Second Class (Edition 2.5) Part A1

Course Outline with Outcomes

These learning materials were designed to directly address the SOPEEC 2015 Canadian syllabus for 2nd Class Power Engineering Certification.

Content

3. Boiler and Pressure Vessel Legislation

Learning Outcome

Describe the components and application of boiler and pressure vessel legislation within Canadian jurisdictions.

Learning Objectives

1. Identify the types and sources of Laws and the levels and scope of the Courts.
2. Define Statutory Delegation of Powers as they apply to the Boilers and Pressure Vessels Act.
3. Describe the authority that Safety Officers (Inspectors) have within their jurisdiction.
4. Determine what are the offences and penalties under the Act and the appeal process.
5. Describe the typical Regulations under the Boilers and Pressure Vessels Act.
6. Describe the typical Codes and Standards referenced by the Boilers and Pressure Vessels Act.

4. Plant Design and Installation

Learning Outcome

Explain the codes and procedures involved in the design and construction of a new plant.

Learning Objectives

1. State the codes and standards that must be followed when designing and building a new plant.
2. Describe the steps involved in developing specifications and contracts for new installations and modifications.
3. Explain the major steps involved in the design and construction of a new plant.
4. Explain the roles and responsibilities in the design and construction of a new plant.
5. Explain how the design and construction of a new plant are administered and controlled.

5. Management and Supervision

Learning Outcome

Describe the roles and basic competencies of a supervisor and manager.

Learning Objectives

1. Define management and explain the general functions of management.
2. Explain how management goals and objectives are developed through planning.
3. Describe how business decisions are made.
4. Describe methods of selecting new employees.
5. Explain how employees are trained.
6. Explain how to provide leadership and motivate employees.
7. Explain how to manage employee performance and behaviours.
8. Demonstrate proper communication skills by writing a formal report.

6. Plant Maintenance

Learning Outcome

Describe plant maintenance management systems.

Learning Objectives

1. Describe the major aspects of managing maintenance activities including management of maintenance, maintenance program development, planning, scheduling, performing maintenance, assessment and improvement.
2. Describe the different approaches to maintenance including preventive, and corrective.
3. Describe how routine maintenance activities are planned, scheduled, and controlled.
4. Describe the use of Gantt and PERT charts and the critical path method to schedule major maintenance activities.
5. Describe the steps involved in preparing for and conducting a pressure vessel inspection.
6. Describe the use of computerized systems in managing maintenance, including a work order system.
7. Describe various methods of monitoring equipment, including log sheets and trending.
8. Describe the steps involved in developing a plant budget and controlling maintenance costs.

7. Safety

Learning Outcome

Explain the components and application of safety programs, safety audits, and safety training.

Learning Objectives

1. Describe the elements of a comprehensive safety program for a power plant.
2. Explain the purpose of and the process used for safety checklists, inspections, audits and reviews.
3. Explain the purpose of and the process used for safety orientation, education, and training.

8. Linear Motion

Learning Outcome

Apply the theory of applied mechanics to bodies at rest and in linear motion.

Learning Objectives

1. Calculate the displacement, velocity, and acceleration of bodies moving in a straight line.
2. Calculate the displacements and flight times of projectiles.
3. Describe the relationship between mass, force, acceleration and weight.
4. Explain inertia, momentum, and conservation of momentum and perform related calculations.
5. Demonstrate graphically the relationship between work, force, and distance.
6. Define and calculate the kinetic energy of moving objects.
7. Define and calculate the potential energy of stationary objects.
8. Explain the Law of Conservation of Energy.
9. Define and calculate indicated power and power cylinder dimensions.

9. Angular Motion

Learning Outcome

Apply the theory of applied mechanics to bodies in angular motion.

Learning Objectives

1. Define and calculate angular displacement, angular velocity and angular acceleration.
2. Define and calculate moment of inertia, radius of gyration and torque.
3. Define and calculate the kinetic energy of rotating masses, including flywheels.
4. Define rotational work and power. Calculate brake power and mechanical efficiency of a reciprocating engine.
5. Calculate the power transmitted by a belt drive.
6. Define centrifugal and centripetal force, centripetal acceleration, and perform calculations involving them.
7. Calculate the distance of movement of a governor due to centrifugal force.
8. Explain the balancing of masses about a center of rotation and perform simple balancing calculations for single and multiple masses.

10. Friction

Learning Outcome

Perform calculations related to frictional force.

