



FOURTH CLASS (EDITION 3)

COURSE OUTLINE WITH OUTCOMES

The material in this series is aligned with the SOPEEC Fourth Class Syllabus, dated November 2017, and the IPECC Curriculum, November 2017.

PART B UNIT 1: Lubrication and Bearings

Chapter 1 Lubrication Principles

Learning Outcome

Describe the importance of lubrication and the principles concerned with lubrication.

Learning Objectives

1. Discuss the concept of lubrication and list the purposes of a lubricant.
2. List the various classes and types of lubricants and describe their respective properties and application.
3. List the properties of lubricating oils, the additives used, and their selection criteria.

Chapter 2 Types of Bearings and Lubrication

Learning Outcome

Describe bearing types, methods for care and maintenance of bearings, and bearing lubrication systems.

Learning Objectives

1. Define boundary and full fluid film lubrication.
2. Describe shell (sleeve) bearings.
3. Describe the construction and operation of antifriction and thrust bearings.
4. Describe how to clean and replace roller and ball type bearings.
5. Explain the causes of bearing failure.

PART B UNIT 2: Pump and Compressors

Chapter 1 Types of Pumps

Learning Outcome

Describe the construction and operating principles of various types of pumps used in plants.

Learning Objectives

1. List common pump applications.
2. Define the terms associated with pump performance.
3. Describe the common pumps found in plants.



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Chapter 2 Pump Operation and Maintenance

Learning Outcome

Describe the major considerations and procedures for pump operation and maintenance.

Learning Objectives

1. Discuss the components of a driver and pump assembly.
2. Discuss pump shaft sealing, compression packing, and the replacement of compression packing.
3. Describe the standard types of mechanical seals.
4. Describe pump bearings, shaft alignment procedures, and the equipment used to align shafts.
5. Describe centrifugal pump startup and priming procedures.
6. Describe positive displacement pump operating characteristics, priming, startup, and routine checks.

Chapter 3 Introduction to Compressors

Learning Outcome

Describe the operating principles of the different types of compressors.

Learning Objectives

1. Describe the main classifications and types of compressors.
2. Describe gaseous compression systems.

Chapter 4 Compressor Operation and Maintenance

Learning Outcome

Describe the major considerations and general procedures for compressor operation and maintenance.

Learning Objectives

1. Describe compressor parts and auxiliary equipment.
2. Describe the construction and operation of seals for compressors.
3. Describe the capacity control of compressors.
4. Describe preventative maintenance and routine procedures for compressors.



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PART B UNIT-3: Boiler Safety Devices

Chapter 1 Pressure Relief Valves

Learning Outcome

Explain the code requirements, design, and operation of pressure relief valves for power boilers, heating boilers, and pressure vessels.

Learning Objectives

1. Discuss the code requirements, construction, and operation of ASME Section I Pressure Relief Valves and Devices.
2. Discuss the code requirements, construction, and operation of ASME Section IV Pressure Relief Valves and Devices.
3. Describe the testing and repair of pressure relief valves.
4. Describe the construction and operation of temperature and pressure relief valves.

Chapter 2 Combustion Safety

Learning Outcome

Explain the design and operation of combustion safety controls on burners and boilers.

Learning Objectives

1. Describe the operation of control and safety devices found on boiler fuel supplies.
2. Describe the construction and operation of flame detectors.
3. Describe the combustion safety controls for boilers and burner systems.
4. Describe burner management systems.
5. Interpret burner operating sequence charts, and provide a typical sequence of startup and shutdown events.

Chapter 3 Water Level Safety Controls

Learning Outcome

Describe feedwater devices, and control methods used on boilers.

Learning Objectives

1. Describe the construction and operation of boiler low water level fuel cut-off equipment.
2. List the CSA and ASME code requirements regarding low water fuel cut-off devices.
3. Describe direct and indirect type boiler water level indicators.



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Chapter 4 Boiler Fittings

Learning Outcome

Relate the code, operation, and required fittings to the operating principles of fittings found on boilers.

