ABSA
the pressure equipment safety authority

REFERENCE SYLLABUS

For

SECOND CLASS
POWER ENGINEER'S

CERTIFICATE of COMPETENCY
EXAMINATION

AB-52a

Edition 1, Revision 8, 2024-11

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GENERAL INFORMATION

Introduction

The Standardization of Power Engineers Examination Committee (SOPEEC) has developed a Second 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 Alberta *Power Engineers Regulation*, the Administrator in the pressure equipment discipline has established this Syllabus to identify the examination subjects for Second 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 Second Class Power Engineer's Certificate of Competency examinations are outlined in the Power Engineers Regulation.

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

Recommended Study Program:

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

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 ten (10) days before the date of examination.

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Examination Instructions:

Effective January 1st, 2025, the 2A1 examination will become multiple choice joining the 2A2, 2A3, 2B1, 2B2, and 2B3 examinations in the multiple choice format. Each paper is 3 hours in duration and consist of 100 multiple choice questions each. Please check the SOPEEC website at http://www.sopeec.org for more details.

To pass a 2nd Class Power Engineer's Certificate of Competency examination, a candidate must obtain at least 65% of the total marks allotted 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 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.

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Part "A" Paper 1

3 Hours
Multiple Choice

1. ASME Code, Sections I & VIII, Calculations:

Design values to be computed for the following boiler and pressure vessel parts:

a. Cylindrical components; dished heads; unstayed flat heads, formed heads, shells and welded covers.

b. Openings and compensation: determine if compensation for openings in shells, headers and heads are required.

c. Stayed surfaces: dimensions and locations of staybolts, ligaments and braced surfaces.

d. Pressure relief valves: size and capacity.

e. Firetube Boilers:

i. Combustion chambers and furnaces: corrugated furnaces; and general knowledge excluding calculation of plain circular, circular flues; and reinforced furnaces.

ii. Stayed surfaces: maximum spacing of stays; areas of heads to be stayed; stresses in diagonal stays.

2. Industrial Administration:

a. Legislation: a thorough knowledge of the jurisdictional Act and the Regulations under the Act.

b. Installations: factors and codes governing plant designs and layouts; contract specifications; working knowledge of the engineering and administration involved in plant erection; practical modifications of existing plant.

c. Management:

i. Functions and objectives of management.

ii. Personnel management: selection of staff; personnel training; motivating personnel; disciplining employees.

iii. Planning; decision making; report writing.

iv. Plant maintenance; inspection; budgeting.

v. Safety programs.

3. Applied Mechanics:

a. Velocity and acceleration: speed; linear velocity and acceleration; projectile motion, angular velocity and acceleration; relative and absolute velocity.

b. Mass, motion and inertia: force of gravity; weight; mass inertia; accelerating force; momentum.

c. Work, power and energy: work, graphical representation; indicated and brake horsepower; potential and kinetic energy; conservation of energy; flywheel.

d. Torque and angular motion: moment of inertia; radius of gyration; work done by torque.

e. Motion in a circular path: centripetal acceleration; centripetal and centrifugal force; balancing of rotating masses; governors.

f. Friction: coefficient of friction; frictional force; motion on horizontal and inclined planes; the screw thread; transmission of power by belt drives.

g. Moments: moments of forces; couple; centroids and second moments of area.

h. Stress and strain: modulus of elasticity; restricted expansion.

i. Shearing forces and bending moments: sign conventions; conditions of equilibrium; simply supported beams and cantilevers; concentrated and distributed loading; mathematical and graphical solutions for shearing force and bending moment diagrams.

j. Torsion: fundamental torsion equation; relationship between torque, stress and horsepower; maximum and mean torque; coupling bolts.

k. Pressure of liquids: density; specific gravity; pressure at any depth; centre of pressure; displacement.

l. Flow of liquids: pressure head; Bernoulli's law; Venturi meter; flow through orifices.

4. Thermodynamics:

a. Heat and measurement of heat: temperature scales; absolute temperature; units of heat and their relationship; specific heat; water equivalent; sensible and latent heat; heat mixtures.

b. Expansion of solids and heat transfer: linear, surface and volumetric expansion; conduction, convection and radiation.

c. Work and heat: mechanical equivalent of heat; laws of thermo-dynamics; Boyle's and Charles' Laws; general gas law; characteristic constant of a gas; specific heats of gases; thermal efficiency.

d. Expansion and compression of gases: Dalton's Law of partial pressures, adiabatic, isothermal and polytropic; ratios of expansion and compression; work done during expansion and compression.

e. Thermodynamics of steam: steam tables; saturated and superheated steam; dryness fraction; specific volume; specific heat of superheated steam; heat mixtures; throttling and separating calorimeters; internal energy of steam, enthalpy.

f. Entropy: entropy of water, evaporation and superheated steam; temperature-entropy diagrams and charts; computations of entropy values.

g. Practical Cycles:

i. Practical cycles: Rankine; Otto; Diesel; Brayton, thermal efficiencies; pressure-volume and temperature-entropy diagrams.

ii. Energy flow calculations; efficiency limits of heat engines, boiler and plant efficiencies, heat balance testing.

5. Metallurgy:

a. Non-ferrous metals: properties, composition and uses; copper; brasses; bronzes; aluminum; white metal.

b. The structure of metals: atoms; elements; crystalline structure of metals; grains and grain boundaries, metallographic examination.

c. Alloying elements in iron; iron-carbon equilibrium diagram; alloy steels; stainless steels and high-chromium alloys; cladding steels.

d. Heat treatment of metals: normalizing; annealing; spheroidizing; hardening; tempering; quenching.

e. Welding symbols

f. Metallurgical applications/specifications to power plant piping and tubing

g. Electrochemistry principles applied to corrosion, corrosion forms, control method, testing, monitoring, prevention and failure analysis (effective July 1, 2011).