Learning Objectives

1. Describe the concept, types and laws of friction.
2. Define and calculate the coefficient of friction and applied forces for objects moved on a horizontal surface by forces parallel to the surface.
3. Define and calculate the applied forces for objects moved on a horizontal surface by forces not parallel to the surface.
4. Define and calculate the applied forces for objects moved on an inclined plane.
5. Define and calculate the frictional forces on a screw jack.
6. Define and calculate maximum torque on a belt drive.

11. Static and Dynamic Forces

Learning Outcome

Perform calculations related to static and dynamic forces acting on a body.

Learning Objectives

1. Define and evaluate forces in terms of moments and couples.
2. Define and calculate centroids and first and second moments of areas.
3. Define and calculate the different types of stress.
4. Define strain, modulus of elasticity, Poisson's ratio and perform calculations.
5. Describe the thermal expansion of bars, including reactions, under conditions of restricted expansion and reactions of bars composed of dissimilar metals.
6. Define and calculate shear forces and bending moments for simply supported beams and cantilevers.
7. Perform calculations involving the fundamental torsion equation and explain the relationship between torque and stress.
8. Explain the relationship between torque and power, and calculate maximum and mean torque for solid shafts of circular cross section.
9. Calculate stress in coupling bolts due to torque.

12. Fluid Mechanics

Learning Outcome

Perform calculations related to fluid flows and pressures.

Learning Objectives

1. Describe the basics of fluid mechanics.
2. Perform calculations related to pressure in a fluid, including center of pressure.
3. Explain buoyancy and perform calculations involving buoyancy principles.
4. Define and calculate thermal expansion of a vessel and its liquid contents.
5. Describe flow in open channels and calculate fluid flow through a weir.
6. Describe liquid flow in a pipe using the continuity equation.
7. Apply the law of conservation of energy to fluid flow and define Bernoulli's equation.
8. Calculate fluid flow from a vessel orifice.
9. Calculate flow using a venturi meter.

Second Class Edition 2.5 Part A2

Course Outline with Outcomes

These learning materials were designed to directly address the SOPEEC 2015 Canadian syllabus for 2nd Class Power Engineering Certification.

Content

3. Thermodynamics of Steam

Learning Outcome

Perform calculations related to properties of steam.

Learning Objectives

1. Describe the basic properties of water and steam.
2. Perform calculations involving specific enthalpy, dryness fraction, specific heat, and specific volume using steam tables.
3. Explain the principles and use of calorimeters to measure the dryness fraction of wet steam.
4. Calculate the dryness fraction of steam based on calorimeter data.
5. Calculate the internal energy of steam under given conditions.
6. Explain entropy and calculate the change in entropy for a particular water/steam process.
7. Determine steam properties using a Mollier Chart.
8. Calculate boiler thermal efficiency using test data.

4. Practical Thermodynamic Cycles

Learning Outcome

Explain the concepts and use of common thermodynamic cycles, using pressure-volume and temperature-entropy diagrams.

Learning Objectives

1. Explain the concept of a heat engine and describe the different types of heat engines.
2. Describe the Carnot cycle and calculate Carnot cycle efficiency.
3. Explain the Rankine cycle using pressure-volume and temperature-entropy diagrams and calculate Rankine cycle efficiency.
4. Explain the Otto cycle using pressure-volume and temperature-entropy diagrams and calculate Otto cycle efficiency.
5. Explain the Diesel cycle using pressure-volume and temperature-entropy diagrams and calculate Diesel cycle efficiency.
6. Explain the Brayton cycle using pressure-volume and temperature-entropy diagrams and calculate Brayton cycle efficiency.
7. Calculate the heat balance at different points in a Rankine cycle system using test data provided.

5. Metallurgy

Learning Outcome

Discuss the uses and structure of common metals.

Learning Objectives

1. Explain the study of metallurgy and the atomic and crystalline structure of metals.
2. Explain the significance of the iron-carbon equilibrium diagram.
3. Explain the purposes of, and processes used, in the heat treatment of steels.
4. Explain how to interpret metal specifications.
5. Explain typical selection of metals for process plant applications (what is selected and why).
6. Describe the composition, physical properties, and uses of copper, lead, and tin.
7. Describe the composition, physical properties, and uses of aluminum and aluminum alloys.

6. Testing of Materials

Learning Outcome

Discuss the common procedures and parameters for testing of metals.

Learning Objectives

1. Differentiate between destructive and non-destructive testing and explain the procedures and interpretation of tensile, hardness, and impact tests.
2. Explain the purpose and procedure of a Proof (Hydrostatic Deformation) Test.
3. Explain the causes and significances of welding discontinuities.
4. Explain Non-Destructive Examination, along with its applications and benefits.
5. Explain visual inspection and the procedures used.
6. Explain magnetic particle inspection and the procedures used.
7. Explain liquid penetrant testing and the procedures used.
8. Explain ultrasonic testing and the procedures used.
9. Explain radiographic testing, including interpretation of results.
10. Explain acoustic emission testing and the procedures used.
11. Explain leak and pressure testing.
12. Explain how to monitor and test metals for creep, fatigue and corrosion.