Learning Objectives

1. Explain the code references for boiler fittings.
2. Describe the code requirements for pressure gauges on steam boilers.
3. Describe the code requirements for the boiler connections and valves on steam boilers.
4. Describe the code requirements for fittings on hot water heating boilers.
5. Describe the non-code fittings used on boilers.

Chapter 5 Firing Rate Controls

Learning Outcome

Describe the operating and safety controls found on boilers.

Learning Objectives

1. Describe basic boiler firing rate controls.
2. Discuss various operating controls for steam and hot water boilers.

PART B UNIT-4: Boiler Plant Operation and Management

Chapter 1 Boiler Plant Startup

Learning Outcome

Describe the operational procedures related to starting up auxiliary equipment in a boiler plant.

Learning Objectives

1. Describe the basic auxiliaries that need to be checked, prepared, or placed in service before starting a boiler plant.
2. Describe the general procedures for starting a plant for the first time, or restarting after an outage or turnaround.
3. Discuss basic operating practices for starting pumps and fans.
4. Describe the general preparation for a hot water boiler startup.
5. Describe the general preparation for a steam boiler startup.
6. Describe the safety and housekeeping preparation requirements for boiler plant startup.



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Chapter 2 Boiler Startup

Learning Outcome

Describe procedures for safely starting boiler systems.

Learning Objectives

1. Describe operating considerations when warming a cold boiler.
2. Describe how to start and cut-in a hot water boiler.
3. Describe how to start a single boiler steam plant.
4. Describe how to cut-in a steam boiler in a multiple boiler plant.
5. Describe semi-automatic burner ignition systems.
6. Discuss the post startup inspection for boilers returning to service after a major outage.

Chapter 3 Boiler Operation

Learning Outcome

Describe operational procedures related to operating boilers.

Learning Objectives

1. Describe the operation of a hot water heating boiler under routine conditions.
2. Describe routine steam boiler operating duties.
3. Describe emergency conditions in boiler plants and the required responses.
4. Describe basic boiler troubleshooting activities.

Chapter 4 Operational Checks

Learning Outcome

Describe operational checks for operating boiler plants.

Learning Objectives

1. Describe the shift based operator responsibilities for boiler plants.
2. Describe the safety device operational checks carried out on boilers.
3. Describe routine maintenance activities for boiler plant operation.
4. Describe the use of Standard Operating Procedures (SOPs).
5. Describe the need for boiler operating and maintenance logs, and the type of information that should be recorded.

Chapter 5 Shutdown Procedures

Learning Outcome

Describe generic shutdown and layup procedures for different boiler types.

Learning Objectives

1. Describe hot water boiler shutdown procedures.
2. Describe steam boiler shutdown and lockout procedures.
3. Describe extended period layup requirements for steam boilers.



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Chapter 6 Boiler Plant Monitoring and Reporting

Learning Outcome

Describe the points and readings that need to be monitored and recorded in a plant.

Learning Objectives

1. Discuss recording requirements for operating and performance conditions.
2. Discuss the various systems required to conduct equipment repairs, and to manage the related maintenance records.
3. Describe the operational causes, consequences, and prevention of water hammer.
4. Describe the consequences and actions required for various equipment failures.
5. Describe the consequences, and actions required, in the event of boiler accidents.

PART B UNIT-5: Energy Plant Maintenance

Chapter 1 Energy Plant Maintenance I

Learning Outcome

Describe the safe use of common hand tools in the powerhouse.

Learning Objectives

1. Describe the types and proper use of hacksaws, files, chisels, hammers, screwdrivers, and wrenches.
2. Describe the types and proper use of hand threading tools.
3. Describe the types and proper use of measuring tools.
4. Describe the proper layout of work and the use of layout tools.
5. Describe the types and proper use of portable and fixed grinders, hand drills, drill presses, and the care of drill bits.

Chapter 2 Energy Plant Maintenance II

Learning Outcome

Discuss and describe the safe and proper setup of equipment for hoisting and working above ground.

