 Hazardous Materials Safety  |           | 563 Efficiency, Reliability, and Environmentally Sensitive Operations |           |
| 130 Behavior Based Safety Training                                    |           | 565 Plant Control System  |           |
| <b>200 - Industrial Maintenance</b>                                   | <b>7</b>  | 581 Diesel Power Plant Operations                                     |           |
| 201 Introduction to Industrial Maintenance and the Tools of the Trade |           | 583 Hydroelectric Power Plant Operations                              |           |
| 202 Belt Drive Maintenance  |           | <b>600 - Industrial Instrumentation</b>                               | <b>46</b> |
| 203 Bearing Maintenance   |           | 603 Process Control Variables   |           |
| 205 Gear Maintenance  |           | 605 Test Equipment  |           |
| 207 Rotating Machinery  |           | 607 Analyzers   |           |
| 208 Piping  |           | 609 Calibration and Troubleshooting                                   |           |
| 209 Shaft Alignment   |           | 611 Prints and Drawings   |           |
| 211 Chain Drive Maintenance   |           | 613 Automated Control   |           |
| 213 Lubrication   |           | 615 Signal Transmission and Conversion                                |           |
| 215 Valve Selection and Maintenance                                   |           | 617 Controllers and Final Control                                     |           |
| 219 Centrifugal Pumps   |           | 621 Programmable Logic Controllers                                    |           |
| 223 Heat Exchangers   |           | 623 Advanced Process Trainer  |           |
| 225 Compressors   |           | <b>800 - Machine Shop</b>   | <b>54</b> |
| 229 Fasteners and Seals   |           | 801 Precision Measurement   |           |
| 231 Positive Displacement Pumps                                       |           | 803 Layout and Bench Work   |           |
| 243 Hydraulics  |           | 805 Vertical Milling Machine  |           |
| 271 Vibration   |           | 807 Engine Lathe  |           |
| 273 Boiler Repair   |           | 809 Surface Grinder   |           |
| <b>400 - Industrial Electricity</b>                                   | <b>21</b> | 811 Pedestal Grinder  |           |
| 401 Direct Current (DC)   |           | 813 Bandsaw   |           |
| 402 Alternating Current (AC)  |           | 815 Drill Press   |           |
| 411 Motor Control   |           | 820 Rigging, Lifting and Elevated Work Surfaces                       |           |
| 413 AC Drives   |           | 841 Welding and Cutting for Maintenance                               |           |
| 415 Transformers  |           |   |           |
| 417 Switchgear Maintenance  |           |   |           |
| 419 Motor Operated Valves   |           |   |           |
| 421 Connections and Terminations                                      |           |   |           |
| 423 Cable Splicing  |           |   |           |

## Course Descriptions

---

Industrial Technologies Curriculum is a dynamic, comprehensive training solution designed as a progression or cross-discipline education and training solution.

Industrial Technologies Curriculum has been developed by subject matter experts with field and educational experience within each discipline. All lessons are designed using learning outcome based instructional design methods. These online courses incorporate varying types of media, including photographs, graphics, video, animations, and three dimensional representations. Interactive remediation and simulation is also developed for each lesson to maximize the learning experience

To order:

Visit: [www.360training.com](http://www.360training.com)

Call: 1.866.601.6742

---

## 100 - Safety and Soft Skills

### 101 Personal Protective Equipment (PPE)

#### 101-01 Personal Protective Equipment

When you complete this lesson, you will be able to prevent injury, illness, and death by properly selecting, using, and maintaining personal protective equipment (PPE).

- 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 that may affect the workers' health and safety.
- Prevent injury, illness, and death by properly using and maintaining 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.

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

#### 101-03 Respiratory Protection 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.

- 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 types or work or conditions requiring respiratory protective equipment.
- Describe the personal medical considerations and evaluation procedures pertaining to a respiratory protection program.
- Identify and explain the appropriate respiratory protective equipment to be used in certain working conditions.
- Apply qualitative and quantitative fit testing procedures.
- Identify the components of a respiratory protection training program.
- Inspect, maintain, and properly store respiratory protective equipment

---

## 102 Worksite Safety

### 102-01 Slip, Trip, and Fall Protection

When you complete this lesson, you will be able to adhere to safe practices to prevent slips, trips, and falls in the workplace.

- Identify the dual causes of slips, trip, and falls as lack of alertness and physical hazards.
- Describe common hazards in the workplace that contribute to injury and death from falls, slips, and trips.
- Apply preventative measures to prevent slips, trips, and falls.
- Determine the responsibilities of employees in ensuring fall, slip, and trip 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.

- 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.

- 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.

- Identify the responsibilities of management, supervisors, and operators in maintaining machine guard safety.
- Identify the hazards associated with the operation of machines and explain the importance of machine guards.

### 102-07 Stationary Power Tool Safety

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

- Adhere to safety standards and practices that oversee the workplace and operation of power tools.

Apply the requirements of specific stationary power tools commonly found in the workplace, including the table saw, the radial arm saw, the band saw and the jig saw, the wheel grinder, the drill press, the lathe, the bending machine or brake, metal shears, welding machines, and the milling machine.

---

## 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 blood borne pathogens and prevent infections. Identify the dual causes of slips, trip, and falls as lack of alertness and physical hazards.

- Describe and apply minor first aid treatments.
  - Determine the need for emergency medical treatment and initiate contact with emergency medical services.
  - Describe actions taken during a medical emergency to include bleeding, physical shock, choking, burns, heat exhaustion and poisoning.
  - Define blood borne pathogens (BBP) and provide examples.
  - Identify the transmission of HBV and HIV.
  - Identify and apply universal precautions to prevent the transmission of blood borne pathogens.
  - Identify personal protective measures to prevent BBP infections.
- 

## 104 Fire Prevention

### 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.

- Describe the fire tetrahedron and its role in fire prevention and extinguishing.
- Apply fire prevention strategies.
- Identify the four classes of fires.
- Apply 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, incipient fire and apply the safest procedures for extinguishing a fire in the workplace.

- Describe the principles of fire extinguisher operation.
  - Classify fuels to determine the proper fire extinguisher to use in case of fire.
  - Apply the safest method of extinguishing a fire in the workplace.
- 

## 105 Lockout/Tagout

### 105-01 Lockout/Tagout Safety Program

When you complete this lesson, you will be able to explain the necessity of a lock out/tag out program and adhere to the procedures and practices of lockout/tagout safety.

