

# FIRST CLASS POWER ENGINEER SYLLABUS - 2012



**TECHNICAL  
SAFETY BC**

Safe technical systems. Everywhere.



## INTRODUCTION

This syllabus has been approved by the Standardization of Power Engineers Examinations Committee (SOPEEC), the Association of Chief Inspectors (ACI), and has been adopted by Technical Safety BC.

This syllabus is intended to assist applicants studying for their First Class Power Engineer certificate of qualification examination.

For more information on First Class Power Engineer certification, visit our [website](#).

## CURRICULUM

Applicants should review the [SOPEEC curriculum](#) for more detailed information on the materials covered here. Applicants should also become familiar with the publications listed in the reference material posted on the SOPEEC website.

## EXAMINATION 1A1

### 1. Applied Thermodynamics and Plant Cycles

Principles, terminologies, and advanced practical calculations involving:

- a. Rankine and Brayton cycles applied to power plant systems.
- b. Steady flow work, energy calculations for steam; calorimeters, steam turbine/condenser systems; steam nozzles.
- c. Constant pressure, constant temperature, adiabatic processes for steam.
- d. Energy relationships in non-flow processes.
- e. Energy relationships, energy balance in steady flow processes; potential, thermal, internal, mechanical; energy conversions; nozzle flow process; throttling; work in heat engines (air compressors, turbines).
- f. Pressure, volume, temperature relationships, and work done during isothermal, adiabatic, and polytropic expansion and compression processes for gases.
- g. Temperature, enthalpy, entropy characteristics, diagrams for steam; Temperature/Entropy chart use.
- h. Enthalpy, entropy, quality calculations for steam.
- i. Expansion and contraction of metals; affects on boiler components and piping systems.
- j. Heat transfer by conduction; compound insulations; boiler component heat transfers; restricted heat transfer.
- k. Refrigeration thermodynamics: capacity; performance; efficiency.
- l. Specific heats of gases and vapours.

## EXAMINATION 1A2

### 2. Principles of Applied & Fluid Mechanics

Principles, terminologies, and advanced practical calculations involving: Work, power, and efficiencies of lifting machines.

- a. Potential and kinetic energy; energy conservation.
- b. Impulse and momentum; conservation of momentum; angular momentum.
- c. Centripetal force and acceleration; balancing rotating masses; stresses in flywheel; radius of gyration, simple harmonic motion.
- d. Torque, angular momentum, moments of inertia; centroids.
- e. Torsion; shaft stresses; shaft power.
- f. Stress and strain; modulus of elasticity; Hooke's Law; restricted expansion; elastic strain energy.
- g. Shear forces and bending moments in beams; modulus of section; beam deflection.
- h. Static fluid pressures and forces; liquid columns; hydraulics; manometers.
- i. Buoyancy.
- j. Fluids in motion; equation of continuity; liquid energy; Bernoulli's Theorem; venturi and orifice flows; turbulent and laminar flow; Reynold's Number.
- k. Nozzle designs and flows.

## EXAMINATION 1A3

### 3. Applied Engineering Technologies

- a. Metallurgy and metallography: in-depth knowledge of metals used in boilers, pressure vessels, piping, pumps, turbines, and ancillary equipment; metal structure; typical operational effects on metals in pressure equipment.
  - i. Thermal and dynamic stresses.
- b. Corrosion: Corrosion theory and mechanisms, in depth corrosion chemistry for boilers, pipelines, cooling towers and pressure vessels; types of corrosion (including flow accelerated; heat affected zone corrosion, etc.); monitoring techniques and equipment; interpretation of corrosion results; prevention strategies (e.g. cathodic protection).
- c. Combustion: Fuel types, compositions, characteristics; low and high heat values; flame characteristics; boiler, fired-heater, and duct burner designs; burner design / operation vs. efficiency and emissions; effects of excess air; combustion troubleshooting; optimizing combustion; combustion and burner safety; combustion calculations for excess air, flue gas composition and analysis; combustion efficiency calculations; heat value calculations; staged combustion.
- d. Advanced water treatment chemistry: in-depth knowledge of pre-treatment and internal boiler chemistry (for all common treatment methods); selection of pre-treatment and internal treatment strategies/programs for various size boilers (including equilibrium phosphate, coordinated phosphate, all volatile treatment, oxygenated, cycle chemistry, etc.); potable water, dealing with water treatment contractors and consultants; cooling water treatment.

