



FOURTH CLASS (EDITION 3.5)

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 A UNIT 1: Elementary Mechanics and Dynamics

Chapter 1 Introduction to Basic Mechanics

Learning Outcome

Apply basic terms and calculations used in the study of mechanics.

Learning Objectives

1. Define mass, force, acceleration, velocity, and weight.
2. Perform simple calculations involving force, pressure, work, power, and energy.

Chapter 2 Forces and Moments

Learning Outcome

Perform calculations involving forces and moments, and determine when a system of forces is in equilibrium.

Learning Objectives

1. Define the moment of a force and its units.
2. Determine the direction and calculate the magnitude of the moment of a force.

Chapter 3 Simple Machines

Learning Outcome

Perform calculations relating to mechanical advantage, velocity ratio and efficiency.

Learning Objectives

1. Define the term simple machine and apply to calculations of mechanical advantage, velocity ratio and efficiency of simple machines.

Chapter 4 Scalars and Vectors

Learning Outcome

Define and identify scalar and vector quantities and solve simple vector problems graphically.

Learning Objectives

1. Define scalar and vector quantities as they apply to drawing vector diagrams.



FOURTH CLASS (EDITION 3.5)

COURSE OUTLINE WITH OUTCOMES

Chapter 5 Linear Velocity and Acceleration

Learning Outcome

Solve simple problems involving linear velocity, time, and distance.

Learning Objectives

1. Solve distance, displacement, speed, and velocity problems.
2. Draw graphs of velocity as a function of time.
3. Define acceleration, state its units, and solve simple acceleration problems.
4. Apply mathematical formulae relating acceleration, velocity, distance and time to solve problems.

Chapter 6 Force, Work, Pressure, Power, and Energy

Learning Outcome

Perform calculations involving force, work, pressure, power, and energy.

Learning Objectives

1. Perform calculations involving force and work.
2. Perform calculations involving gauge, atmospheric, and absolute pressure.
3. Perform calculations involving power and different forms of mechanical energy.

Chapter 7 Friction

Learning Outcome

Solve problems involving friction.

Learning Objectives

1. Apply the laws governing the types of friction.
2. Apply the coefficient of friction to problems involving forces on a horizontal plane.

Chapter 8 Stress and Strain

Learning Outcome

Explain physical properties of materials and how their behaviour is affected when external forces are applied.

Learning Objectives

1. Describe the mechanical properties of materials, including elasticity, stiffness, plasticity, ductility, toughness, brittleness, and hardness.
2. Calculate stress including tensile, compressive, and shear stresses within rigid bodies due to external loads.
3. Calculate the strain of members under load.



FOURTH CLASS (EDITION 3.5)

COURSE OUTLINE WITH OUTCOMES

Chapter 9 Power Transmission

Learning Outcome

Perform calculations pertaining to common power transmission systems.

Learning Objectives

1. Calculate pulley speeds, transmitted power, and efficiency of belt drive systems.
2. Calculate gear speeds for gear and chain drive systems.

PART A UNIT-2: Elementary Physical, Chemical, and Thermodynamic Principles

Chapter 1 Introduction to Matter and Chemistry

Learning Outcome

Identify basic types of matter, their properties, and the associated chemical principles.

Learning Objectives

1. Differentiate among the physical states of matter.
2. Differentiate between chemical and physical changes in matter.
3. Classify matter as either a type of mixture or a pure substance.
4. Describe the purpose and uses of the periodic table using the parts of an atom.
5. Describe the three main ways atoms bond together: covalent, ionic, and metallic bonding.
6. Discuss chemical equations and their purpose.
7. Perform simple stoichiometric calculations.
8. Demonstrate how unstable compounds are combined to make stable compounds.

Chapter 2 Introduction to Thermodynamics

Learning Outcome

Explain the principles and laws of thermodynamics.