- Explain the necessity of a lockout/ tagout program.
  - Identify lockout/ tagout terminology.
  - Describe the training requirements of a lockout/tagout safety program.
  - Apply the sequence of actions required by the lockout/tagout program.
  - Adhere to procedures for returning equipment or machines to service.
  - Apply communications requirements to ensure the safe lockout/ tagout of equipment and machines.
- 

## 106 Confined Space Safety

### 106-01 Confined Space Safety

When you complete this lesson, you will be able to safely work within confined spaces.

- Define a confined space.
- Provide examples of confined spaces.
- Identify permit-required confined space policies.
- Identify the qualities of a hazardous atmosphere.
- Identify hazards associated with entry into a confined space.
- Describe responsibilities of the person entering a confined space, the attendant, and the supervisor.
- Describe rescue and emergency services.
- Describe training requirements.
- Identify outside contractor responsibilities.

## 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.

- 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.

- 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).
- 

## 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 safely handling and storing materials in the workplace.

- 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.

- 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.

- 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 complete this lesson, you will be able to explain importance of operating the scissor lift according to the step by step procedures listed in most operating manuals. You will also explain the safety measures that must be followed in detail, and the importance of thorough pre-inspections.

- Explain the importance of following all safety rules.
  - Explain the pre-operation inspections of the scissor lift.
  - Describe the importance of good maintenance practices.
  - Explain 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 and perform hand signals as well as perform a safety checklist for the operation of cranes and hoists.

- Identify operator responsibilities.
  - Explain general safety rules.
  - Describe operation rules.
  - Explain rigging safety requirements.
  - Display and understand hand signals.
  - Conduct a crane and hoist safety checklist.
- 

## 113 Forklift Safety

### 113-01 Forklift and Powered Industrial Truck Safety

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

- Describe supervisor responsibilities.
  - Identify operator training requirements.
  - Describe the components of a lift truck.
  - Apply safe operating rules.
  - Describe proper load handling.
  - Apply safe operating procedures.
- 

## 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.

- Identify examples of situations requiring fall protection.
  - Identify fall protection systems utilized in the workplace.
  - Describe the personal fall arrest systems.
  - Describe safety net systems.
  - Describe warning line systems.
  - Describe the proper use of covers and protection from falling objects.
  - Meet employee training requirements.
- 

## 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.

- 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 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.

- 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.

## 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 Programs – Basic Concepts

When you complete this lesson, you will be able to describe the factors that affect 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 that affect safety in the workplace.
- Describe three personal characteristics that affect an individual's safety on the job.
- Describe three factors that affect an employee's work environment.
- Explain the difference between a safe working attitude and safe working behavior.

### 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. In addition, you will be able to discuss some of the procedures used when 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 describe the basic information that is 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 the purpose of an atmospheric test and describe the purpose of the 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.

---

## 200 - Industrial 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 discuss the reason for a confined space procedure and describe the basic information that is 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 the purpose of an atmospheric test and describe the purpose of the test.
- Describe the primary difference between a non-permit required confined space and a permit required confined space.

#### 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.
- Identify and describe the types of grinders used in industrial facilities.
- Identify and describe types of impact wrenches used in industrial facilities.
- Identify and describe types of portable power drill used in industrial facilities.
- Identify and describe types of 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 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 and explain the proper procedures for their use.
  - 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
  - Sheave pitch diameter
- Discuss conventional, high capacity, and light duty V-belt sizing.
- 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-belt applications.
- 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.
- Discuss the sheave design used on these systems.
- Describe the 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 course, 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 automated roller conveyors.

### 202-06 Conveyor System Design

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.
- List the components that collectively comprise a typical industrial conveyor drive.
- Identify two functions of a snub pulley.
- 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 3 checks you should make when inspecting a running conveyor belt.
- Discuss the purpose of a belt wiper.

### 202-08 Conveyor Belt Installation and Repair

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 three types of friction forces that affect bearings.
- Explain the basic mechanical functions of bearings.
- Describe the loading forces that affect 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.

- Identify tools used to install a rolling contact bearing.
- Explain methods of installing a shrink fit bearing.
- Discuss the steps to check an installed rolling contact bearing for proper operation.
- List the sounds an improperly installed rolling contact bearing can make and explain their causes.
- Describe alignment of a sliding surface bearing.
- Identify tools used in the removal of sliding surface and rolling contact 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 that may indicate failing bearings. In addition, you'll be able to troubleshoot bearing failures and use the information you gain to prevent a reoccurrence.

- Identify the symptoms of failing bearing.
- Discuss bearing failure due to:
  - Normal fatigue
  - Overheating
  - Lubricant
  - Corrosion
  - Brinelling and false brinelling
  - Equipment misalignment
  - Fretting.
  - Electrical arcing
  - Thrust forces

- Identify types of background data you should gather when troubleshooting bearings.
  - List troubleshooting questions that can help you determine whether bearing failure was related to specific problems with the:
    - 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 used when working with gears and gear drives.

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

### 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 be able to explain factors affecting gear backlash and proper gear lubrication.

- Describe gear maintenance troubleshooting techniques.
- 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.

---

## 207 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'll 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 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 will 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

### 208-01 Pipe and Pipe-fitting Symbols

When you complete this lesson, you will be able to recognize symbols commonly used to indicate types of pipes, pipe-fittings, and welding connections.

- Identify line symbols used in pipe-fitting.
- Describe how pipe-fitting symbols can represent the following:
  - Size of a pipe
  - Method of branching and coupling
  - Purpose for which the pipe will be used
- Identify welding symbols used for pipe-fitting.

### 208-02 Pipe Joining Methods

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.

- 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.

### 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.

---

## **209 Shaft Alignment**

### **209-01 Shaft Alignment**

When you complete this lesson, you will be to identify common problems of shaft misalignment and apply practices to properly align shafts.

- Identify the various types of couplings and understand their design features.
- Identify common conditions found during a pre-alignment inspection.
- Describe three types of misalignment.
- Identify tools and processes for correcting the conditions of soft foot, bent foot, foundation instability, and nozzle induced soft foot.
- Describe two methods of shaft alignment.
- Perform straight edge and thickness gauge alignment.
- Perform rim and face graph alignment.

---

## **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 different 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 grease.
- Discuss additives and explain how they impact your grease selection.
- Describe the importance of a viscosity grade system.
- Explain how each of the following organizations relates to viscosity grade:
  - Society of Automobile Engineers (SAE)
  - International Standards Organization (ISO)
  - American Gear Manufacturers Association (AGMA)
- Identify the basic classifications of engine oils.
- List six 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.