## EXAMINATION 1A4

### 4. Power Plant Operations

- a. Energy Management practices; energy recovery systems (power factor correction; synchronous compensation; uninterruptible power supplies; distributed generation; emergency power; peak load reduction); controllable losses; computerized performance management systems (data dumping, spreadsheets, and performance databases).
- b. Factors, components, calculations, and strategies/procedures for testing, maintaining and maximizing power plant efficiencies:
  - boiler efficiency.
  - gas turbine and combined cycle efficiency, including turbine inlet cooling.
  - power generation efficiencies.
  - overall plant/cycle efficiencies.
- c. Power Plant construction practices: major factors, approaches, components in the design and construction process for a power (or process) plant; include new plant vs. expansion; equipment/system modifications; role of the chief engineer before and during construction; receiving/acceptance procedures for new vessels; tying into existing plant.
- d. Commissioning and de-commissioning practices: outlines and specific procedures for commissioning new equipment, including boilers and auxiliaries, steam and gas turbines, piping systems, large pumps; start-up sequences; performance contracts for new plants/equipment; re-commissioning after major outages; de-commissioning.
- e. Retrofitting: purposes, practices in redesign of existing boilers, turbines, and ancillary equipment; approval, design processes.

## EXAMINATION 1B1

### 5. Legislation and Codes for Industrial Equipment

Familiarity with all applicable Codes and Standards applicable to the Chief Power/Operating Engineer, particularly the application and authority of each Code to vessel operation and repair, including the following:

- a. Local and National Jurisdictional Codes, Acts and Regulations regarding boilers and pressure vessels: design, registration, operation, fees; engineer regulations; specific procedures of the chief engineer in applying the Acts and Regulations.
- b. ASME, Section I – Power Boilers
  - i. includes thickness and pressure calculations, using Code paragraphs, for cylindrical components, heads, headers, tubing, power piping, compensations for openings, stayed surfaces, ligaments, staybolts, furnaces; safety valves sizes and capacities.
- c. ASME, Section VIII – Pressure Vessels
  - i. includes design calculations for shells, heads, covers, opening reinforcements, and stayed surfaces.
- d. ASME, Section IX – Welding.
- e. CSA Standard B.51 – Construction and Inspection of Boilers and Pressure Vessels.
- f. CSA Standard B.52 – Mechanical Refrigeration Code.
- g. Power and Process Piping: ANSI B31.1 and B31.3.
- h. API 510, 570 – Pressure Vessel Inspection Codes.

## EXAMINATION 1B6

### 6. Safety, Loss, and Environmental Program Management

- a. Components and administration of a loss control program; loss control standards.
- b. Implementation and management of a complete plant safety program: safety attitude and motivation techniques; incident investigation & reporting; emergency response programs; work with occupational health and safety committee; safe work permits, safe work procedures and planning.
- c. Safety Legislation in the workplace: identify Labour Canada, Workers' Compensation Board, and provincial legislation; legalities; responsibilities to enforce.
- d. Risk Assessment and Risk Management Techniques including; Safety Audits (components, procedures, analysis, follow-up; working with safety inspectors) and HAZOP (hazardous operability).
- e. Insurance programs; factors affecting insurance rates; insurance inspection procedures; working with insurance inspectors.
- f. Environmental Legislation: identify/explain all applicable legislation (provincial and federal); legalities, responsibilities.
- g. Environmental Permits: components of, including understanding of all terminology and units.
- h. Environmental Audits: components, procedures, analysis, follow-up; working with environmental inspectors.
- i. Environmental reporting procedures: routine reports and exceedences; spill clean up and containment.
- j. Environmental Management Systems, including ISO 14000 series; purpose, components and influence.
- k. Disposal and Reclamation: procedures and practices, including waste manifests.