Learning Objectives

1. Define the first two laws of thermodynamics.
2. Define heat and specific heat, and perform sensible heat calculations.
3. Describe the expansion of solids and liquids.



FOURTH CLASS (EDITION 3.5)

COURSE OUTLINE WITH OUTCOMES

Chapter 3 Introduction to Heat Transfer and Heat Exchangers

Learning Outcome

Explain the modes of heat transfer and the theory of heat exchanger operation.

Learning Objectives

1. Describe the three modes of heat transfer with reference to heat exchangers.
2. Discuss the general design and construction of typical heat exchangers.
3. Describe heat transfer fluids and how they affect the operation of a heat exchanger, including fouling, leakage, and vapour locking.
4. Describe heat exchanger inspection, maintenance, and operation, including placing them in service and removing them from service.

Chapter 4 Thermodynamics of Steam

Learning Outcome

Apply the thermodynamics principles through practical applications using the steam tables and the temperature-enthalpy chart.

Learning Objectives

1. Describe heat as it relates to steam, water, and ice.
2. Explain the various columns of the steam tables.
3. Explain the thermodynamic principles of steam, using the steam tables.

PART A UNIT-3: Introduction to Power Engineering and its Governance in Canada

Chapter 1 Introduction to Power Engineering

Learning Outcome

Describe the Power Engineer profession.

Learning Objectives

1. Describe steam, its uses and the basic steam cycle.
2. Describe the role and duties of a Power Engineer.
3. Describe how shift work affects sleep patterns, diet, and overall health.

Chapter 2 Jurisdictional Legislation for Power Engineers

Learning Outcome

Describe the application of Jurisdictional Acts and Regulations with respect to boilers and pressure vessels.

Learning Objectives

1. Describe how the Power Engineering profession is regulated in Canada.
2. Explain the purpose and scope of your Jurisdictional Act and Regulations pertaining to Power Engineering and Pressure Equipment.
3. Explain the purpose and intent of the Regulations governing Power Engineers and Pressure Welders.



FOURTH CLASS (EDITION 3.5)

COURSE OUTLINE WITH OUTCOMES

Chapter 3 Codes and Standards for Power Engineers and Pressure Vessels

Learning Outcome

Describe the purpose of boiler and pressure vessel Codes and Standards.

Learning Objectives

1. Discuss the history of how codes and standards became necessary in the pressure equipment field.
2. Explain the content and use of the CSA B51 Boiler, Pressure Vessel, and Pressure Piping Code.
3. Explain the content and use of the CSA B52 Mechanical Refrigeration Code.
4. Explain the content and use of ASME Boiler and Pressure Vessel Code (ASME BPVC) Section I Power Boilers.
5. Explain the content and use of ASME BPVC Section VII - Recommended Guidelines for the Care of Power Boilers.
6. Explain the content and use of ASME BPVC Section IV - Rules for Construction of Heating Boilers.
7. Explain the content and use of ASME BPVC Section VI - Recommended Rules for Care and Operation of Heating Boilers.
8. Explain the purpose, intent, and limitation of ASME CSD-1 (Controls and Safety Devices) Standard.

PART A UNIT-4: Introduction to Plant and Fire Safety

Chapter 1 Introduction to Plant Safety

Learning Outcome

Describe general plant safety as it related to Power Engineers.

Learning Objectives

1. Discuss the cost and effects of workplace accidents.
2. Describe the basic hazards that may be in an energy plant, and the basic Personal Protective Equipment that may be required.
3. Define, give examples of, and describe common power house hazards.
4. Describe Industrial health and safety management system.
5. Describe Hazard Assessment and Control programs.

Chapter 2 Plant Safety Programs

Learning Outcome

Describe common safety programs generally applied in plants.

Learning Objectives

1. Describe common occupational health and safety (OH&S) programs found in most plants.
2. Describe industrial safety programs in which Power Engineers may require additional training.
3. Discuss safe work permits.
4. Describe methods of equipment isolation and lock out.