- 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 that 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

---

## 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.
- Describe the four basic types of flow control elements employed in valve design.
- Explain how valve stem leakage is controlled.
- Identify the following valve components:
  - Body
  - Bonnet
  - Stem
  - Actuator
  - Packing
  - Seat
  - Disc

### 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:
  - Manual
  - Electric motor
  - Pneumatic
  - Hydraulic
  - 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.

- Describe the operation of a gate valve.
- Discuss some advantages and disadvantages of a gate valve.
- List various gate valve disc 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 disc designs used in globe valves.
- Discuss the advantages and disadvantages of these designs.
- Explain how the disc 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 disc 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:
  - Swing
  - Tilting Disc
  - Lift
  - Piston
  - Butterfly
  - 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 relief valve.
- Describe the use of a pilot operated relief valve.

## 219 Centrifugal Pumps

### 219-01 Introduction to Centrifugal Pumps

When you complete this lesson, you will be able describe 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.
- Explain the difference between vertical and horizontal centrifugal pumps.
- 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 describe various centrifugal pump designs and explain the role design plays in matching a pump to an application.

- Compare centrifugal pumps to positive displacement pumps.

- Explain the design of a volute pump casing.
- Identify the difference between a solid casing and a split casing.
- Describe the following impeller designs & provide examples of fluids each might pump.
  - Open impellers
  - Closed impellers
  - Semi-open impellers
- Describe the purpose of a thrust bearing on a centrifugal pump.
- Describe the purpose of a mechanical seal on a centrifugal pump.

### 219-03 Centrifugal Pump Fundamentals

Centrifugal pumps are used extensively in plant systems to move liquids through processes under various operating conditions. To effectively operate these systems, you need to know the terminology associated with centrifugal pumps and understand factors that affect centrifugal pump operation.

- 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

When you complete this lesson, you will be able describe the basic start-up and shutdown procedures used on single and multi-stage centrifugal pumps. In addition, you will be able to explain the basic inspections that should be completed on operating centrifugal pumps during each shift.

- Identify basic pre-start checks and inspections to complete prior to starting a centrifugal pump.
- Explain the additional checks to make on a large, multi-stage centrifugal pump.
- Describe what is meant by the phrase, "priming a pump".
- Describe inspections conducted on an operating centrifugal pump.
- Define the term, "air bound pump", in reference to a centrifugal pump.
- Describe the basic procedure for shutting down a centrifugal pump.

## 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 through the use of heat exchangers. In addition, you will be able to describe the basic differences between open and closed heat exchangers, and give examples of each.

- Describe how heat exchangers are used to transfer heat from one substance to another.
- Define thermal conductivity and explain its relationship to heat exchanger design.
- Define latent heat.
- Describe how heat exchangers can be used to increase the efficiency of the plant cycle.
- Explain the difference between open heat exchangers and closed heat exchangers in a typical feedwater system.
- Describe how open and closed heat exchangers are used in condensate and feedwater systems to increase the efficiency of the plant cycle.

### 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 with regard to condensate.
- Explain the purpose of a deaerator, and 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
- Explain 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 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 basic components that make up a typical shell and tube heat exchanger.
- Explain the difference between a single pass heat exchanger and a multi-pass heat exchanger.
- Explain what is meant by parallel flow, cross flow, and counter-flow in regard to shell and tube heat exchanger operation.
- Describe how extraction steam is removed from a steam turbine, and how that steam is routed to a series of high and low pressure feedwater heaters.
- Describe how a cascading heater drain system works in regards to a series of feedwater heaters in a condensate and feedwater system.
- Explain some common start-up checks to follow when putting a shell and tube feedwater heater in service.
- Explain some common shutdown procedures taken when removing a shell and tube feedwater heater from service.
- Describe a typical valving arrangement used to bypass the condensate or feedwater flow around a shell and tube heat exchanger if a tube leak develops.

## 225 Compressors

### 225-01 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".
- Compare the two basic categories of air compressors and explain the primary difference between them.
- Give four examples of prime movers that can be 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 trouble shooting 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 and explain the operation of both single-acting and double-acting reciprocating air compressors.
- Identify the basic design characteristics and 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 the 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 multi-stage centrifugal air compressor.
- Explain 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.

## 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.
- Identify characteristics that determine thread strength and describe bolt grading.
- Describe failure modes of bolted connections.
- List and describe different locking mechanisms used on fastener.

### 229-02 O-Rings

O-rings are used in many sealing applications in an industrial facility. They ensure tight seals and prevent leakage of fluids from a wide variety of equipment in the plant. Knowledge of O-ring sealing characteristics and the various materials used in their production will aid you in selecting the proper O-ring for a given application. Proper installation techniques and failure troubleshooting procedures will also prevent future problems with the sealing application.

- 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 troubleshoot these failures.
- Describe proper techniques for installing and caring for O-rings.

### 229-03 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.

### 229-04 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'll 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 packing 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'll be able to explain proper seal care.

- Describe the principles behind the operation of mechanical seals.
- List 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 the two categories of positive displacement pumps.

- Explain the basic design differences between a positive displacement pump and a centrifugal pump.
- Discuss the operating principle behind positive displacement pumps.
- Describe the overall operation of a reciprocating positive displacement pump.
- Describe the overall operation of a rotary positive displacement pump.

### 231-02 Reciprocating Positive Displacement Pumps

When you complete this lesson, you will be able to describe the design and function of commonly used Reciprocating Positive Displacement pumps.

- Describe the operating characteristics of reciprocating piston and plunger 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:
  - Simplex pumps
  - Duplex pumps
  - Multiplex pumps
- Explain how steam engines can be used to power Reciprocating Positive Displacement pumps.
- Describe the 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 several, commonly used styles of this type of pump.

- 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:
  - Screw pumps
  - Vane pumps
  - 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 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.
- 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:
  - Displacement
  - Velocity
  - 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 that a machine is unbalanced.
- Recognize the characteristics of vibration caused by:
  - mechanical looseness
  - a faulty bearing
  - a faulty gear or belt
  - an electrical fault

### 271-03 Basic Vibration Troubleshooting Techniques

When you complete this lesson, you will be able to describe basic techniques to investigate vibration problems and troubleshoot their root cause.

- Discuss how to examine preliminary vibration problem data and findings.
- List the common machine vibration data collection points.
- Explain how to inspect a machine when investigating vibration problems.
- Identify the steps, procedures, and communication techniques employed in successful vibration troubleshooting.
- Differentiate between vibration problem symptoms and root causes.