Learning Objectives

1. Describe the requirements for setting up work platforms in general and ladders and scaffolding in particular.
2. Describe the general safety precautions and calculations used when rigging equipment.
3. Describe the general safety precautions used when hoisting equipment.
4. Discuss the correct use and limitations of wire cable and rope, including cable attachments and rope knots.
5. List and describe common types of metal fasteners, such as screws, bolts, studs, nuts, and washers.



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Chapter 3 Boiler Maintenance

Learning Outcome

Describe the service and maintenance required for boilers.

Learning Objectives

1. Describe the general maintenance and service of packaged firetube and cast iron sectional boilers.
2. Identify the operational procedures for wet and dry boiler layups.
3. Describe ways of detecting firetube and tubesheet leaks.
4. Describe the general procedure for the removal and replacement of defective firetubes.

Chapter 4 Boiler Cleaning

Learning Outcome

Discuss the procedure for preparing a boiler for inspection and cleaning, and describe mechanical and chemical boiler cleaning methods.

Learning Objectives

1. List the steps and precautions to prepare a boiler for inspection.
2. Describe the internal inspection of a boiler.
3. Describe the methods and tools used to mechanically clean boilers.
4. Describe two methods used to chemically clean boilers.

PART B UNIT-6: Water Treatment

Chapter 1 External Boiler Water Treatment

Learning Outcome

Describe the general principle, methods, and equipment used in preparing raw feedwater for steam production.

Learning Objectives

1. Describe typical impurities and their effects on plant and boiler water pre-treatment systems, and their treatment process.
2. Describe the equipment requirements for pre-treatment of plant water systems.
3. Describe water filtration and the removal of suspended solids.
4. Describe the purpose, processes, and equipment used in water softening.
5. Describe the theory, process, and equipment used in deaeration.



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Chapter 2 Internal Boiler Water Treatment

Learning Outcome

Describe the general principles, methods, and equipment used for internal boiler water treatment.

Learning Objectives

1. Describe the types of problems, and associated treatments, related to internal boiler water contamination.
2. Describe internal boiler feedwater chemical feed systems.
3. Describe standard boiler water testing.

Chapter 3 Condensate Treatment

Learning Outcome

Discuss the general principles, methods, and equipment used for the treatment of condensate.

Learning Objectives

1. Describe condensate treatment and the effects of non-treatment.
2. Describe the tests conducted on condensate.

Chapter 4 Cooling Tower and Condenser Water Treatment

Learning Outcome

Discuss the general principles, methods, and equipment used for the treatment of condenser water, and their effects on the cooling tower.

Learning Objectives

1. Describe the effects of water on condensers and cooling tower materials.
2. Describe condenser and cooling tower water treatment.
3. Describe cooling tower and condenser water tests for common treatment methods.

Chapter 5 Recirculating System Water Treatment

Learning Outcome

Describe recirculating water systems, their effects, treatment, and tests.

Learning Objectives

1. Describe recirculating water system corrosion and deposition.
2. Describe the use of sacrificial anodes, and measurement techniques to determine corrosion.
3. Describe glycol system testing requirements.
4. Discuss the monitoring tools, procedures, and tests used in recirculating water systems.



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PART B UNIT-7: Types of Prime Movers and Heat Engines

Chapter 1 Heat Engines and Prime Movers

Learning Outcome

Discuss the historical conversion of heat energy into mechanical energy.

Learning Objectives

1. Differentiate between the terms “heat engine” and “prime mover.”
2. Discuss the history of the steam engine and the expansive power of steam.

Chapter 2 Steam Turbines

Learning Outcome

Describe the construction and operation of steam turbines.

Learning Objectives

1. Describe the principle of operation and major components of a steam turbine.
2. Describe the lubrication and sealing of steam turbine shafts.
3. Describe how the rotational speed of a steam turbine is governed and controlled.
4. List the steps to follow in a typical steam turbine start-up and shut-down.

Chapter 3 Condensers and Cooling Towers

Learning Outcome

Describe the operation and maintenance of condensers and cooling towers.

Learning Objectives

1. Explain the construction and operation of condensers, and how they relate to the operation of cooling towers.
2. Explain the principle of operation, the purpose, and the major components of cooling towers.
3. Describe the construction and operation of natural draft cooling towers.
4. Describe the construction and operation of mechanical draft cooling towers.
5. Discuss cold climate operation for cooling towers.
6. Explain typical problems and resolutions required within the operation of cooling towers.