FOURTH CLASS (EDITION 3.5)

COURSE OUTLINE WITH OUTCOMES

Chapter 3 Handling of Dangerous Materials

Learning Outcome

Describe the policies and procedures for safe storage and handling of dangerous materials.

Learning Objectives

1. Discuss the WHMIS system.
2. Discuss the essential components required in the WHMIS systems.
3. Describe the safe handling and use of gas cylinders in an energy plant (power plant).
4. Discuss the safe handling of Hydrocarbons.

Chapter 4 Plant Fire Safety

Learning Outcome

Explain fire safety in an industrial plant.

Learning Objectives

1. Discuss the theory, terminology, and the life safety issues associated with fires.
2. Explain the five classes of fires, and describe the types of fire extinguishing media and how they act on these fires.
3. Explain fire prevention.
4. Discuss fire prevention methods for the five types of fires.

Chapter 5 Fire Extinguishing Methods and Equipment

Learning Outcome

Describe typical fire extinguishing equipment and its operation in plant environments.

Learning Objectives

1. Describe the construction and operation of various types of portable fire extinguishers.
2. Discuss the inspection and maintenance requirements of portable fire extinguishers.
3. Describe the types, layout, and operation of standpipe and sprinkler systems.
4. Discuss the maintenance requirements of standpipe and sprinkler system components.
5. Describe the purpose, operation, and maintenance of fire pumps.



FOURTH CLASS (EDITION 3.5)

COURSE OUTLINE WITH OUTCOMES

PART A UNIT-5: Introduction to Plant Operations and the Environment

Chapter 1 Introduction to the Environment

Learning Outcome

Identify environmental considerations and how they relate to an operating plant.

Learning Objectives

1. Describe four important Biogeochemical Cycles that operate within the environment.
2. Describe typical interdependencies seen among elements within an “ecosystem.”
3. List the types of impacts that operating facilities can have on the environment.
4. Describe the alert processes related to environmental problems of plants.
5. Explain the importance of “attitude” in limiting environmental impacts of plants.
6. Describe the long-term environmental impacts after the decommissioning and abandonment of plants.

Chapter 2 Gas and Noise Emissions

Learning Outcome

Explain how gas and noise emissions affect plant operations.

Learning Objectives

1. Identify the sources and effects of common gases and vapours that have an adverse environmental impact.
2. Identify the common greenhouse and acid rain causing gases and describe their effects.
3. Describe the common methods for monitoring and reducing gaseous pollutants.
4. Describe the effects of noise pollution and methods of identifying, measuring, and controlling it.

Chapter 3 Liquid and Solid Emissions

Learning Outcome

Explain how liquid and solid emissions affect plant operation.

Learning Objectives

1. Describe the sources and effects of solid pollutants from energy plants.
2. Describe the theory of operation of separators/collectors and monitoring of flue gas particulates.
3. Describe the disposal methods of solid waste from energy plants.
4. List sources and effects of liquid and thermal pollution.
5. Describe the preventive measures that can be taken to prevent liquid and thermal pollution.
6. Describe methods of liquid waste disposal.



FOURTH CLASS (EDITION 3.5)

COURSE OUTLINE WITH OUTCOMES

PART A UNIT-6: Elements of Material Science and Welding Technology

Chapter 1 Energy Plant Construction and Operation Materials

Learning Outcome

Describe the mechanical properties of engineering materials used in engineering.

Learning Objectives

1. Describe the mechanical properties of materials.
2. Describe the various types of ferrous materials.
3. Describe the various types of non-ferrous materials.

Chapter 2 Introduction to Welding

Learning Outcome

Describe welding processes relevant to the plant and Power Engineering.

Learning Objectives

1. Describe non-fusion welding process, equipment used, and methods.
2. Describe forge and oxy-fuel fusion welding processes and cutting processes.
3. Describe metal arc welding processes.
4. Describe heat treatment of welds.
5. Describe the types of weld joints used in pressure vessel construction.
6. Describe the additional construction components required for pressure vessels to ensure structural integrity and “access”.