7. Corrosion of Metals

Learning Outcome

Discuss the common procedures and parameters for testing of metals.

Learning Objectives

1. Define corrosion and explain the electrochemical principles involved.
2. Explain how the environment can affect corrosion.
3. Explain the most common corrosion mechanisms.
4. Describe the predominant corrosion mechanisms that potentially affect various power plant systems and equipment.
5. Explain methods used to monitor and test for corrosion during plant operation.
6. Explain the methods used to control and prevent corrosion at the design stages and during operation.
7. Explain the main components of a corrosion failure analysis and a typical corrosion failure report.

8. Introduction to Welding Symbols

Learning Outcome

Describe how weld joints are constructed, using standard weld symbol terminology.

Learning Objectives

1. Explain the purpose of welding symbols.
2. Describe the common weld joints and weld types, including groove, fillet, plug and slot welds, with related weld terminology.
3. Recognize and describe symbols that identify weld types.
4. Identify and explain the meaning of the reference line, the arrow, and the tail in a welding symbol.
5. Identify and explain the meaning of supplemental welding symbols, not specific to the weld itself.
6. For groove and fillet welds, identify and explain welding symbols that relate to the weld configuration and joint preparation.

Second Class (Edition 2.5) Part A3

Course Outline with Outcomes

These learning materials were designed to directly address the SOPEEC 2015 Canadian syllabus for 2nd Class Power Engineering Certification.

Content

3. Boiler and Steam Generator Operation

Learning Outcome

Describe in detail the typical procedures for operation of a large steam generator.

Learning Objectives

1. Describe the detailed hot and cold startup procedures for a steam generator including safety precautions.
2. Describe the detailed shutdown procedure for a steam generator including safety precautions.
3. Describe the detailed lay-up procedures for a steam generator including safety precautions.
4. Describe the detailed refractory dry out procedure for a new steam generator including safety precautions.
5. Describe the detailed boil out procedure for a new steam generator including safety precautions.

4. Boiler and Steam Generator Maintenance and Inspection

Learning Outcome

Describe in detail the typical procedures for boiler maintenance and inspection.

Learning Objectives

1. Describe the mechanical cleaning procedures for a boiler including safety precautions.
2. Describe the detailed chemical cleaning procedures for a watertube boiler including safety precautions.
3. Describe the detailed hydrostatic testing procedure for a boiler including safety precautions.
4. Describe standard shutdown activities and preventive maintenance procedures required for a boiler.
5. Describe the detailed procedure for complete inspection of a boiler including waterside, fireside, and auxiliary equipment.
6. Describe boiler inspection techniques and equipment.
7. Describe the required inspection records and reporting procedures.
8. Describe the roles and responsibilities for an inspection including engineering staff, operators, and boiler inspector.
9. Describe the safety requirements during a boiler inspection.

5. Pumps

Learning Outcome

Discuss the application of large centrifugal pumps.

Learning Objectives

1. Explain selection criteria for pump applications.
2. Interpret pump operating characteristics and performance curves.
3. Describe the procedure for the installation of a large multi-stage centrifugal pump.
4. Describe the typical repairs and preventive maintenance procedures required for a multi-stage centrifugal pump.
5. Describe the methods of control for a multi-stage centrifugal pump including recirculation control.
6. Describe the selection criteria for seal types and materials in a centrifugal pump.
7. Describe the methods of counteracting thrust in a large centrifugal pump.

6. Water Chemistry and Analysis

Learning Outcome

Discuss the significance of common water impurities, and the application of water analyses.

Learning Objectives

1. Describe the sources of the impurities found in raw water.
2. Describe the effect of the listed water impurities on power plant equipment and processes.
3. Explain the significance and importance of standard methods of water analysis.
4. Describe which analyses are appropriate at given sampling points including the significance of the sampling point locations.
5. Interpret the results of a comprehensive standardized water analysis including the relationship of the various parameters.
6. Explain the purposes and principles of testing instruments, including embrittlement detector, total solids meter, and pH meter.
7. Explain the purpose of steam purity measurement and process of steam sampling.

7. Water Pre-Treatment I

Learning Outcome

Describe water pre-treatment processes for removal of suspended solids, oil, and gases.

