



REFERENCE SYLLABUS

FOR

REVISED FIRST CLASS

POWER ENGINEER'S

CERTIFICATE of QUALIFICATION

EXAMINATION



**BOILER & PRESSURE VESSEL SAFETY PROGRAM
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Note: Please ensure that this is the appropriate reference syllabus for the examination applied for.

GENERAL INFORMATION

Implementation of the Revised 1st Class Syllabus

On July 01, 2006, a [revised First Class syllabus](#) for Power Engineer examinations will become effective.

This revised First Class syllabus will bring about a major change in the layout of the examinations.

This change is so substantial that examination papers already successfully completed can not be integrated into the revised Standardized First Class program.

To assist in this transition, the examinations for both the old and revised First class syllabi will be available and run concurrently for 5 (five) years. This will give examination candidates, who have already successfully completed at least one examination paper under the old First Class Syllabus, ample time to finish up their examinations and earn their certificate of qualification.

There will be a transition period from July 01, 2006 to January 01, 2007.

During this transition period, candidates will have the option of starting examinations under either the old syllabus or revised syllabus. By January 01, 2007, all applicants who have not successfully completed at least one examination paper under the old syllabus will have to write their examinations under the revised syllabus format.

If you have any comments, concerns, or questions concerning the revised first class syllabus please feel free to telephone Fred Golar, Certification & Licensing Analyst, at 604-660-6245 or email Fred.Golar@safetyauthority.ca .



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Introduction

This syllabus is intended to assist candidates studying for the First Class Power Engineers Certificate of Qualification Examinations. You may also access our web site at <http://www.safetyauthority.ca/> and the national examination web site at www.sopeec.org. The requirements to qualify for a First Class Power Engineer Examinations are outlined in the *Safety Standards Act* and applicable regulation.

Recommended Study Programme

It is recommended that, before undertaking a First Class Power Engineers Examination, the Candidate completes a First Class Power Engineers Course offered through either a British Columbia or national institute or technical college recognised by the provincial safety manager. In addition to the foregoing and in order to prepare for the examination, it is recommended that the Candidate becomes familiar with the pertinent publications listed in the *“Reference Material for Candidates of Power Engineer Examinations”*, which is obtainable from the various technical Colleges.

Reference Material for candidates of Power Engineer Examinations

The publications listed here are intended to supplement the course material for students studying for Fourth, Third, Second and First Class Power Engineers Certificate of Qualification Examinations. Inquiries regarding the above mentioned course material should be directed to the British Columbia Institute of Technology (BCIT) at telephone number (604) 432-8390 or the Energy and Natural Resources Department at Southern Alberta Institute of Technology (SAIT), telephone numbers (403) 284-8451 or 1-800-661-1268. The following listed publications can be ordered through most bookstores or directly from the publisher using the ISBN number. The code books listed are quite expensive, and therefore it is suggested that candidates use the codes located at their company library or at public libraries to obtain the necessary information.

It is strongly recommended that candidates complete an appropriate formal course of study offered by a recognised technical institute before undertaking to write any of the Standardized Power



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Engineer Examinations.

Candidates should be aware that the following list of publications are "Reference Material only" and although candidates do not have to purchase all these publications, they should have access to them. This list was compiled and approved by the Interprovincial Power Engineers Curriculum Committee (IPECC), and the Standardization of Power Engineers Examination Committee (SOPEEC). It is intended to assist candidates in achieving an excellent working knowledge of related topics.

Candidates who are entering into the Power Engineer field should realise that as they progress through their career it becomes necessary to build a good personal library. Candidates should start building their library at the Fourth Class level and regard their library as a necessary tool of their career. The Interprovincial Power Engineers Curriculum Committee (IPECC) would also like to remind candidates that they may also supplement their course material by purchasing periodicals and special reports from engineering and power related magazines.

Candidates should refer to the appropriate SOPEEC reference syllabus for the level of examination that they are preparing to attempt, as well as receive assistance from their local technical institute before commencing their studies.

Code Books

The following code books are used from the Fourth Class level to the First Class level. The Candidates must be aware that although there will be questions on all levels of examinations from the following codes, the difficulty and depth of questions will increase significantly as the candidate advances in levels. We wish to repeat at this point, these code books are quite expensive and some are revised on an annual basis. Therefore we recommend to students that they use code books from their company library or from public libraries to assist with their studies.

	1st	2nd	3rd	4th
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<i>Safety Standards Act</i> and applicable regulation	X	X	X	X
Canadian Regulation (C. S. A. B-51, For the Construction and Inspection of Boilers and Pressure Vessels (Latest edition) ISSN # 0317-5669	X	X	X	X
Canadian Regulations (C. S. A.) B-52, Mechanical Refrigeration Code, (latest Edition) ISSN # 0317-5669	X	X	X	X
A.S.M.E. Code. Section I Power Boilers (Latest edition) LCCCN # 56-3934	X	X	X	
A.S.M.E. Code Section IV Heating Boilers (Latest edition) LCCCN # 56-3934	X	X	X	
A.S.M.E. Code Section VI Recommended Rules for Care and Operation of Heating Boilers (Latest edition) LCCCN # 56-3934	X	X	X	X
A.S.M.E. Code Section VII Recommended Rules for Care and Operation of Power Boilers (Latest edition) LCCCN # 56-3934	X	X	X	X
A.S.M.E. Code Simplified (Power Boilers-Section 1- Latest edition) LCCCN # 56-3934	X	X	X	X

One of the most comprehensive and complete sets of books for Power Engineer Candidates to study from, is the Reed's Marine Engineering Series. It is recommended that Candidates start to compile this series from the beginning of their Power Engineer career. However, by the time a Candidate begins to study for the Second Class examination; they should have or have access to all of these books. This series does not cover all topics in the syllabus, however it is very useful.