Chapter 4 Gas Turbines

Learning Outcome

Describe the application, startup, operation, and maintenance required for gas turbines.

Learning Objectives

1. Describe the principle of construction and operation of gas turbines.
2. Identify the operational characteristics of gas turbines.
3. Describe regeneration and combined steam-gas turbine operating cycles.
4. Describe the key elements of gas turbine startup, operation, and auxiliaries.



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Chapter 5 Internal Combustion Engines

Learning Outcome

Describe the application, construction, and operation of internal combustion engines.

Learning Objectives

1. Discuss the fuels used in internal combustion engines.
2. Describe the working cycles of the 4-stroke and 2-stroke spark ignition engines.
3. Describe the working cycle of the 4-stroke compression ignition (diesel) cycle.
4. Describe the construction of basic spark and compression engines.
5. Explain the basic operating considerations for diesel engines.

PART B UNIT-8: Plant Auxiliary Systems

Chapter 1 Lighting Systems

Learning Outcome

Explain the various lighting systems and some of the basic design considerations for lighting a space.

Learning Objectives

1. Describe the common types of lighting equipment and systems.
2. Discuss the different types of artificial light sources.
3. Explain the various methods of lighting control.
4. Describe the general requirements and criteria for emergency lighting in buildings.
5. Discuss the interrelationship between lighting, air conditioning, and energy conservation in buildings.

Chapter 2 Building Water Systems

Learning Outcome

Explain the various water supply systems used in buildings.

Learning Objectives

1. Describe the cold water distribution system in a building.
2. Describe the hot water distribution system in a building.
3. Describe the construction and operation of building system hot water heaters, including temperature regulation.
4. List and describe the construction and operation of water system protective devices in buildings.
5. Explain what is meant by “backflow prevention” and describe the common methods used.
6. Describe the maintenance requirements for the components in a building water distribution system.



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Chapter 3 Drainage Systems

Learning Outcome

Describe the design and components of various drainage systems used in facilities.

Learning Objectives

1. Describe the overall layout of building drainage systems.
2. Describe storm water drainage systems for buildings.
3. Describe how surface runoff is managed in order to minimize environmental impact.

PART B UNIT-9: Basic Concepts of Compression and Absorption Refrigeration

Chapter 1 Refrigeration Basics

Learning Outcome

Explain the basic concept of refrigeration and refrigerants.

Learning Objectives

1. Explain the fundamentals of refrigeration.
2. Describe the cycle of operations in a vapour compression refrigeration system.
3. Explain how the operating temperatures and pressures are selected and related for a vapour compression refrigeration system.
4. State how the capacity of a refrigeration system is described and how refrigeration tables are used to calculate system performance.
5. Describe how refrigerants are classified.
6. Describe the thermodynamic properties of refrigerants.
7. Describe the properties of refrigerants relating to miscibility, leakage tendency, odour, moisture reaction, toxicity, and flammability.

Chapter 2 Compression Refrigeration Systems

Learning Outcome

Describe the operating principles of compression refrigeration systems.

Learning Objectives

1. Describe the basic layout of compression refrigeration systems.
2. Distinguish between direct and indirect refrigeration systems.
3. Describe the layout of packaged refrigeration systems and the role of a refrigeration economizer.
4. Describe the special types of refrigeration compressors, and how they are similar to and different from air compressors.
5. Describe the special designs of refrigeration system evaporators and condensers.



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Chapter 3 Refrigeration System Control and Operation

Learning Outcome

Describe the purposes and operating principles of refrigeration system operational and safety controls.

Learning Objectives

1. Describe refrigeration system controls.
2. List the safety shutdown devices specific to centrifugal compressor water chillers.
3. Describe typical refrigeration system safety shutdown devices.
4. Describe the construction and operation of refrigerant metering devices.
5. Describe the different methods used to control evaporator capacity.
6. Describe the different methods used to control the capacity of refrigeration compressors.