Learning Objectives

1. Explain the purpose, equipment, operation, and limitations of sedimentation.
2. Explain the purpose, equipment, operation, and limitations of coagulation and flocculation.
3. Explain the purpose, equipment, operation, and limitations of filtration.
4. Explain the purpose, principles, equipment, operation, and limitations of microfiltration.
5. Describe how oil is removed from water.
6. Explain the purpose, equipment, operation, and limitations of mechanical deaeration.
7. Explain the purpose, equipment, operation, and limitations of evaporation.

8. Water Pre-Treatment II

Learning Outcome

Describe water pre-treatment processes for ion removal.

Learning Objectives

1. Explain the purpose, equipment and operation of lime-soda softening.
2. Explain the purpose, equipment, operation and limitations of hot process phosphate softening.
3. Explain the purpose, equipment, operation, and limitations of sodium zeolite softening.
4. Explain the purpose, equipment and operation, of hydrogen zeolite softening.
5. Describe how silica is removed from water.
6. Explain the purpose, equipment, and operation of demineralization, including condensate polishing.
7. Explain the purpose, equipment, and operation of electrodialysis (ED) and electrodeionization (EDI.)
8. Explain the purpose, equipment, and operation of reverse osmosis (RO.)

9. Internal Water Treatment

Learning Outcome

Describe boiler internal water treatment processes.

Learning Objectives

1. Explain the causes, effects, and control of scale.
2. Explain the causes, effects, and control of foam in boiler water.
3. Explain the causes, effects, and control of caustic embrittlement.
4. Explain the causes, effects, and control of return line corrosion.
5. Explain the use of chelating agents in boiler water.
6. Explain the use of sludge conditioning in boiler water.
7. Explain the use of pH control in boiler water.
8. Explain the use of chemical deaeration in boiler water.
9. Explain the causes, effects, and control of carryover of boiler water.
10. Explain the use of blowdown from boiler water.
11. Explain the use and control of chemical feed systems for boiler water.
12. Explain the control of silica to avoid turbine blade deposits.

10. Non-Boiler Water Treatment

Learning Outcome

Discuss water treatment applications for cooling water, wastewater, and potable water.

Learning Objectives

1. List the water impurities of concern in a cooling water system and the effects caused by each one.
2. Describe control methods for a cooling water system for control of corrosion, fouling, and microbiological attack including chloride corrosion, and delignification.
3. Describe the potential effects of wastewater discharge.
4. Compare and contrast mechanical, chemical, and biological methods of wastewater treatment including the advantages and disadvantages of each.
5. Specify an appropriate method of wastewater treatment for a particular case study.
6. Describe the methods used for potable water treatment and analysis.

Second Class (Edition 2.5) Part B1

Course Outline with Outcomes

These learning materials were designed to directly address the SOPEEC 2015 Canadian syllabus for 2nd Class Power Engineering Certification.

Content

3. Steam Turbine Operation and Maintenance

Learning Outcome

Discuss procedures for operation and maintenance of a large steam turbine.

Learning Objectives

1. Describe the detailed hot and cold start-up procedures for a large steam turbine, including safety precautions.
2. Describe the detailed shutdown procedure for a large steam turbine including safety precautions.
3. Explain what checks are performed on a large steam turbine during normal operation.
4. Sketch the flow of steam and condensate through a condensing steam turbine and a non-condensing steam turbine.
5. Explain the preventive maintenance requirements for a large steam turbine. Include shaft alignment, bearings, clearances for thrust, blades, shaft seals, correction of blade fouling, erosion and cleaning.
6. Describe the purpose of and procedure for static and dynamic balancing.

4. Steam Condensers

Learning Outcome

Discuss condenser principles, performance, operation and auxiliaries.

Learning Objectives

1. Describe the principles and design of jet, air cooled, and surface condensers.
2. Describe the purpose, principle and design of surface condenser support and expansion systems.
3. Explain the significant parameters in condenser performance.
4. Calculate condenser thermal efficiency from the test data.
5. Explain the procedures used to troubleshoot condenser performance.
6. Explain the procedures used to backwash and clean a condenser.
7. Describe the purpose, principle and design of air ejectors and vacuum pumps.
8. Describe the purpose and flow of cooling water systems.
9. Describe the purpose, principle and design of cooling water intake screens, circulating pumps, cooling towers, and cooling ponds.
10. Describe the purpose, principle and design of condenser atmospheric exhaust (relief) valves.
11. Describe the purpose, principle and design of condensate pumps.

5. Internal Combustion Engines - Components and Auxiliaries

Learning Outcome

Explain the design, selection, and components of internal combustion engine installations, including auxiliaries.