	1st	2nd	3rd	4th



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Vol. 1 Mathematics ISBN # 0-947-637-90-7	X	X	X	X
Vol. 2 Applied Mechanics ISBN #0-901-281-55-7	X	X		
Vol. 3 Applied Heat ISBN #0-947-637-51-6	X	X		
Vol. 6 Basic Electrotechnology ISBN #0-900-335-96-3	X	X	X	
Vol. 7 Advanced Electrotechnology ISBN #0-901-281-65-4	X	X		
Vol. 8 General Engineering Knowledge ISBN #0-947-637-76-1	X	X	X	
Vol. 9 Steam Engineering Knowledge ISBN #0-900-335-58-0	X	X	X	X
Vol. 10 Instrumentation and Control Systems ISBN #0-947-637-86-9	X	X		

The following books will cover other topic areas in the syllabus from Fourth Class to First Class Power Engineering Exams.

	1st	2nd	3rd	4th
Applied Engineering Mechanics First Canadian, Jensen, Chenoweth Snail & Stassen-(Latest edition) ISBN#007-032-492-1	X	X		
National Board Inspection Code LCCCN #52-44738	X	X		
Applied Thermodynamics for Engineering Technologists. T.D. Eastop (Latest edition) ISBN #0-582-09193-4	X	X	X	
Blueprint Reading and Technical Sketching for Industry Thomas P Olivo (Latest edition) ISBN#0-8273-5077-5	X	X	X	



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Electric Circuits & Machines Lister, Golding (Latest edition) ISBN#0-07-552603-4	X	X	X	
Process/Industrial Instrumentation and Control Handbook-Considine (Latest edition) ISBN#0-07-012445-0	X	X	X	
Standard Handbook of Power Plant Engineering-Elliot, Chen, Swanehart (Latest edition) ISBN#0-07-019435-1	X	X	X	
Engineering Manual of Automatic Controls Purchased through Honeywell Offices I-P Edition	X	X	X	
Trane Air Conditioning Manual (780) 454-4905 The Trane Company	X	X	X	
Metals and How to Weld Them T.B. Jefferson, Gorham Woods (Latest edition) LCCCN# 54-2508	X	X	X	X
Betz Handbook of Industrial Water Conditioning (Latest edition) LCCCN# 62-21097	X	X	X	X
Steam Babcock and Wilcox (Latest edition) LCCCN# 92-074123	X	X	X	X

Note: Texts other than those listed above, which are current and are of a similar technical content may be considered equivalent.

Students preparing for Standardized Power Engineer Examinations will find the "Periodicals" and "Special Reports" from Engineering and Power related magazine(s) very beneficial not only for examination preparation, but also for current general engineering knowledge.

Excerpts:

Power Engineers, Boiler, Pressure Vessel and Refrigeration Safety Regulation



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Application for first class power engineer's certificate of qualification

13 (1) An applicant for a first class power engineer's certificate of qualification must hold a second class power engineer's certificate of qualification or a second class power engineer's standardized certificate of competency, and have been employed, while in possession of that certificate, for a period of not less than

- (a) 36 months as chief engineer of a power plant that has a boiler capacity that exceeds 500 m²,
- (b) 36 months as an assistant chief engineer of a power plant that has a boiler capacity that exceeds 1000 m²,
- (c) 36 months as a safety officer for the purposes of this regulation,
- (d) 48 months as a shift engineer of a power plant that has a boiler capacity that exceeds 500 m², or
- (e) 48 months as an assistant shift engineer of a power plant that has a boiler capacity that exceeds 1 000 m².

(2) If an applicant has successfully completed a first class power engineering course that has been approved by a provincial safety manager, the required periods of employment referred to in subsection (1) are reduced by 12 months.

(3) If an applicant holds an engineering degree acceptable to a provincial safety manager the required period of employment for the positions and types of plants set out in subsection (1) is 24 months.

What a first class power engineer may do

14 A first class power engineer's certificate of qualification entitles the holder to be chief engineer of any plant.



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Part "A" Examination

**First Paper
Morning Session
3 ½ Hours**

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.



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Part “A” Examination

**Second Paper
Afternoon Session
3 ½ Hours**

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.



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Part “A” Examination

**Third Paper
Morning Session
3 ½ Hours**

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.



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Part “A” Examination

**Fourth Paper
Afternoon Session
3 ½ Hours**

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.



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Part “B” Examination

**Fifth Paper
Morning Session
3 ½ Hours**

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.



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Part “B” Examination

**Sixth Paper
Afternoon Session
3 ½ Hours**

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.



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Part “B” Examination

**Seventh Paper
Morning Session
3 ½ Hours**

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 turbosvisory 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.



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Part “B” Examination

**Eighth Paper
Afternoon Session
3 ½ Hours**

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.)