### 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 structure, limitations, and 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.
- Formulate a solution for handling a vibration problem on a machine.
- List the 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 I

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 II

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 explain some specific things to look for when doing a waterside inspection on steam drums, moisture separators, headers and tubes of a large watertube boiler.

- Describe how to inspect the waterside of the steam drum and moisture separators of a large watertube boiler.
- Describe how to inspect the waterside of the headers and tubes of a large watertube boiler.

### 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 Cleaning of a Boiler

When you complete this lesson you will be able to explain some methods and procedures for cleaning and testing the waterside of a large watertube boiler.

- Explain how to perform a chemical cleaning procedure on the waterside of a large watertube boiler.
- Explain how to use a hydrostatic testing procedure to test for leaks in a large watertube boiler.
- Explain how to use a compressed air testing procedure to test for leaks in a large watertube boiler.

### 273-07 Fireside Cleaning of a Boiler

When you complete this lesson you will be able to explain some methods and procedures for cleaning the fireside of a large watertube boiler.

- Explain how to perform a cleaning procedure on the fireside of a large watertube boiler.
- Explain how to close a boiler after fireside cleaning.
- Explain how to pressurize a boiler and check for leaks after a fireside cleaning.

## 400 - Industrial Electricity

### 401 Direct Current (DC)

#### 401-01 Electron Theory

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.

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

### 401-03 Ohm's and Kirchoff'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 Kirchoff'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 Kirchoff's current law using a DC circuit example.
- Explain Kirchoff's voltage law using a DC circuit example.

### 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.

### 401-05 Determine Circuit Outputs from Specified Inputs

When you complete this lesson, you will be able to use formulas to compute DC series and parallel circuit outputs based on the known inputs.

- Compute total current flow through a DC series circuit.
- Compute total resistance in a DC series circuit.
- Compute voltage drops across individual resistors in a DC series circuit.
- Compute total voltage drop through all resistors in a DC series circuit.
- Compute power dissipated in DC series circuits.
- Calculate the total power in a DC series circuit.
- Compute the current in branches of a parallel DC circuit.
- Compute the total current in a DC parallel circuit.
- Compute the potential (voltage drop) across resistors in a DC parallel circuit.
- Compute power dissipated in the resistors of a DC parallel circuit.
- Compute total power in a DC parallel circuit.
- Compute the total resistance in a DC parallel circuit.

## 402 Alternating Current (AC)

### 402-01 Introduction to Alternating Current

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.
- 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 Kirchoff's Laws Involving AC Circuits

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.
- 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 Kirchoff's Laws Involving AC Circuits

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

## 409-01 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 motor uses the principles of magnetism and magnetic fields to convert electrical energy into mechanical energy.

- Describe the make-up of a magnetic field.
- State the law of magnetism.
- Define the following terms:
  - Magnetic flux
  - Polarity
  - Motor slip
  - Synchronous speed
- Describe electromagnetic force.
- Discuss the theory behind the operation of single-phase AC motor, rotating stator fields.
- Explain the rotation of an AC squirrel cage rotor.
- Discuss the three-phase motor's rotating stator field and its associated waveform.

## 409-04 Troubleshooting AC Induction Motors

When you complete this lesson, you will be able to discuss procedures for effective troubleshooting of AC induction motors.

- Describe five primary steps you should 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 and demonstrate how the superposition, Thevenin's, and Norton's theorems can be used to simplify computations for complex AC circuits.

- Explain the superposition theorem for complex circuits.
- Explain Thevenin's theorem for complex circuits.
- Explain Norton's theorem for complex circuits.

### 409-06 Overhauling Induction Motors

When you complete this lesson, you will be able to describe each of the steps taken to overhaul an induction motor.

- 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 Systems

When you complete the lesson, you will be able to describe the design and function of generator systems.

- Explain why hydrogen is used as a generator cooling system.
- Identify the hydrogen monitoring systems.
- Explain why a seal oil system is needed.
- Identify the parts of a stator cooling system.
- Describe isolated-phase bus and how it is cooled.
- Describe a generator excitation system.

### 409-08 Generator Overhaul

When you complete this lesson, you will be able to discuss the steps taken in shutting down and preparing a generator for maintenance. In addition, you will be able to describe what to look for when disassembling a generator.

- 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.

## 411 Motor Control

### 411-01 Introduction to Motor Controls

When you complete this lesson, you should be able to draw a simple motor control circuit and describe its applications of 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 semi-automatic and an automatic circuit.
- Describe the path of flow through a motor control circuit drawing.

### 411-02 Motor Protection and Fault Diagnosis

When you complete this lesson, you will be able to explain the difference between an overload and a short circuit fault. In addition, you will be able to select the proper over-current and short circuit protection devices for motor branch circuits.

- Describe a magnetic breaker and discuss its use in motor protection.
- Describe a thermal magnetic breaker and discuss its use in motor protection.
- Identify the function of an over-current protection device.
- Explain the difference between non time-delay and time-delay fuses.
- Describe the design and function of overload relays.
- Explain how to determine the cause of a fault and identify corrective measures.

### 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 can help you find a problem.
- Describe how to use wiring diagrams and schematics to locate problems in a circuit.

---

## 413 AC Drives

### 413-01 AC Drives Overview

When you complete this lesson, you will understand the basic design and use of AC drives.

- 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 Basic Operation and Theory

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.

- 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.
- Identify 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.
- Explain the purpose of a gas relay.
- Describe 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:
  - Phase voltage
  - Phase current
- Discuss three-phase, wye-connected line and:
  - Phase voltage
  - 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.

## 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:
  - Breakers and switches
  - Generator breaker
  - Electrical bus
  - 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.

## 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<sup>®</sup> 00/000 and 0-3.
-

## 419-02 MOV (Motor Operated Valve) Disassembly and Inspection

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-000/00 MOV, inspect its components, and reassemble it.

## 419-03 MOV (Motor Operated Valve) 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:
  - Declutch shaft and fork
  - Drive sleeve
  - Worm shaft
  - Worm and spring pack
  - Spring cartridge cap
  - Declutch lever
  - Handwheel assembly
  - Tripper lever
  - Torque switch
  - 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 Connections and Terminations

## 421-01 Wire and Cable Management

When you complete this lesson, you will be able to determine how to place your wire and cable in the conduit and cable tray.