Learning Objectives

1. Explain design, applications, and selection criteria for the different types of reciprocating internal combustion engines.
2. Explain fuels and combustion processes and fuels used by internal combustion engines.
3. Describe the design of internal combustion engine scavenging and supercharging arrangements.
4. Describe the design and components of internal combustion engine fuel conditioning systems, injection systems, and ignition systems.
5. Describe the design and components of internal combustion engine cooling systems and cooling water conditioning systems.
6. Describe the purpose, design and components of internal combustion engine lubricating oil systems.
7. State the purpose and describe the control of a typical internal combustion engine including the operation of safety devices.

6. Internal Combustion Engines - Operation and Maintenance

Learning Outcome

Describe general maintenance requirements, and detailed operating and troubleshooting procedures for internal combustion engines.

Learning Objectives

1. Describe the detailed startup procedures for an internal combustion engine.
2. Describe the detailed shutdown procedures for an internal combustion engine.
3. Explain the routine maintenance and monitoring requirements for an internal combustion engine.
4. Explain the major maintenance and overhaul requirements for an internal combustion engine.
5. Explain the troubleshooting of combustion and engine problems.

7. Gas Turbine Design and Auxiliaries

Learning Outcome

Explain the design and components of a large gas turbine and related auxiliaries.

Learning Objectives

1. Explain applications and selection criteria for the different types of gas turbine engines.
2. Describe the principles and design of open and closed cycle gas turbine systems.
3. Describe the principles and design of combined cycle and cogeneration systems using gas turbines.
4. Describe the principles and design of gas turbine regeneration, intercooling, and reheating.
5. Describe the principles and design of gas turbine shaft arrangements.
6. Describe the design and components of gas turbine compressors, combustors (combustion chambers) and turbines.
7. Describe the design and operation of gas turbine air intake and exhaust systems.
8. Describe the design and operation of a gas turbine lubricating oil system.
9. Describe the design and operation of a gas turbine fuel system.
10. Describe the design and operation of a gas turbine steam or water injection system and a dry low NO_x system.

8. Gas Turbine Operation and Control

Learning Outcome

Discuss operating procedures, and control and monitoring components of a large gas turbine.

Learning Objectives

1. Describe the components and operation of gas turbine supervisory and control systems.
2. Describe the principles and design of gas turbine protection devices.
3. Describe the detailed hot and cold startup procedures for a gas turbine, including safety precautions.
4. Describe the detailed shutdown procedure for a gas turbine, including safety precautions.
5. Explain the routine maintenance and monitoring requirements for a gas turbine.
6. Describe the major maintenance and overhaul requirements for a gas turbine.
7. Explain the troubleshooting of gas turbine problems.

9. Lubrication

Learning Outcome

Explain the components of a lubrication application and maintenance program.

Learning Objectives

1. Describe the methods of manufacture and the different classifications of lubricants.
2. Describe the significance and measurement of lubricating oil characteristics, including viscosity, relative density, API (American Petroleum Institute) gravity, pour point, and dielectric strength.
3. Explain the typical causes of lubricating oil deterioration.
4. Describe the types of lubrication additives.
5. Describe a typical power plant lubrication program, including a lubrication survey.
6. Explain the different types of lubricating/governing/seal oil systems.
7. Describe the components and operation of a typical lubricating oil purification system.
8. Describe the various applications of ball-and-roller bearings and their lubrication, including bearing seals.

10. Piping

Learning Outcome

Explain piping system design, inspection, and maintenance.

Learning Objectives

1. Explain selection criteria for piping materials.
2. Calculate the required thickness and the internal design pressure of piping.
3. Describe typical inspection procedures for piping installations and repairs.
4. Describe a typical routine inspection procedure and schedule for high-energy piping.
5. Explain the effects of high temperature on piping strength.
6. Describe the design and installation criteria for a piping system layout.
7. Explain the theory and effects of water hammer.

11. Mechanical Drawing

Learning Outcome

Interpret construction and process drawings.

Learning Objectives

1. Interpret the information provided in orthographic, isometric, and oblique projections.
2. Interpret the information provided in construction drawings with sectioning and dimensioning.
3. Interpret the information provided in Process Flow Diagrams.
4. Interpret the information provided in Piping and Instrumentation Diagrams (P&IDs).
5. Explain the use of isometric piping system and spool drawings in piping systems.

Second Class (Edition 2.5) Part B2

Course Outline with Outcomes

These learning materials were designed to directly address the SOPEEC 2015 Canadian syllabus for 2nd Class Power Engineering Certification.