Chapter 3 Boiler and Pressure Vessel Inspection

Learning Outcome

Describe inspection processes and testing methods for welds and materials.

Learning Objectives

1. Describe common weld defects.
2. Describe the process of Visual Testing of welds.
3. Describe the process of Penetrant Testing for detecting weld or material defects.
4. Describe the process of radiographic weld testing.
5. Describe the process of ultrasonic weld testing.



FOURTH CLASS (EDITION 3.5)

COURSE OUTLINE WITH OUTCOMES

PART A UNIT-7: Introductory Fluid Handling Technology

Chapter 1 Introduction to Energy Plant Piping Systems

Learning Outcome

Discuss the basic types of piping, piping connections, supports, and drainage devices used in industry.

Learning Objectives

1. State the applications for the most common materials and identify the sizes of commercial pipe.
2. Describe methods of connection for screwed, flanged, and welded pipe; identify fittings and their markings.
3. Describe methods and devices used to allow for pipe expansion and support.
4. Explain the methods used to promote good drainage of steam pipes, including the installation and maintenance of steam traps, to reduce the effects of water hammer.
5. Explain the requirements, materials, and methods for insulating pipe.

Chapter 2 Introduction to Energy Plant Valves

Learning Outcome

Discuss the design and uses of the valve designs most commonly used in industry and on boilers.

Learning Objectives

1. Describe standard valve designs.
2. Describe design and operation of specialized boiler valves.
3. Describe a typical steam pressure reducing station, and the design and operation of steam system pressure-reducing valves.
4. Discuss valve details, including materials of construction and identification markings.
5. Describe typical valve maintenance requirements.

UNIT A-8: Basic Concepts in Electrotechnology

Chapter 1 Basic Electricity

Learning Outcome

Apply the concepts of basic electricity while performing simple calculations using voltage, current, resistance, and power.

Learning Objectives

1. Describe the atomic structure of matter and its relationship to electricity.
2. Describe basic electrical circuits.
3. State Ohm's Law and apply it to single-resistor circuits.
4. Apply Ohm's Law to series resistance circuits.
5. Apply Ohm's Law to parallel resistance circuits.
6. Explain electrical conductors and insulators using examples.
7. Explain the factors that affect resistance mathematically.
8. Calculate the power developed in an electrical circuit.



FOURTH CLASS (EDITION 3.5)

COURSE OUTLINE WITH OUTCOMES

Chapter 2 Magnetism and Electromagnetism

Learning Outcome

Describe the basic principles of magnetism.

Learning Objectives

1. Describe magnetism and the relationship between magnetism and electricity.
2. Describe the relationship between electricity and magnetism in an electrical generator.
3. Describe the relationship between electricity and magnetism in an electric motor.

Chapter 3 Electrical Metering Devices

Learning Outcome

Describe the design and application of electrical metering devices.

Learning Objectives

1. Describe electrical meters and their uses.
2. Describe how voltage, current, and resistance are measured in an electric circuit.
3. Describe the construction and operation of a kilowatt hour meter.

Chapter 4 Motors and Generators

Learning Outcome

Describe the operating principles of the various types of AC and DC motors and generators.

Learning Objectives

1. Describe the construction and operation of DC generators and motors.
2. Describe the construction and operation of AC generators (alternators) and motors.
3. Interpret the information on a motor nameplate.
4. Perform basic calculations relating to power factor and power factor correction.

Chapter 5 Transformers

Learning Outcome

Describe the operating principles of electrical transformers.

Learning Objectives

1. Describe the principle of operation of transformers.
2. Perform basic transformer calculations as they relate to the construction and operation of single-phase transformers.
3. Describe the construction and operation of three-phase transformers.
4. Discuss special transformer types and their applications.
5. Discuss transformer cooling, safety, and maintenance.