## EXAMINATION 1B7

### 7. Inspection, Maintenance and Repair Practices

- a. Project management skills: identify and apply project management techniques to plant maintenance; managing maintenance contractors; long term service agreements.
- b. Predictive and preventive maintenance programs: components and management of; strategic/operational maintenance planning; run-to-failure, etc.; maintenance optimization.
- c. Root Cause Analysis: purpose, procedure.
- d. National Board requirements for owner inspection and quality control programs: components of a quality control program for vessel repairs; scope, authorities, interaction with jurisdictional inspectors, records and reporting procedures.
- e. Boiler repairs: procedures for typical repairs to boiler parts, including cracks, ruptured tubes, etc. (step-by-step management of such repairs); safety valve maintenance.
- f. Pressure vessel inspection and repair procedures (other than boiler) including cracks, corrosion etc.
- g. Pressure vessel repair: repair procedures for pressure vessels, including cracks, corrosion, etc.
- h. Pressure and power piping repairs: procedures for typical repairs to power plant piping.
- i. Non-destructive examination: describe, in depth, the selection, equipment, applications, procedures, and interpretation of the results for the non-destructive examination methods (dye penetrant, magnetic particle, eddy current, radiographic, ultrasonic, electro-magnetic acoustic transducer); manage contracts and interpret results with non-destructive examination contractors; ASME Code, Section V; identify / explain inspection techniques as per Code.
- j. Typical monitoring, inspection, and overhaul procedure for a large steam turbine, gas turbine, large multi-stage pump, and large alternator.
- k. Rotating equipment monitoring including turbovisory monitoring (overall expansion, differential expansion, differential temperature, critical speed, oil whip, oil whirl, eccentricity) and vibration analysis (vibration theory, measurement, interpretation of results).
- l. Oil analysis: purpose, theory and interpretation of oil analyses including lube oil and transmission oil.

## EXAMINATION 1B8

### 8. Business & Workforce Management

- a. Budgets: techniques in preparation, control, and reporting; components of plant and department (utilities/power plant) budgets; zero-based budgeting (advantages & disadvantages).
- b. Balance sheet and bottom-line accounting: knowledge / significance of terminology (e.g. dual entry, credits, debits, revenue, expenses, liabilities, assets, balance sheet, income statements, cash flow); financial statements; accruals.
- c. Inventory management techniques, such as: automated and computerized inventory systems; max / min; just in time.
- d. Cost benefit and financial analysis calculations; net present value and internal rate of return models; return on investment.
- e. Contracts: types of and control of; legalities of contracts; torts, legal and ethical liability, due diligence; force majeure.
  - f. Ethics and social responsibilities.
- g. Problem solving and decision making techniques/models.
- h. Leadership: styles, responsibilities; establishing and communicating plant/department goals; motivational models; communication practices; conflict resolution.
- i. Labour Relations: internal and external; legislation; working with union and non-union workforces; recognizing & enforcing special workforce legislation; contract / term employees; contingent workforce; human resource and capacity planning; conflict resolution techniques.
- j. Benchmarking: purposes, practices and techniques.
- k. Public relations: communication practices; typical areas of public concern.
- l. Recruitment, hiring, and interviewing techniques (including behavioral descriptive interviewing).
- m. Workforce development techniques: employee orientation; needs assessment; gap analysis; competency profiles; training methods and standards; performance management.
- n. change management techniques; psychology of change; promoting and managing workplace change; the manager's role as a change agent.
- o. Plant management structures and organization; inter-departmental relationships and responsibilities, workforce styles (promoting teamwork; elements of teamwork and self- directed work teams; supervised work teams).