Content

Book 5 (Part B2): Combustion and Plant Systems (352 pages)

1. Power Plant Fuel Systems

Learning Outcome

Describe the design and operation of typical power plant systems.

Learning Objectives

1. Describe, using a sketch, the design and operation of fuel oil supply systems.
2. Describe, using a sketch, the design and operation of fuel gas supply systems.
3. Describe, using a sketch, the design and operation of solid fuel supply systems.

2. Power Plant Water and Steam Systems

Learning Outcome

Describe the design and operation of typical power plant systems.

Learning Objectives

1. Describe, using a sketch, the design and operation of feedwater systems.
2. Describe, using a sketch, the design and operation of steam distribution systems.
3. Describe, using a sketch, the design and operation of condensate systems.
4. Describe, using a sketch, the design and operation of cooling water systems.
5. Describe, using a sketch, the design and operation of waste handling systems.
6. Explain how different power plant water systems interconnect and what parameters are significant to each.

3. Measurement and Control Components

Learning Outcome

Explain the design and application of measuring devices and final control elements.

Learning Objectives

1. Describe the design, use, and placement of electrical and electronic pressure measuring devices.
2. Describe the design, use, and placement of electrical and electronic temperature measuring devices.
3. Describe the design, use, and placement of Venturi tubes, orifice plates, flow nozzles, and Pitot tubes.
4. Describe the design and use of: manometers, ring balance, force balance, and electric flow indicating mechanisms.
5. Describe the design, use, and placement of the following liquid level measurement devices: ball-float, displacement-type, hydrostatic head, electric and pneumatic level transmission, electric and magnetic type level-limit devices, and remote water-level indicators.
6. Describe the types, construction, and flow characteristics of control valves.
7. Describe the design, operation, and application of the following valve operators: solenoid, pneumatic-diaphragm, power cylinder, and electric motor.

4. Control Instrumentation Systems

Learning Outcome

Explain and apply the theory of automatic boiler, distributed control, and programmable logic control systems.

Learning Objectives

1. Describe the principle, design, application, and limitations of the following automatic control methods: proportional, proportional-plus-reset, and proportional-plus-reset-plus-rate.
2. Describe the principle, design, application, and limitations of single, two, and three-element boiler feedwater control systems.
3. Describe the principle, design, application, and limitations of superheated and reheated steam temperature control systems.
4. Describe the principle, design, components, application, and limitations of Distributed Control Systems (DCS).
5. Describe the principle, design, application, and limitations of Programmable Logic Controllers (PLC).

5. Fuels and Combustion Calculations

Learning Outcome

Perform combustion and furnace draft calculations and explain flue gas analysis.

Learning Objectives

1. Describe the nature of combustion and the different types of fuels.
2. Calculate the mass and volumetric analysis of a fuel.
3. Describe the proximate and ultimate analysis and calculate the heating value of fuel.
4. Given the results of a bomb calorimeter test, calculate the heating value of a fuel.
5. Calculate the amount of air and excess air required for combustion of fuel.
6. Explain flue gas analysis parameters and their significance.
7. Calculate theoretical draft, flue gas velocity, and stack diameter.
8. Calculate draft fan power and efficiency.

6. Firing and Draft Equipment

Learning Outcome

Explain the design, components, and auxiliary equipment of steam generator furnaces.

Learning Objectives

1. Describe steam generator furnace designs including cyclone furnaces and divided furnaces. Explain the purpose and placement of furnace arches.
2. Explain the purpose and design of separately fired superheat and reheat furnaces.
3. Explain the purpose, types, characteristics, and placement of refractory in a furnace.
4. Describe the principle, design, and application of oil, gas, and coal burners.
5. Describe the principle, design, and application of pulverizers.
6. Describe the principle, design, and application of ash and slag disposal systems.
7. Explain the significance, monitoring, and control of ash fusion temperature.
8. Describe the designs and applications of forced and induced draft fans.
9. Explain the methods which control furnace draft.

7. Combustion Control and Safeguards

Learning Outcome

Explain combustion control methods and safeguard components.

Learning Objectives

1. Describe, using a sketch, the combustion control arrangements in a steam generator.
2. Explain series, parallel, and series/parallel combustion control.
3. Explain turbine-following, boiler-following, and integrated combustion control systems.
4. Describe the operation of purge, fan failure, and flame failure interlock systems.
5. Describe the operation of flame detectors.
6. Describe, using a sketch, a typical programming sequence for a packaged boiler control system.
7. Describe the typical limiting devices and alarms for a packaged boiler combustion system.

8. Environmental Monitoring

Learning Outcome

Explain the significance of environmental parameters and methods of monitoring.