FOURTH CLASS (EDITION 3.5)

COURSE OUTLINE WITH OUTCOMES

Chapter 6 Electrical Distribution Circuits

Learning Outcome

Describe an electrical distribution system.

Learning Objectives

1. List and describe the standard types of electrical voltage systems.
2. Interpret electrical single-line diagrams and circuit symbols.
3. Describe the major components of an electrical distribution system.
4. Describe the function and operation of fuses and circuit breakers.
5. Describe the function and operation of alternate power supply system equipment.

Part A UNIT-9: Energy Plant Instrumentation and Controls

Chapter 1 Introduction to Energy Plant Controls and Instrumentation

Learning Outcome

Describe the overall purpose and function of plant instrumentation systems.

Learning Objectives

1. Describe the concept and basic components of a control loop.
2. Describe the various means by which control signals are transmitted, and the function of transducers.
3. List and describe the types of instruments that are not control loop components.

Chapter 2 Introduction to Process Measurement

Learning Outcome

Describe the construction and operation of common devices used to measure pressure, level, flow, temperature, humidity, and composition.

Learning Objectives

1. Describe the types of pressure sensing and measuring devices.
2. Describe the types of level sensing and measuring devices.
3. Describe the types of flow sensing and measuring devices.
4. Describe the types of temperature sensing and measuring devices.
5. Describe the types of humidity sensing and measuring devices.
6. Describe the types of gas sensing and measuring devices.



FOURTH CLASS (EDITION 3.5)

COURSE OUTLINE WITH OUTCOMES

Chapter 3 Basic Control and Instrumentation Components

Learning Outcome

Describe the basic types and functions of transmitters, recorders, controllers, and control actuators.

Learning Objectives

1. Describe the construction and operational principles of instrumentation transmitters.
2. Describe the construction and operational principles of instrumentation indicators and recorders.
3. Describe the construction and operational principles of instrumentation controllers.
4. Describe the construction and operational principles of final control elements.

Chapter 4 Introduction to Programmable Controllers

Learning Outcome

Describe the operation of programming controls for boilers, including applicable testing and maintenance procedures.

Learning Objectives

1. Discuss how programmable controllers work and how they act as sequencers for equipment.
2. Describe applications of programmable controllers.
3. Explain the HMI (human machine interface) and purpose of touchscreen displays, functions, and alarm handling.

Chapter 5 Electronic Control Systems and Computer Applications

Learning Outcome

Describe the design and operation of electronic control systems.

Learning Objectives

1. Discuss electronic process control systems.
2. Describe computers and how they operate within control systems.
3. Describe the applications of computerized control systems and plant computers.

Chapter 6 Electrical Control Systems

Learning Outcome

Describe the design and operation of electrical control systems.

Learning Objectives

1. Describe the basic construction and operation of various electric control system components.
2. Describe the function of control devices in electric control systems.
3. Explain the operating sequence of basic electric control circuits.



FOURTH CLASS (EDITION 3.5)

COURSE OUTLINE WITH OUTCOMES

PART A UNIT-10: Fundamental Industrial Communication Skills

Chapter 1 Energy Plant Sketching

Learning Outcome

Create engineering equipment sketches.

Learning Objectives

1. Create sketches using center lines and dimensioning.
2. Recognize standard views of an object.
3. Recognize cross-hatching methods in sectional drawings.
4. Identify common symbols and lines used in plant system trace drawings.
5. Complete a plant line tracing.

Chapter 2 Plant Diagrams and Drawings

Learning Outcome

Identify common types of diagrams used in plants.

Learning Objectives

1. Explain the layout of plant diagrams.
2. Explain the use of process flow diagrams (PFDs).
3. Explain the use of piping and instrumentation diagrams (P&IDs).
4. Explain the use of general arrangement, block plans and equipment diagrams.