Chapter 4 Refrigeration System Operation and Maintenance

Learning Outcome

Describe the operating principles and maintenance of refrigeration systems.

Learning Objectives

1. Discuss refrigeration auxiliaries.
2. Describe refrigeration system leak test procedures.
3. Describe how a refrigeration system is dried and charged prior to start-up.
4. List the steps for adding oil to an in-service refrigeration compressor.
5. Describe the start-up and shut-down procedure for a compression refrigeration system.
6. Describe operational log sheets and preventative maintenance procedures for refrigeration systems.
7. Describe how a refrigeration system is purged of noncondensable gases.
8. Discuss refrigeration condenser operation and maintenance requirements.
9. Explain typical problems and resolutions related to refrigeration systems.

Chapter 5 Absorption Refrigeration Systems

Learning Outcome

Describe the operating principle, maintenance, and operation of absorption refrigeration systems.

Learning Objectives

1. Describe the basic absorption system, comparing the differences to the compression system.
2. Describe the theory and operation of an ammonia absorption refrigeration system.
3. Describe the theory and operation of a lithium bromide absorption refrigeration system.
4. Explain the operation of absorption refrigeration systems with respect to crystallization and dilution.
5. Describe the major parts and systems of an absorption system, including: heat exchanger bypass system, pump motor lubrication and cooling system, and purging system.
6. Describe the startup and shutdown procedures for an absorption refrigeration system.
7. Describe the preventive maintenance that should be performed on an absorption refrigeration system.
8. Explain typical problems and resolutions related to an absorption refrigeration system.



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Chapter 6 Refrigeration Plant Safety

Learning Outcome

Outline the potential hazards inherent to refrigeration plants, the CSA requirements intended to mitigate hazards, and typical responses taken in the case of a significant leak.

Learning Objectives

1. Identify and provide a basic explanation of the CSA B52 Code requirements for refrigeration plant machinery rooms.
2. Identify safe practices for refrigeration plant operation and maintenance.
3. Describe the appropriate emergency response to a significant refrigerant leak.
4. Describe the Canadian Environmental Emergency Regulations and how they relate to refrigeration plants.

PART B UNIT-10: HVAC Fundamentals for Facility Operators

Chapter 1 Conditioning the Air

Learning Outcome

Explain the methods and techniques for conditioning air in plants and buildings.

Learning Objectives

1. Discuss the process to condition air for human comfort and health.
2. List the categories and functions of HVAC systems.
3. Describe the operation of air-handling units.
4. Define the terms humidity, relative humidity, and dewpoint.
5. Define the terms dry-bulb temperature, wet-bulb temperature, wet-bulb depression, and how they relate to relative humidity.

Chapter 2 Humidification

Learning Outcome

Explain the equipment and principles of humidification.

Learning Objectives

1. Describe the general purpose and principles of humidification.
2. Describe residential and warm air types of humidifiers.
3. Describe industrial and commercial types of humidifiers.



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Chapter 3 Fans for Air Distribution Systems

Learning Outcome

Describe the airflow behaviour and movement of air through distribution systems.

Learning Objectives

1. Discuss the theory of airflow and pressure conversions.
2. Describe the major types of air handling fans, their construction, and operation.
3. Interpret fan performance curves.
4. Describe fan motors, drives, and belt guards.
5. Describe fan volume controls.

Chapter 4 Ventilation and Air Filters

Learning Outcome

Describe the various ventilation systems, including various types of air filters used in these systems.

Learning Objectives

1. Explain the difference between natural and mechanical ventilation.
2. Describe the various contaminants found in air.
3. Describe the types of air cleaning devices used in industrial/commercial buildings.

Chapter 5 HVAC Duct Systems

Learning Outcome

Describe the designs and components of duct systems used in HVAC applications.

Learning Objectives

1. Explain how air duct systems are classified.
2. Describe air duct materials, system layout, fabrication, and installation.
3. Describe air duct leakage.
4. List and describe the types of liners, dampers, and louvres used in air duct systems.
5. Discuss terminal air distribution devices, and the principles of diffusion, induction, entrainment, and aspiration.