- Describe the use of the following:
  - Cable trays
  - Junction boxes
  - 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 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:
  - Use a wire nut connector
  - Terminate wires using a terminal strip
  - Form wire in a junction box

---

## 423 Cable Splicing

### 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 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 of re-shielding and re-insulation
- Describe the steps in preparing for cable termination.
- Explain what is needed for a Class 1 termination. Explain where stress control is needed in the termination.

---

# 500 - Power Generation and Alternate Energy Operations

## 501 Power Generation

### 501-01 Energy Conversion

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.
- Explain the difference between renewable and non-renewable energy sources.
- Explain the difference between potential energy and kinetic energy.
- Describe the three basic energy conversions that take place in a fossil fuel-fired power plant: chemical to thermal, thermal to mechanical, and mechanical to electrical energy.
- Define efficiency.

### 501-02 System 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.

- Discuss the role of the steam turbine in power plant operations.
- Describe the basic design of a turbine rotor.
- Explain the purpose of the stationary blades.
- List three common classifications of steam turbines.
- Discuss the function of the main steam stop valves.
- Describe the design and purpose of the steam chest and control valves.
- Identify two primary functions of the turbine lube oil system.
- Describe the role of each of the oil pumps.

### 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.
- Explain how electricity usage is measured in a typical household.
- Describe the purpose of the electromagnet in a generator.
- Describe the purpose of the generator stator.
- Explain what is meant by 3-phase power.
- 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 that comprise 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 that takes place in a steam turbine.
- Explain the difference between impulse and reaction blades, 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 typical steam turbine design.
- Trace the steam flow path through a high, intermediate, and low pressure turbine.

### 505-02 Steam Turbine Valves and Control

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 the purpose of the turbine governor and control valves.
- Explain the difference between reheat and intercept valves.
- Describe what happens during a turbine trip.
- Describe the basic operation of a flyweight governor control system.
- Explain the difference between full arc admission and partial arc admission.

### 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.

## 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.
- Use an equation to account for the mechanical forces resultant in the production of electricity.
- Identify the function of the rotor.

- Discuss generator cooling techniques.
- List advantages of hydrogen cooling and identify auxiliary systems associated with its use.
- Describe the design and function of the rotor winding assembly.
- Explain 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 & systems and identify their place in the flow path:
  - Hydrogen side of the seal oil system
  - Air side of the seal oil system
  - Defoaming tank
  - Seal oil return
  - 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.
- Describe the construction of a three-phase, two pole DC generator.
- Explain how a sinusoidal waveform illustrates the number of amps produced over a given time.
- List methods of control and identify their importance 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 the 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 generator & auxiliary system shutdown.

- Explain the steps followed when shutting down each of the following:
  - Generator
  - Seal oil system
  - 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 Combustion Turbine Fundamentals

When you complete this lesson, you will be able to discuss the overall operation and function of combustion turbines.

- Describe the basic design and purpose of a combustion turbine.
- List the components of a typical combustion turbine package and discuss the function of each.
- Explain the Brayton Cycle, as it relates to the basic principles behind gas turbine operation.
- Recognize the importance of temperature monitoring and identify heat's potential for system damage.

## 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 basic function of combustion air.
- Apply the combustion process to the principles of boiler operations.
- List the four things necessary for fuel to burn.
- Identify three indications of incomplete combustion.
- Describe the overall design and basic function of the flue gas system.
- Identify flue gas system components.

## 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:
  - Combustion air
  - Primary air
  - Secondary air
- Explain the functions of the reheat and superheat sections of the boiler.
- Explain the use of forced and induced draft fans.
- Describe the flue gas path through the major components of a power plant.
- Explain the purpose and operation of the flue gas system components.
- Compare particulate recovery and scrubbing techniques used in the flue gas path.

## 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 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 ID fan.
- List verifications and tests that should be completed prior to FD fan start-up.
- Describe the steps to start the FD fan.
- Describe preparations to ensure the igniter air blowers are ready for service.
- List typical permissives that must 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 Normal 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 igniter 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 Shut Down 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:
  - PA fan
  - ID fan
  - FD fan
  - Air preheaters
- Identify the importance of following shutdown procedures step-by-step, in their prescribed order.
- Define thermal shock and explain how to avoid it during shutdown.

# 523 Boiler Fuel Systems

## 523-01 Function, Flow Path, and Major Components of the Boiler Fuel System

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 supply systems.

- Explain the function of the boiler fuel system.

- Describe various types of coal used in the fuel system.
- Identify the conveyer, tripper, silo components and path.
- 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 corner 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 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 start-up.

- 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 start-up 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 describe the normal operation parameters of the boiler fuel system and assess the performance of system components to those parameters.

- 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 origin of fossil fuels and their basic chemical composition.
- Describe the chemical reaction that takes place during combustion to release the stored energy in the fuel.
- Describe the relationship between each of the elements found in the combustion triangle.
- Define the following terms as they pertain to combustion:
  - Chemical energy
  - Hydrocarbon
  - The 3 T's of combustion
- Describe the difference between viscosity, flash point, fire point, and pour 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 in for different processes. In addition, you will be able to describe the basic components that make up a fire tube and water tube boiler and explain the circulation paths through each type of boiler.

- Define the following terms as they pertain to steam boilers:
  - Heating surface
  - Low pressure boilers
  - High pressure boilers
- Describe the difference between package boilers and field erected boilers.
- Describe the differences between fire tube boilers and water tube 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 water tube boiler.
- Describe the advantages and disadvantages of fire tube boilers and water tube boilers.

### 531-03 Boiler Valves and 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 and describe the common uses of each type of valve in conjunction with steam boiler operation.
- Describe the purpose and basic design of a water column.
- Describe two types of gauge glasses used in boiler operation.
- Describe the basic design and operation of a bourdon tube pressure gauge.
- 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 steam traps in conjunction to 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 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 the operation of each type of system.
- 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:
  - Draft
  - Forced Draft
  - Induced Draft
  - Balanced Draft
- Explain the difference between primary air and secondary air and the role of each during boiler operation.

### 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.

- Explain the concept of heat transfer.
- Define the following terms:
  - Radiation
  - Conduction
  - 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 and identify its location in the boiler.
- Explain the purpose of a radiant superheater and identify its location in the boiler.
- 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 Boiler Environmental Controls

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 and process used to remove bottom ash from a boiler.
- Explain the basic equipment and process 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 a shift.

- Define shift work.
- 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.
- Explain the basic procedure to start up a boiler.
- Explain the basic procedure to shut down a boiler.