Chapter 3 Plant Communications

Learning Outcome

Describe the types and proper usage of plant communication systems.

Learning Objectives

1. Discuss effective written and verbal communication skills, including the use of two-way radios.
2. Describe the legal documentation requirements for Power Engineers, including log books and log sheets.
3. Discuss the elements of Maintenance Management Systems, including work requests, and work orders.
4. Discuss the purpose, revision, and control of Standard Operating Procedures.
5. Discuss updating procedures for piping and instrumentation diagrams.



FOURTH CLASS (EDITION 3.5)

COURSE OUTLINE WITH OUTCOMES

PART A UNIT-11: Introduction to Boiler Designs

Chapter 1 Introduction to Boilers

Learning Outcome

Describe the historical development of boilers, boiler design, components, and configuration.

Learning Objectives

1. Describe the history of boiler applications, boiler design, and modern boiler improvements.
2. Describe packaged boilers.
3. Describe the construction of shop-assembled and field-erected boilers.
4. Describe components and design aspects common to all boiler vessels.

Chapter 2 Firetube Boilers

Learning Outcome

Describe the design, components, and characteristics of firetube boilers.

Learning Objectives

1. Differentiate the Scotch Boiler from the other firetube boilers, and describe its development history.
2. Describe circulation patterns in firetube boilers.
3. Discuss construction details of firetube boilers.

Chapter 3 Watertube Boilers

Learning Outcome

Describe the design, components, and characteristics of watertube boilers.

Learning Objectives

1. Describe the design and operating principles of watertube boilers.
2. Describe watertube boiler components.
3. Explain the design and application of packaged watertube boilers.
4. Describe the design, construction, and components of large-scale steam generating units.

Chapter 4 Electric Boilers

Learning Outcome

Explain the general design and application of electric boilers.

Learning Objectives

1. Discuss the advantages and disadvantages of electric boilers.
2. Describe the construction and operating principle of electric boilers.



FOURTH CLASS (EDITION 3.5)

COURSE OUTLINE WITH OUTCOMES

Chapter 5 Special Boiler Designs for Heating Plants

Learning Outcome

Describe the special design considerations of boilers used in heating plants.

Learning Objectives

1. Describe the design of watertube and coil tube heating boilers.
2. Describe cast iron boilers and vertical firetube boilers.
3. Describe the construction and application of firetube heating boiler designs.

Chapter 6 Differences between Power and Heating Boilers

Learning Outcome

Differentiate between ASME Section I and ASME Section IV boilers.

Learning Objectives

1. Discuss the differences between power boiler and heating boiler design and installation.
2. Discuss the differences between power boiler and heating boiler operation.

PART A UNIT-12: Elements of Boiler Systems

Chapter 1 Combustion

Learning Outcome

Discuss the basic theory of combustion, and the equipment used to provide proper combustion conditions within a boiler.

Learning Objectives

1. Discuss combustion, combustion equations, and the relationship between theoretical and excess air.
2. Discuss the characteristics of solid, liquid, and gaseous fuels.
3. Explain the effects of fuels and combustion on refractory materials.

Chapter 2 Fuel Delivery and Firing Systems

Learning Outcome

Describe common fuel systems found in boiler systems.

Learning Objectives

1. Describe solid fuel delivery systems.
2. Describe the main types of solid fuel firing systems.
3. Describe gaseous fuel delivery systems.
4. Describe the main types of gaseous fuel firing systems.
5. Describe liquid fuel delivery systems.
6. Describe the main types liquid fuel firing systems.
7. Describe flue gas analysis and how it relates to boiler efficiency.



FOURTH CLASS (EDITION 3.5)

COURSE OUTLINE WITH OUTCOMES

Chapter 3 Draft

Learning Outcome

Describe basic concepts and equipment used to supply combustion air to boiler furnaces.