Learning Objectives

1. Explain the significance of the following air quality parameters: particulates, stack opacity, SO_2 concentration, SO_2 mass flow, NO_x concentration, NO_x mass flow, mercury, O_2, CO_2, and hydrocarbons.
2. Explain the basic principles of operation for Continuous Emissions Monitoring System (CEMS) measurement instruments.
3. Explain the general requirements for Continuous Emissions Monitoring Systems (CEMS).
4. Explain the significance of the following water quality parameters: iron, phosphorous, biochemical oxygen demand (BOD), chemical oxygen demand (COD), hydrocarbons, temperature, flow, pH, and nitrogen.
5. Explain the general requirements for wastewater monitoring.
6. Explain how data received from environmental monitoring equipment is interpreted.
7. Explain the significance of environmental monitoring equipment failure.
8. Describe the procedures used for troubleshooting environmental monitoring equipment.

9. Environmental Control Methods

Learning Outcome

Explain the methods used to remove SO_2, NO_X, CO_2, and particulates from boiler flue gases.

Learning Objectives

1. Describe the purpose, design, operation, and application of Flue Gas Desulphurization (FGD) systems.
2. Describe the purpose, design, operation, and application of Selective Catalytic Reduction (SCR) systems.
3. Explain the significance of NO_X reduction in a power plant, and the procedures and equipment used to reduce NO_X emission from a boiler and from a gas turbine.
4. Explain the purpose, effects, and application of flue gas chemical conditioning in a power plant.
5. Explain the significance, procedures, and equipment for reduction of CO_2 emission from a boiler.
6. Describe the purpose, design, operation, and application of a baghouse.
7. Describe the purpose, design, operation, and application of an electrostatic precipitator.

Second Class (Edition 2.5) Part B3

Course Outline with Outcomes

These learning materials were designed to directly address the SOPEEC 2015 Canadian syllabus for 2nd Class Power Engineering Certification.

Content

Book 6 (Part B3): Electricity and Refrigeration (456 pages)

1. Alternating Current Theory

Learning Outcome

Explain characteristics and perform calculations involving AC circuits.

Learning Objectives

1. Explain the vector relationships between AC voltage and current.
2. Explain the significance of root mean square values for AC sine waves. Calculate root mean square and peak-to-peak values for AC sine waves.
3. Explain voltage/current relationships and calculate power in purely resistive circuits.
4. Explain voltage/current relationships in purely inductive circuits.
5. Explain voltage/current relationships in purely capacitive circuits.
6. Explain voltage and current relationships in circuits having resistance/inductance and resistance/capacitance combinations.
7. Calculate impedance, reactance, true and apparent power, and power factor in AC circuits.
8. Explain the significance of power factor and how it can be improved in AC circuits.
9. Explain the principle and significance of three-phase AC circuits, star, and delta connections in alternators, transformers and AC motors.
10. Calculate phase voltage, phase current and apparent and true power in a three-phase AC circuit.

2. Direct Current Machines

Learning Outcome

Explain the construction and operating principles of DC generators and motors.

Learning Objectives

1. Describe the construction and operating principles of a DC generator.
2. Explain the principle and application of compensating windings, interpoles and lap and wave armature windings.
3. Explain the principles, applications, and load/voltage characteristics of generators.
4. Describe the parallel operation and voltage regulation of DC generators.
5. Review the principle of DC motor operation, including torque development and back EMF.
6. Calculate torque and speed of a DC motor.
7. Explain the principle and application of shunt, series, and compound-wound DC motors including speed control.
8. Explain the principle and application of counter-E, current limit and time limit DC motor automatic starters.
9. Explain the principle and application of dynamic and regenerative braking.
10. Calculate efficiency and discuss the reasons for power losses in a DC motor and generator.

3. Alternating Current Generators

Learning Outcome

Explain the construction and operating principles of AC generators.

Learning Objectives

1. Explain the operating principles, design and construction of alternators with salient-pole and cylindrical rotors.
2. Explain the relationship between alternator speed, frequency, and number of pole pairs.
3. Describe the purpose and construction of an exciter.
4. Describe the purpose and design of alternator voltage regulators.
5. Describe alternator cooling systems, including circulating air cooling, hydrogen cooling, and stator winding cooling water systems.
6. Describe shaft sealing arrangements for an alternator.
7. Explain the theory and significance of alternator synchronization and parallel operation including the impact on power factor.
8. Explain efficiency and power losses in an AC generator.

4. Alternating Current Motors

Learning Outcome

Explain the construction and operating principles of AC motors.