Chapter 6 Types of Coils and Operation

Learning Outcome

Describe the various types and operation of coils used in HVAC systems.

Learning Objectives

1. Explain how steam, hot water, and glycol coils are sized, configured, and operated to reduce the chance of freezing.
2. Describe the installation recommendations for coils, piping, steam traps, control valves, air vents, and vacuum relief devices.



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PART B UNIT-11: Building Environmental Systems and Control

Chapter 1 Steam Heating

Learning Outcome

Describe the components, operating principles, and maintenance procedures of steam heating systems.

Learning Objectives

1. Describe the construction and operation of steam heating system devices used to transfer heat from the steam to a heated space.
2. Describe the auxiliary equipment used in a steam heating system, including air vents, radiator valves and traps, and condensate return equipment.
3. Describe standard types of piping and equipment layout for steam heating systems.
4. Describe the general operation and maintenance of steam heating systems.
5. Apply a steam heating system troubleshooting guide.

Chapter 2 Hot Water Heating

Learning Outcome

Describe the various designs, equipment, and operation of hot water heating systems.

Learning Objectives

1. Describe the standard piping and circulation layouts of hot water heating systems.
2. Compare the advantages and disadvantages of hot water and steam heating systems.
3. Describe various types of special hot water heating systems.
4. Describe the purpose and function of standard hot water heating system accessories.
5. Explain how the location of the hot water circulating pump and the expansion tank are determined.
6. Describe the routine operation of hot water heating systems, including cleaning, filling, starting, and use of glycol/antifreeze.
7. Apply a hot water heating troubleshooting guide.

Chapter 3 Other Heating Systems

Learning Outcome

Describe common heating systems encountered by Power Engineers.

Learning Objectives

1. Describe natural gas fueled warm air heating systems.
2. Describe the recommended maintenance procedures for warm air heating and ventilating systems.
3. Discuss the concept and application of infrared heating.
4. Describe the different methods of electric heating, and their advantages and disadvantages as compared to other types of systems.



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Chapter 4 Cooling Systems and Combination Systems

Learning Outcome

Describe central, unitary and combined HVAC systems.

Learning Objectives

1. Describe the general layout and operation of unitary air conditioning systems.
2. Describe the general layout and operation of central air conditioning systems.
3. Describe the general layout and operation of combined air conditioning systems.
4. Discuss how HVAC systems should be operated under different situations.

Chapter 5 Heat Gains and Losses, and Heat Recovery Methods

Learning Outcome

Describe heat gains and losses, and common methods for energy recovery.

Learning Objectives

1. Define heat transmission terminology.
2. Describe heat gain and heat loss analysis in a building or plant.
3. Describe the general principles of HVAC heat recovery.

Chapter 6 HVAC Control Strategy

Learning Outcome

Describe the control systems strategies used in HVAC systems.

Learning Objectives

1. Describe a basic ventilation control strategy for HVAC systems.
2. Describe heating control strategies for HVAC systems.
3. Describe humidification, dehumidification, and cooling control strategies for HVAC systems.
4. Describe volume control with static pressure regulation for HVAC systems.



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PART B UNIT-12: Typical Industrial Plant Configurations

Chapter 1 Common Plant Configurations in Hydrocarbon Centric Industries

Learning Outcome

Identify steam-related processes employed in common types of plants.

Learning Objectives

1. Identify standard thermal system pathways and segments commonly used in plants.
2. Identify equipment and processes in heat transfer fluid (HTF) heating systems.
3. Identify the main thermal processes used in oil refining industries.
4. Describe the main processes used in steam assisted gravity drainage (SAGD) and cyclic steam stimulation (CSS).
5. Identify thermal processes used in gas separation and compression plants.

Chapter 2 Common Plant Configurations in Energy Intensive Industries

Learning Outcome

Identify steam related processes employed in common types of plants.

Learning Objectives

1. Identify the main steam/boiler processes used in wood and biomass processing plants.
2. Identify the important thermal processes used in food production and preservation.
3. Identify the common processes and equipment used in metallurgical processing plants.