Learning Objectives

1. Describe the various air streams that deliver combustion air to a furnace.
2. Relate differential pressure to the creation of draft.
3. Describe forced, induced, and balanced mechanical draft.
4. Discuss common methods of controlling combustion airflow.
5. Discuss common methods of measuring furnace pressures.

Chapter 4 Feedwater Systems

Learning Outcome

Describe feedwater systems used with boilers.

Learning Objectives

1. Describe the overall layout of feedwater, condensate, and make-up water systems.
2. Describe the valves used in feedwater systems.
3. Describe the control strategies for single-element, two-element, and three-element boiler feedwater systems.
4. Describe methods of supplying feedwater to steam heating boilers.
5. Explain the operation of condensate receiver make-up water controls.
6. Describe the return of condensate, and the supply of feedwater to high-pressure boilers.

Chapter 5 Blowoff and Blowdown Systems

Learning Outcome

Describe the equipment, operation, and purpose of boiler blowoff and blowdown systems.

Learning Objectives

1. Describe blowoff, blowoff equipment and blowoff procedures.
2. Describe continuous blowdown, blowdown equipment, and blowdown procedures.
3. Describe the maintenance and repair of blowoff systems.

Chapter 6 Boiler Fireside Cleaning Systems

Learning Outcome

Describe types of boiler fireside cleaning equipment, their purpose, and their operation.

Learning Objectives

1. Describe common options for in-service fireside cleaning.
2. Describe the construction and operation of retractable soot blowers.
3. Describe the construction and operation of stationary soot blowers.
4. Describe falling shot cleaning methods.



FOURTH CLASS (EDITION 3.5)

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: Pumps 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.



FOURTH CLASS (EDITION 3.5)

COURSE OUTLINE WITH OUTCOMES

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.



FOURTH CLASS (EDITION 3.5)

COURSE OUTLINE WITH OUTCOMES

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.



FOURTH CLASS (EDITION 3.5)

COURSE OUTLINE WITH OUTCOMES

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.



FOURTH CLASS (EDITION 3.5)

COURSE OUTLINE WITH OUTCOMES

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.



FOURTH CLASS (EDITION 3.5)

COURSE OUTLINE WITH OUTCOMES

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.



FOURTH CLASS (EDITION 3.5)

COURSE OUTLINE WITH OUTCOMES

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.



FOURTH CLASS (EDITION 3.5)

COURSE OUTLINE WITH OUTCOMES

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.



FOURTH CLASS (EDITION 3.5)

COURSE OUTLINE WITH OUTCOMES

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.



FOURTH CLASS (EDITION 3.5)

COURSE OUTLINE WITH OUTCOMES

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.



FOURTH CLASS (EDITION 3.5)

COURSE OUTLINE WITH OUTCOMES

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.



FOURTH CLASS (EDITION 3.5)

COURSE OUTLINE WITH OUTCOMES

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.



FOURTH CLASS (EDITION 3.5)

COURSE OUTLINE WITH OUTCOMES

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.

Chapter 7 Ammonia Refrigeration Safety

Learning Outcome

Apply safety procedures to ammonia refrigeration systems.

Learning Objectives

1. Discuss the basic guidelines for oil removal from piping or vessels on ammonia refrigeration systems.
2. Discuss the properties and testing of secondary refrigeration systems.
3. Describe the steps and precautions to take when pumping down a compression refrigeration system.
4. Explain the specific points to isolate and lock out for various maintenance on specific refrigeration plant equipment.

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.



FOURTH CLASS (EDITION 3.5)

COURSE OUTLINE WITH OUTCOMES

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.

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.



FOURTH CLASS (EDITION 3.5)

COURSE OUTLINE WITH OUTCOMES

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.

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. Explain typical problems and resolutions in the operation of steam heating systems.



FOURTH CLASS (EDITION 3.5)

COURSE OUTLINE WITH OUTCOMES

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.

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.



FOURTH CLASS (EDITION 3.5)

COURSE OUTLINE WITH OUTCOMES

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.