ABSA
the pressure equipment safety authority

# REFERENCE SYLLABUS

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**For**

## FIRST CLASS
## POWER ENGINEER'S

## CERTIFICATE of COMPETENCY
## EXAMINATION

**AB-51a**

Edition 1, Revision 1, 2017-09

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## GENERAL INFORMATION

### Introduction:

The Standardization of Power Engineers Examination Committee (SOPEEC) has developed a First Class Power Engineer's Syllabus (SOPEEC Syllabus) which has been approved by the Association of Chief Inspectors (ACI) to be used across Canada.

As provided for under the *Power Engineers Regulation*, the Administrator in the pressure equipment discipline has established this Syllabus to identify the examination subjects for First Class Power Engineer's Certificate of Competency examinations. The subjects described in this Syllabus are identical to the subjects in the SOPEEC Syllabus.

The requirements to qualify for a First Class Power Engineer's Certificate of Competency examinations are outlined in the Power Engineers Regulation.

A candidate may write the First Class examinations at any scheduled examination after obtaining a Second Class Power Engineer's Certificate of Competency.

### Recommended Study Program:

It is recommended that, before undertaking this examination, the candidate completes the First Class Power Engineering Course offered through a recognized technical institute.

In addition to the foregoing course, it is recommended that the candidate becomes familiar with the publications listed in the "Reference Material for Power Engineering Students and Examination Candidates" which is obtainable from the various technical institutes or from the SOPEEC website. (www.sopeec.org)

### Application to Undertake Examination:

A candidate must submit an application and the prescribed fee at least twenty-one (21) days before the date of examination.

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## GENERAL INFORMATION

**Examination Instructions:**

The examination consists of eight (8) examination papers, each of 3½ hours duration. Each paper consists of seven (7) questions of which five (5) should be attempted. The examinations are all long-answer essay style questions. If more than five (5) questions are attempted, only the first (5) attempted will be marked.

To pass a First Class Power Engineer's Certificate of Competency examination, a candidate must obtain at least 65% of the total marks for each examination paper.

A candidate is allowed to use the following items in the examination room:

- The Safety Codes Act and Regulations under the Safety Codes Act;
- CSA B51, Boiler, Pressure Vessel and Pressure Piping Code;
- CSA B52, Mechanical Refrigeration Code;
- Extract for CSA B51 and CSA B52 Codes;
- ASME Boiler & Pressure Vessel Codes except for Sections VI and VII;
- The 2007 ASME Boiler & Pressure Vessel Code Academic Extract and Supplement produced by PanGlobal Training Systems;
- ASME/ANSI B31.1 Pressure Piping Code and B31.3 Process Piping Code;
- Handbook of Formulae and Physical Constants, Steam Tables and Refrigeration Tables are normally provided;
- A non-technical English language dictionary;
- Pens and pencils;
- Non-programmable calculator and
- Drawing instruments and drawing templates.

Note:

- The candidate must provide picture ID to the Examiner prior to the examination.
- No cell phone or any electronic communication devices are allowed to be brought into the examination room.
- The items referenced above must be shown to the Examiner for approval.
- No other reference material is allowed.
- The information in the 1983 Edition of the ASME Boiler and Pressure Vessel Code Academic Extract is outdated. Using this 1983 Edition of the ASME Extract for any power engineering examination is not recommended. Besides using the 2007 Edition of the ASME Academic Extract and Supplement, candidates may use the current edition of the ASME Code.

**Part "A" Paper 1**

**3 ½ Hours**
**Essay, Sketch & Describe Examination**

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.

**Part "A" Paper 2**

**3 ½ Hours**
**Essay, Sketch & Describe Examination**

2. **Principles of Applied & Fluid Mechanics**

Principles, terminologies, and advanced practical calculations involving:

a. Work, power, and efficiencies of lifting machines.

b. Potential and kinetic energy; energy conservation.

c. Impulse and momentum; conservation of momentum; angular momentum.

d. Centripetal force and acceleration; balancing rotating masses; stresses in flywheel; radius of gyration, simple harmonic motion.

e. Torque, angular momentum, moments of inertia; centroids.

f. Torsion; shaft stresses; shaft power.

g. Stress and strain; modulus of elasticity; Hooke's Law; restricted expansion; elastic strain energy.

h. Shear forces and bending moments in beams; modulus of section; beam deflection.

i. Static fluid pressures and forces; liquid columns; hydraulics; manometers.

j. Buoyancy.

k. Fluids in motion; equation of continuity; liquid energy; Bernoulli's Theorem; venturi and orifice flows; turbulent and laminar flow; Reynold's Number.

l. Nozzle designs and flows.

**Part "A" Paper 3**

**3 ½ Hours**
**Essay, Sketch & Describe Examination**

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.

**Part "A" Paper 4**

**3 ½ Hours**
**Essay, Sketch & Describe Examination**

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.

**Part "B" Paper 1**

**3 ½ Hours**
**Essay, Sketch & Describe Examination**

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

**Part "B" Paper 2**

**3 ½ Hours**
**Essay, Sketch & Describe Examination**

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.

**Part "B" Paper 3**

**3 ½ Hours**
**Essay, Sketch & Describe Examination**

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.

**Part "B" Paper 4**

**3 ½ Hours**
**Essay, Sketch & Describe Examination**

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).