Learning Objectives

1. Describe the principle of a pulsating magnetic field for single-phase AC motors and rotating magnetic field for three-phase AC motors. Describe general rotor and stator construction.
2. Describe the torque/speed characteristics of induction motors and the relationship between torque, slip and rotor speed.
3. Define full-load amps, locked rotor amps, service factor amps.
4. Describe the principles, applications, and operation of wound rotor motors.
5. Describe the principles, applications, and operation of single-phase AC motors. Include universal, shaded-pole, split-phase, capacitance-start, repulsion-start, and reluctance-start.
6. Describe the principles, applications, starting methods and operation of a synchronous motor.

5. Transformers

Learning Outcome

Explain the construction and operating principles of transformers.

Learning Objectives

1. Describe the construction of core type and shell type transformers.
2. Explain the factors that affect transformer rating.
3. Calculate load, power, iron and copper losses, and efficiency in a transformer.
4. Explain the purpose and procedures for transformer short and open circuit tests.
5. Describe the methods of cooling a transformer.
6. Describe the methods of connecting a transformer, including delta-delta, star-star, delta-star, and star-delta.
7. Explain the theory and significance of transformer paralleling.
8. Describe the applications of instrument transformers.
9. Describe the protective measures and devices used on transformers.

6. Electrical System Protection

Learning Outcome

Describe the protective devices used on alternators, motors, and electrical circuits.

Learning Objectives

1. Describe the significance of fuses and circuit breakers for circuit protection including continuous rating, interrupting capacity, and inverse time principle.
2. Describe the purpose and designs of different types of fuses.
3. Describe the operation of circuit breakers used for different voltages, including moulded-case, oil-immersed, airblast, air-break, vacuum, and SF_6 switchgear.
4. Describe the operation of switches and contactors used for different voltages.
5. Explain the purpose, and significance of protection relaying as it applies to a large alternator.
6. Explain the purpose and significance of the protection devices for a large electric motor.

7. Air and Gas Compression

Learning Outcome

Explain the construction and operation of large air compressors and compressed air systems.

Learning Objectives

1. Describe the design and application of compressors, including prime mover selection.
2. Describe reciprocating compressor designs.
3. Describe rotary compressor designs.
4. Describe centrifugal and axial compressor designs.
5. Describe the types and operation of coolers and air dryers, including desiccant types.
6. Describe the installation of a compressed air system, including all ancillary equipment and typical instrumentation.
7. Describe the regulation and control of compressors.
8. Describe the monitoring and protection devices for a compressed air system.
9. Explain the effects of altitude, air temperature, and humidity on air compressor performance.
10. Describe the monitoring, troubleshooting, and typical preventive maintenance for a compressed air system.

8. Refrigeration Systems and Equipment

Learning Outcome

Explain the construction and operation of refrigeration systems.

Learning Objectives

1. Describe the types of refrigerants.
2. Describe the principles and operation of vapour compression refrigeration systems.
3. Describe the principles and operation of absorption refrigeration systems.
4. Describe the principles and operation of multi-stage and cascade refrigeration systems.
5. Describe the principles, applications, and operation of heat pump and thermoelectric systems.
6. Describe the design of hermetic refrigeration systems.
7. Describe the design and operation of refrigeration compressors.
8. Describe the design and operation of evaporators, condensers, receivers, scale traps and dehydrators.
9. Describe the design and operation of absorbers.
10. Describe the design and operation of valves and fittings.

9. Refrigeration Safety, Control and Operation

Learning Outcome

Explain the procedures, standards, instrumentation, and controls for a refrigeration system.

Learning Objectives

1. Describe the codes and standards which apply to the design, installation, and operation of a refrigeration plant.
2. Describe the purpose and operation of the various operating, actuating, limiting and safety controls used in refrigeration systems.
3. Explain refrigeration metering devices.
4. Explain evaporator and compressor capacity controls.
5. Describe the detailed startup and shutdown procedures for a refrigeration system.
6. Explain absorption system startup and shutdown.
7. Explain leak testing, charging, purging, and compressor lubrication.
8. Describe the common operating problems and troubleshooting procedures for a refrigeration system.

10. Refrigeration Calculations

Learning Outcome

Perform refrigeration system calculations.

Learning Objectives

1. Describe the general refrigeration cycle and the application of the Carnot cycle.
2. Describe the relationship between enthalpy and pressure for a refrigeration cycle.
3. Define and calculate the refrigerating effect and the mass of refrigerant circulated.
4. Calculate the coefficient of performance for a refrigeration system.
5. Calculate the capacity of a refrigeration machine.
6. Calculate the theoretical power of a refrigeration compressor.
7. Calculate the theoretical bore and stroke of a refrigeration compressor.