## **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 the design and operation of 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 igniter 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 (FGDS) Open Spray Design (Part I)**

When you complete this lesson, you will be able to understand how the design of the open spray FGDS effectively reduces SO<sub>2</sub> and provides substantial flexibility in meeting SO<sub>2</sub> 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:
  - Absorber bypass fraction

- Number of absorbers in service
- Number of spray levels in service
- Fly ash and lime feed

### 535-03 Flue Gas Desulfurization System, Open Spray Design (Part II)

When you complete this lesson, you will have an understanding of the overall process of cleaning the SO<sub>2</sub> 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

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.

## 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 start-up.
- Identify the steps completed during start-up.
- Discuss operators' responsibilities during start-up.
- Describe the inspections and checks performed after start-up.

### 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 with 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 automatic controls typically used in the circulating water system:
  - Intake Structure Instruments
  - Cooling Tower Instruments
  - Condenser Instruments

## 553 Condensate and Feedwater Systems

### 553-01 Introduction to the Condensate and Feedwater Systems

When you complete this lesson, you will be able to distinguish the differences between condensate and feedwater and be able to describe the system functions.

- Examine condensate.
- Define the system function of condensate.
- Examine feedwater.
- Define the system function of feedwater.

### 553-02 Major Components of the Condensate System

When you complete this lesson, you will be able to identify all of the major components in the condensate system and describe the processes employed by the condensate system in boiler operations.

- Identify the condenser and its function.
- Explain the purpose and characteristics of the hotwell.
- Describe the characteristics and function of low pressure heaters.
- Locate and explain the operation of condensate feed lines and pumps.
- Identify the air ejectors and gland steam exhaust systems.
- Describe the location and function of deaerators.

### 553-03 Major Components of the Feedwater System

When you complete this lesson, you will be able to identify the major components of the feedwater system, their arrangement along the system, and explain their operations.

- Identify boiler feed pumps and their function.
- Explain the operation of high pressure heaters.
- Explain the purpose of the cascading drains arrangement.
- Describe the design and function of the boiler drum.

### 553-04 Process and Control Loops for the Condensate and Feedwater Systems

When you complete this lesson, you will be able to explain the relationship and controls of the feedwater and condensate systems.

- Identify and explain process controls for levels.
- Identify and explain the process controls for vacuum.
- Describe the process controls for condensate and feedwater.
- Describe the operation of control element applications.
- Explain the function of the sequential valve control.

### 553-05 Start-up for the Condensate and Feedwater Systems

When you complete this lesson, you will be able to apply the standard operating procedure for the start-up of a typical plant's feedwater and condensate system.

- Prepare to fill the hot well.
- Describe filling the hot well.
- Explain placing the condensate system in service.
- Apply the procedure for starting extraction steam and feedwater heater systems.
- Fill the boiler drum.

### 553-06 Normal Operation of the Condensate and Feedwater Systems

When you complete this lesson you will be able to examine the normal operational aspects of the condensate and feedwater systems. The lesson will focus on the normal limits of various plant components. By covering the normal operational water temperature and flow levels of the plant components the student will be able to identify what they are.

- Examine deaerator and condensate operations.
- Examine feedwater system normal operations.
- Illustrate extraction steam operations.

### 553-07 Shutdown Procedures for the Condensate and Feedwater Systems

When you complete this lesson, you will be able to describe the shutdown process and adhere to standard procedures for the process.

- Describe and apply the procedures for the condensate system shutdown.
- Apply procedures for removing the feedwater system from service.
- Describe boiler drum blanketing.
- Describe the laying up of heaters during shutdown.

## 555 Boiler Feed Pumps

### 555-01 Boiler Feed Pumps and Associated Auxiliary Equipment

When you complete this lesson, you will be able to distinguish the differences between condensate and feedwater and be able to describe the system functions.

- 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 condition 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 Functions of the 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. The operator 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 Major 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 the 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 for boiler start-up.
- 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 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 a power plant.

- Define corrosion and discuss its causes.
- Explain how corrosion relates to erosion.
- Identify major types of corrosion and describe how each can affect power 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 a Power Plant

When you complete this lesson, you will be able to describe how corrosion affects various systems within a power plant. 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 power plants take to control or eliminate corrosion in the water and steam path.

### 559-06 Steam Chemistry Control and 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 in a power plant.

- 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 Power Plant 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 power 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 of water from the source through the power plant 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.

## 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 start-up.

- Describe the role an electrical dispatcher plays in preparing for a power plant start-up.
- Discuss the purpose of determining appropriate ramp rates for starting up the boiler and turbine.
- Describe the four basic categories of pre-start 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 on-line.

- 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 Shutdowns

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/energy 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 be able to explain the relationship of thermodynamic principles to plant efficiency. You will be able to use operating plant data to plot plant processes on a chart to evaluate 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 of 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 affect 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 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 and differences.
- 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.
- Describe how a control system responds when it receives an erroneous signal from an instrument such a thermocouple.
- Discuss 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 and 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:
  - Chemical deposits and internal erosion
  - Internal and external seal leakage
  - Variations in steam temperature and pressure
  - Backpressure
  - Attemperation spray flow
  - 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.
- Explain the relationship between backpressure, 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 of remedying specific condenser problems and optimizing operational performance.

- Describe the symptoms of these problems that reduce the effective heat transfer area of an operating condenser:
  - Air in-leakage
  - Problems with air removal equipment
  - High hotwell levels

- Improperly vented waterboxes
- Blocked or plugged tubes
- Describe the symptoms of these problems that reduce the heat transfer coefficient of a condenser:
  - Scaling
  - Micro-fouling
  - Dirt, debris, and sludge
  - Oxidation and rust
- Describe the symptoms of these problems that increase average circulating water temperature of an operating condenser:
  - Overloading
  - Insufficient circulating water flow
  - High circulating water inlet temperature
- Determine the optimum number of circulation water pumps to run, given condenser pump selection curves and condenser operating parameters.

### 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.
  - Feedwater heater temperature rise
  - Drain Cooler Approach (DCA)
  - 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:
  - Capacity
  - Head
  - Power
  - 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:
  - Greenhouse gases
  - Incomplete combustion
  - 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 distributive control system (DCS).

- Describe the functions of a typical distributive 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 DCS.
- 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 distributive control system (DCS) and describe their functions.

