



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

Book 3 (Part A3): Boilers and Water Treatment

1. Boiler and Steam Generator Components and Design

Learning Outcome

Discuss the components and design considerations of a steam generator.

Learning Objectives

1. Explain how the ratings of boilers and steam generators are calculated.
2. Explain the factors to be considered in designing a steam generator.
3. Contrast the influence of solid fuel, liquid fuel, and gas fuel on steam generator design.
4. Explain the principles of natural water circulation in a steam generator. Explain why forced circulation is used in a steam generator and how it is attained.
5. Explain the design, placement, and installation considerations for water walls, superheaters, desuperheaters, reheaters, economizers, and air heaters.
6. Explain the purpose and placement of screen tubes, division walls, water-cooled stringer tubes in superheaters, and wall-mounted radiant superheaters.
7. Describe top and bottom support systems for a steam generator.
8. Describe furnace casing design considerations.
9. Describe the purpose and use of specialized steam generator duct arrangements, including air heater bypass, economizer bypass, and air heater recirculation.
10. Describe the methods used to insulate different parts of a steam generator.
11. Explain the general steps used to construct a steam generator.

2. Specialized Boiler Designs

Learning Outcome

Identify and discuss common specialized boiler designs.

Learning Objectives

1. Describe typical designs, components, and operating strategies for once-through steam-flood boilers.
2. Describe typical designs, components, and operating strategies for fluidized bed boilers (bubbling bed and circulating bed types).
3. Describe typical designs, components, and operating strategies for heat recovery steam generators.
4. Compare different designs of heat recovery steam generators (HRSG): natural circulation, controlled circulation and once-through (OTSG).
5. Describe typical designs, components, and operating strategies for supercritical steam generators.
6. Describe typical designs, components, and operating strategies for black liquor recovery boilers.
7. Describe typical designs, components, and operating strategies for refuse boilers used in waste disposal.
8. Describe typical designs, components, and operating strategies for biomass boilers.
9. Describe typical designs, components, and operating strategies for waste-heat boilers (firetube and watertube types).



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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.



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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.)



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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.