1st Class Power (Operating) Engineer Certification and Examination Guide

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Syllabus

The following SOPEEC syllabus has been adopted by TSSA and provides the subject matter upon which a candidate will be examined, and all related topics of study.

1A-1

***A*. 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; effects 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.

1A-2

***B*. 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.

1A-3

***C*. 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.

1A-4

***D*. 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:
   i. boiler efficiency.
   ii. gas turbine and combined cycle efficiency, including turbine inlet cooling.
   iii. power generation efficiencies.
   iv. 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.

1B-1

***E*. 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.
   API 510, 570 – Pressure Vessel Inspection Codes.

1B-2

F. **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 exceedances; 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.

1B-3

G. **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.

1B-4

H. **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.)

Certification Information

Qualifying Experience Time:
Qualifying experience time served shall be in a plant that is attended by an Operating Engineer. Please refer to Table 8 of the Operating Engineers Regulation for plant rating/capacity, Table 8 in the Director's Order, or the Alternate Table 8 in the Minister's Order.

- The practical operating training requirement for first-class certification is **4,800 hours** as a chief operating engineer in a second-class plant; or **4,800 hours** as a second-class operating engineer in a first-class plant.

- The practical operating time requirement for first-class certification is **3,360 hours** for candidates who have successfully completed a full-time TSSA "approved-for-time-reduction" first-class Operating Engineer program.
- The certification process will require a minimum of 33% Qualifying Experience Time in the operation of boilers at a registered plant. There will be a maximum of 33% of experience permitted on the maintenance of regulated equipment, and the remainder of the experience requirements can be any combination of the technologies.

Qualifying Experience attained in a Canadian Jurisdiction outside Ontario
Qualifying experience time toward Operating/Power Engineering attained in a Canadian jurisdiction outside Ontario must be attained in the operation and management of boilers at least of the type and capacities indicated in Table 3 of the Operating Engineers Regulation, Ontario Regulation 219/01. The following information must be demonstrated to TSSA in a request for certification:

- A letter addressed to the candidate, on company letterhead and signed by the Chief Operating/Power Engineer, indicating the number of boilers trained on, the boiler types, boiler manufacturer, boiler(s) pressure, capacities in Kilowatts or Boiler Horsepower and when the experience was gained (dates). The Chief Operating/Power Engineer must indicate their certificate number and classification, as well as their formal position and contact information (i.e. telephone number, email address, etc.).

Training Providers

As a convenience for students, TSSA has compiled a list of organizations, and/or institutions currently offering 'TSSA Approved for Time Reduction', training. The list can be found in the 'Operating Engineer section', of our TSSA Corporate website located at www.tssa.org.

It is recommended that before undertaking examinations, the candidate complete a First-Class Power Engineering Course offered through a recognized Technical Institute or Training Provider.

Note: The process for 'TSSA approval' began in December of 2001. Trainers who are successful in obtaining TSSA approval to offer "practical-time-reduction-training" will be identified accordingly by being listed on TSSA's Training Providers list.

Examination Information

There are eight (8) essay style examinations that must be written that are 3 ½ hours in duration.

- The 1A-1, 1A-2, 1A-3, 1A-4, 1B-1, 1B-2, 1B-3 & 1B-4 examinations require the candidate to answer any five (5), of the seven (7) questions. Only the first five (5) questions attempted will be marked. Read the introduction carefully as some examinations have mandatory questions, which must be attempted.

The minimum passing mark for each examination is 65%, rewrites are allowed after 60 days.

Note: effective June 14, 2021, Operating Engineers/Operators will have the option to pursue exams and meet the experience requirements concurrently or at their own pace.

When answering examination questions, the candidate is expected to give sufficient information to warrant the marks assigned. For questions involving calculations, the candidate is expected to state the formula, insert given data, work through the steps and state their answer with the correct units in an appropriate closing statement.

The examination candidate is expected to write legible, neat, and in pen. Sketches or drawings are to be in pencil and properly labeled. Rulers and (drawing) templates are to be used as neatness is considered in the marking scheme.

Examinations may be written at either a Ministry of Labour, Training and Skills Development exam centre or at a TSSA approved examination centre. To locate nearest centre, refer to “Register for an Exam” listing at www.tssa.org.

Examination security will be strictly enforced. The examination administrator or invigilator reserves the right to revoke an examination at any time if the examination candidate is found to be in violation of the TSSA examination or Ministry of Training, Colleges and Universities procedures. The examination candidate will be subject to further investigation, which may result in the revocation of an authorization or restrictions may be applied to all future examinations.

TSSA is no longer offering review of essay examinations.

Important: Candidates for any class of certification as an Operating Engineer or Operator who have passed the required examinations, or any parts thereof, MUST obtain their certificate of qualification within five (5) years of such passing or re-writing of the examination will be required.

Suggested Study Materials

It is recommended that the candidate becomes familiar with the publications listed in the Reference Material for Power Engineering Students and Examination Candidates, listed below:

- **Technical Standards & Safety Act,** the **Operating Engineers Regulation** and the **Boilers and Pressure Vessels Regulation**; along with all pertinent **Director’s Orders**, are posted on TSSA Website and can be printed off for use in your studies.
- **‘1st class Power Engineering’** available from PanGlobal Publishing
- **Reed’s Marine Engineering Series**
- **“Metals & How to Weld Them”** by Jefferson & Woods
- **2007 ASME Boiler and Pressure Vessel Code** – Academic Extract contains materials from Sections I, II, IV and VIII of the 2007 ASME Boiler and Pressure Vessel Code and is available from PanGlobal Publishing
- **CSA B51: “Boilers, Pressure Vessel and Piping Code”**
- **CSA B52: “Mechanical Refrigeration Code”**
- **2007 ASME Extract**
- **ASME Section I:** Rules for the Construction of Power Boilers Extract
- **ASME Code Simplified**
- **ASME Section VI:** Recommended Guidelines for the Care and Operation of Heating Boilers
- **ASME Section VII:** Recommended Guidelines for Care and Operation of Power Boilers
- **ASME Section IX:** Welding and Brazing Qualifications
- **Stationary Engineering, Fourth Edition,** 2008, by American Technical Publishers, Inc. Author(s) Fredrick M. Steingress, Harold J. Frost and Daryl R. Walker
- **Boiler Operator’s Workbook, Fourth Edition** 2008, by American Technical Publishers, Inc. Author R. Dean Wilson

- **Commercial and Industrial Wiring** 2009, by American Technical Publishers, Inc. Author Randy Barnett

Additional engineering text and reference materials are available from a broad range of authors and publishers and no specific text or reference material beyond the Act, Regulations and Codes should be considered as official. More information is made available at www.sopeec.org.

Obtaining Certificate

Upon successful completion of the 1st class examinations and the completion of the required practical operating experience, the candidate may apply to TSSA for their **"Certificate of Qualification"** by submitting:

- A completed '*Application for an Ontario Certificate of Qualification as an Operating Engineer or Operator';*which includes the **'Testimonial of Qualifying Experience';** attesting to the experience obtained and,

- The certification fee, please view the **OE Fee schedule** from the Fee Schedule.

  For a copy of the application, visit Certification: Operating Engineer