- List and briefly describe plane 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:
  - Instrumentation
  - Transmitters & Input/Output Modules
  - Processors
  - Multiplexers
  - Electrical/Computer Buses
  - Human-Machine Interface
  - 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 Distributive 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.
- Describe how the DCS maintains parameters at their designed values when unit load changes.
- Discuss the relationship between the following:
  - Fuel flow and associated unit parameters.
  - Fuel flow, furnace draft, air flow, and excess oxygen.
  - Feedwater flow, steam flow, unit load and boiler drum level.
- Identify operator responsibilities in controlling key operating parameters, systems, and equipment during normal operation.

## 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:
  - Intake
  - Compression
  - Injection
  - Combustion
  - Power
  - 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.
- Explain 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:
  - Prime mover
  - Generator and exciters
  - Switchgear

## 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 hydroelectric 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 the hydroelectric power generator and the components of the lower unit.

- Examine the design characteristics of the penstock, scroll case, and suction tube.
- Describe the wicket gate operations.

- List a number of turbine types and their uses.
- Describe seal and servomotor operations.
- Identify stators and generator supports.
- Explain generator operations.

### 583-05 Hydroelectric 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 and explain the operations of the auxiliary systems within 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 lock out/tag out 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 lock out/tag out procedures.
- Identify the process for the hydroelectric plant's system start-up and removal from service.

## 600 - Industrial Instrumentation

### 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 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:
  - Pressure
  - Temperature
  - Flow
  - Level
  - Analytical
- Describe basic function of process instrumentation.
- Explain the relationship between common process variables.
- Define terms associated with process instrumentation:
  - Differential ( $\Delta$ )
  - Local control
  - Remote control
  - Control loop
  - Electronic
  - Pneumatic
  - Analog
  - Digital

#### 603-02 Principles of Temperature

When you complete this lesson, you will be able to discuss the principles of temperature measurement and heat transfer.

- Define temperature and explain the difference between temperature and heat.
- Recognize different temperature scales and list their basic units of measurement.
- Describe the three methods to transfer heat.

- Define the following terms associated with temperature:
  - Conduction
  - Convection
  - 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.
- List the factors and conditions that affect pressure.
- Explain how Boyle's Law and Charles' 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:
  - Innage
  - Ullage (outage)
  - Level
  - Interface
  - Meniscus
  - Buoyancy

### 603-05 Principles of Flow

When you complete this lesson, you will be able to identify the principles behind flow and fluid dynamics, and understand how flow is measured in the process industry.

- Define flow and flow rate.
- List the basic units of flow measurement.
- Discuss the properties of fluids and the dynamics behind the movement of a fluid.
- Explain how the Reynolds Number indicates laminar or turbulent flow.

### 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.

- Identify types of thermometers and discuss the principles behind their operation.
- Explain the differences between operation of direct and indirect temperature measurement devices.
- Describe the basic operation of resistance temperature detector (RTD).
- Define the following terms associated with temperature
  - Measurement
  - Thermocouple
  - Fluid thermometer
  - Thermowell
  - Bimetallic thermometer
  - Resistance temperature detector
  - Pyrometer
  - Thermometer
  - Temperature gauge

### 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 basic operation of manometers, pressure gauges, and differential pressure cells.
- Identify the difference between direct and indirect pressure measurement devices.
- Describe the basic operation of a pressure transmitter.
- Define terms associated with pressure measurement.
  - Manometer
  - Bourdon tube
  - Diaphragm
  - Bellows
  - Transmitter

### 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 operation of common level sensing and measurement devices.
- Define the following terms associated with level measurement:
  - Sight glass
  - Float
  - Tape/Tape gauge
  - Differential pressure cells
  - Bubbler
  - Displacer
  - Ultrasonic/Radar
  - Nuclear
  - Load cell
  - Probes
  - Level Switches

### 603-09 Flow Measuring Devices

When you complete this lesson, you will be able to identify and describe the basic operation of various flow sensing and measurement devices that directly or indirectly measure flow.

- Describe common direct flow measurement devices and discuss their operation.
- Describe common indirect flow measurement devices and discuss their operation.
- Define the following terms associated with flow measurement:
  - Venturi
  - Tube velocity
  - Orifice plate
  - Flow nozzle
  - Pitot tube
  - Straightening vanes
  - Rotameter
  - Differential pressure
  - Mass flow meter

## 605 Test Equipment

### 605-01 Multimeters

When you complete this lesson, you will be able to correctly use a volt ohm meter (VOM) and a digital multimeter (DMM).

- 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.

- Describe how oscilloscopes work.
- Identify the differences between analog & digital oscilloscopes.
- Discuss waveform types and measuring waveform parameters.
- Demonstrate how to use the basic controls of an oscilloscope and take simple measurements.

### 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.

- 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'll 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 Thermometers and Calibrators

When you complete this lesson, you will understand the basic function and operation of thermometers.

- Explain the difference between contact and non-contact sensors.
- Describe the operating principles behind the following:
  - Radiation thermometers
    - Thermocouples
    - Resistive temperature devices
    - Thermistors
- Discuss the types of available calibrators, and identify the sensors they validate.

### 605-06 Manometers

When you complete this lesson, you will understand how different types of manometers function and will be able to read them.

- Identify types of manometers.
- Recognize and identify the factors that affect manometer accuracy.
- Explain how to read the pressure on a manometer.

### 605-07 Pressure and Vacuum Calibrators

When you complete this lesson, you will be able to understand how pressure and vacuum calibrators operate and how to use them.

- Explain the use of a dead weight calibrator.
- Explain the use of a variator.
- Explain the use of an aspirator bulb.
- Explain the use of a hand pump.
- Explain the use of pneumatic calibrators.

### 605-08 Megohmmeters

When you complete this lesson, you will be able to select, set up, and safely use a megohmmeter.

- Define insulation and identify factors that degrade its quality.
- Describe different types of megohmmeter tests and how to select the correct megohmmeter for the job.
- Identify safety issues to consider when using a megohmmeter.
- Describe how to attach the leads to the system.
- Discuss how a megohmmeter works and demonstrate the steps to take a reading.

## 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 plants.

- Explain the use of analyzers in a plant.
- 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
- Describe how these analyzers contribute to the overall safety and efficiency of a plant.

## 609 Calibration and Troubleshooting

### 609-01 Calibration Overview I

When you complete this lesson, you will be able to describe basic calibration methods and equipment.

- Discuss the three-point and five-point methods of calibration.
- Identify pneumatic and analog calibration equipment.
- Discuss calibrating procedures for electronic, pneumatic, and analog calibration equipment.
- Define:
  - Calibration
  - Noisy signal
  - I/P Transducer
  - Zero
  - Span (Range)
  - Live Zero

### 609-02 Calibration Overview II

When you complete 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
  - 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 Prints and Drawings

### 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.
- Interpret examples of P&ID numbering systems used for labeling equipment.
- Explain why instruments and control loops are important for plant safety and operation.
- Identify instrument symbols.
- Describe how the instruments in control loops are related and named on a P&ID.
- Identify piping and determine information about a pipeline including:
  - Material in the line
  - Size of the pipe
  - Line number, and
  - Whether the line is insulated or traced.
- 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 the devices and components and their relationships to each other.

- Describe the purpose of an electrical drawing.
- Describe what kind of information is found in the title block.
- Describe the revision block, reference block, and legend block.
- Describe how the drawing grid and grid coordinates help locate components.
- Identify symbols commonly used in electrical drawings.
- Explain why device numbers are used in electrical drawings.
- Describe the purpose of each of the following:
  - Block drawing
  - One-line diagram
  - Wiring diagram
  - Schematic diagram
  - Connection diagram
  - Interconnection diagram
  - Raceway diagram
  - Cable schedule
  - Logic diagram
- Identify symbols used in logic diagrams.

### 611-04 Logic Diagrams

When you complete this lesson, you will be able to identify different types of number systems as they relate to computers, and describe how each is used. You will also be able to identify devices and components and explain their relationship to each other.

- Identify the purpose of a logic diagram.
- Describe what kind of information is found in the title block.
- Describe the revision block, reference block, and legend block.
- Explain how the drawing grid and grid coordinates help locate components.
- Identify the basic elements associated with logic function and their symbols.
- Identify and define the following terms:
  - Logic Gates
  - Boolean 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 plant employees to design, repair, and maintain equipment in the power plant. 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 that are commonly used in power plants when new buildings or large equipment are constructed.
- Describe the use of mechanical drawings by plant 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.
- Identify ways in which an operator might interact with a control system.

### 613-02 Pneumatic and Electronic Control System

When you complete this lesson, you will be able to describe the design and function of typical pneumatic and electronic control systems used in industrial facilities.

- Identify pneumatic control system components.
- Explain pneumatic signal transmission ranges.
- Describe a typical pneumatic control room layout.
- Identify electronic control system components.
- Describe some precautions taken when using electronic instruments in hazardous environments.
- Identify how some field devices are used in electronic control systems.
- Describe a typical electronic control room layout.
- Identify advantages and disadvantages of pneumatic and electronic systems.

## 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, air, current, voltage, frequencies, pulses, tones, fiber optics, 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:
  - Mechanical
  - Optical
  - 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:
  - Pneumatic transmitters
  - Electrical transmitters
  - 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 and features of smart 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 that 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 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.
- Identify some means of comparing manual and controller output signals.
- 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.

## 621 Programmable Logic Controllers

### 621-01 Programmable Logic Controller (PLC)

When you complete this lesson, you will be able to describe the function of a PLC and explain its use of ladder logic.

- Explain the purpose of these PLC controls:
  - Sequential control
  - On/Off
  - Emergency shutdown
- Discuss how "ladder logic" applies to a PLC.
- Define terms associated with a ladder logic diagram.

## 623 Advanced Process Trainer

### 623-01 Introduction and Panel Components of the DAC #603 Advanced Process Trainer

When you complete this lesson you will be able to describe the Utility Distribution Panel, the Side Power Distribution Panel, the Front Control Panel and their respective components of a the DAC (Design Assistance Corporation) #603 Advanced Process Trainer.

- Describe the DAC #603 Advanced Process Trainer.
- Describe the Utility Distribution Panel on the DAC #603 Advanced Process Trainer.
- Describe the Side Power Distribution Panel on the DAC #603 Advanced Process Trainer.
- Describe the Front Control Panel on the DAC #603 Advanced Process Trainer.

### 623-02 Standard Instrumentation of the DAC #603 Advanced Process Trainer

When you complete this lesson you will be able to describe the valves, fittings, flow elements, heater, heat exchanger, process loops, instrument connections and their respective components of a the DAC #603 Advanced Process Trainer.

- Describe the valves on the DAC #603 Advanced Process Trainer.
  - Describe the fittings on the DAC #603 Advanced Process Trainer.
  - Describe the flow elements on the DAC #603 Advanced Process Trainer.
  - Describe the heater on the DAC #603 Advanced Process Trainer.
  - Describe the heat exchanger on the DAC #603 Advanced Process Trainer.
  - Describe process loops on the DAC #603 Advanced Process Trainer.
  - Describe the instrument connections on the DAC #603 Advanced Process Trainer.
- 

## 800 - Machine Shop

### 801 Precision Measurement

#### 801-01 Introduction 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 you must 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'll 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

#### 801-05 Measuring with Calipers

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 and 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 work piece layout, bluing, measuring, scribing lines, and marking hole centers.
- Describe tools and methods for hand cutting material with a hacksaw, including hacksaw parts description, 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 hand taps and dies.
- Describe tools for broaching and techniques for keyway broaching using an arbor press and broach set.

## 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 work piece 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
  - Work piece materials
- Describe the use of each of the following cutting tools:
  - End mills
  - Woodruff cutters

---

## 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:
  - Carbide and alloy turning tools and drills
  - Drill bits
  - Turning tools
  - Facing tools
  - Boring bars and tools
  - 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:
  - Turning operations
  - Shaft work
  - Thread cutting
  - Boring
  - 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 used to manufacture replacement parts used to repair various types of equipment.

- Identify 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 Bandsaw

When you complete this lesson, you will be able to describe the design and operation of a band saw. In addition, you'll be able to explain how to use a bandsaw to produce various cuts.

- List the major components of a vertical band saw.
- Describe different types of available band saw cutting blades.
- Explain how to manufacture a band saw blade using the shearing, welding, grinding, and annealing attachments.
- 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 construction 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 I

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 II

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 III

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:
  - Chains
  - Drum assemblies
  - Sheaves
  - Hooks
  - Blocks
  - 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 the factors that affect the service life of a fiberglass ladder.
- Identify some tests performed on ladders.
- 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 Setup and Safety Considerations for Welding and Cutting for Maintenance**

\*This lesson is currently in development.

### **841-02 Metalurgy**

\*This lesson is currently in development.

### **841-03 SMAW/MIG**

\*This lesson is currently in development.

### **841-04 Gas Tungsten**

\*This lesson is currently in development.

### **841-05 Oxyacetylene Braising and Soldering**

\*This lesson is currently in development.

### **841-06 Oxyacetylene Fusion Welding**

\*This lesson is currently in development.