6. Testing of Materials:

a. Procedures and interpretations affecting tensile, hardness and impact tests; forms of specimens tested.

b. Mechanical, physical and thermal properties of ferrous metals: creep resistance, corrosion resistance and fatigue tests.

c. Weldment defects: dimensional defects; structural discontinuities; defective properties.

d. Nondestructive testing: visual inspection; magnetic particle inspection; liquid penetrant testing; proof tests; leak tests, ultrasonic, radiography, acoustic emission.

7. Boilers:

a. Steam generator design considerations.

b. Methods of heat transfer; circulation; steam generator ratings.

c. Specialized boiler designs and applications.

d. Types and applications of firetube and watertube boilers/steam generators.

e. Boiler fittings, including safety devices, drum internals, soot blowers.

f. Boiler details: waterwalls; superheaters; desuperheaters; attemperators; economizers; air heaters; blow-down systems; flash tanks; steam separators.

g. Methods of installation and support: foundations; settings; methods of tubing; top drum erection; shop and field assembly.

h. Insulation: duct and baffle arrangements; boiler casings.

i. Operation: start up and shut down; boiling out; drying out refractory; lay-up procedure; safety precautions.

j. Maintenance; mechanical and chemical cleaning; inspection; upkeep and repairs; hydrostatic test; safety precautions.

k. Boiler Inspections: detailed procedure for complete inspection of a large boiler, including water side, fire side, and auxiliary equipment; thermal radiation techniques; inspection records and reporting procedures; liaison procedure with boiler inspector; involvement of other personnel in inspection (engineering staff, operators); inspection equipment; inspection safety.

8. Pumps:

a. Practical Applications of pumping theory for power plants;

b. Installation; maintenance; operation/control.

c. Constructional details including: impeller types; seal selection; shaft alignment; thrust balancers; tachometers.

d. Boiler feed pump re-circulation control.

9. Water Treatment:

a. Water and its impurities.

b. Methods of feedwater treatment: subsidence; coagulation; filtration; oil removal; lime-soda softening; hot process phosphate softening; sodium and hydrogen zeolite softening; silica removal; demineralization; deaeration; evaporation; electro-dialysis and electro-deionization (ED / EDI); reverse osmosis (RO); microfiltration.

c. Internal treatment of boiler water: control of scale, foam, embrittlement, return line corrosion; chelating agents; sludge conditioning; pH control; deaeration; carryover; blowdown; chemical feed systems; silica turbine blade deposits.

d. Analytical methods and equipment:

i. Instruments: embrittlement detectors; steam purity; total solid meters; methods of steam sampling; measurement of pH.

ii. Water analysis and interpretation of analytical results.

e. Cooling water treatment; slime and algae control, corrosion control.

f. Industrial waste treatment: effects caused by waste discharge; mechanical, chemical and biological methods of waste treatment.

g. Potable Water treatment and testing.

10. Heat Engines and Prime Movers:

a. Steam Turbines:

i. Applications of operating principles: impulse and reaction turbines, classifications.

ii. Construction: casings; rotors; dummy pistons; blading; diaphragms; glands; seals; flexible couplings; bearings; thrusts.

iii. Details: turning gears; drains; rotor adjustment; dynamic and static balancing; critical speed; lubricating oil systems; jacking oil pump; piping; reducing gears; expansion and anchoring.

iv. Control: governors; governor systems; control valves; grid type extraction valves; casing relief valves; overspeed trips; turbine supervisory equipment.

v. Operation: starting up and shutting down; normal operation; flow diagrams; efficiencies.

vi. Maintenance: repairs; shaft alignment; bearing; thrust, blade and packing clearances; blade fouling and erosion; cleaning after erection.

vii. Theory: nozzles; velocity diagrams; angle of entry and velocity calculations; work done on blades and blade characteristics.

viii. Condensing Equipment

a. Condensers: types and constructional details; backwashing and cleaning; leak testing.

b. Condenser ancillary equipment: air ejectors; cooling water systems; intakes and intake screens; cooling towers and ponds; atmospheric exhaust valves; circulating pumps; condensate pumps.

b. Internal Combustion Engines:

i. Applications: two and four stroke, oil burning, gas and dual-fuel.

ii. Fuels: classification; properties; impurities; methods of purifying and clarifying; injection systems; ignition systems; scavenging and supercharging arrangements.

iii. Operation and maintenance: causes and prevention of incomplete combustion; starting up and shutting down: prevention of crankcase explosions; crankcase safety fittings; piston and cylinder troubles; repair and replacement of worn or broken parts.

iv. Cooling: piston and jacket cooling water systems; cooling water treatment and removal of deposits; lubricating oil systems.

c. Gas Turbines:

i. Applications of operating principles; types of gas turbines.

ii. Open and closed cycle systems; regeneration; intercooling and reheating.

iii. Gas turbine applications: dual shaft machines; free-piston gas generators, combined cycle.

iv. Construction: rotors; blading; compressors; combustors: combustion chambers.

v. Operation and control: starting up and shutting down; normal running procedures; control systems; safety devices.

11. Lubrication:

a. Plant lubrication programme: lubrication survey; types of lubricating systems, air compressor, gas turbine, internal combustion engine, steam turbine; lubricating oil / governing/seal oil systems.

b. Engine Lubricating oil maintenance: causes of deterioration; additives; oil purification equipment.

c. Applications of ball and roller bearings and their lubrication; bearing seals.

12. Piping:

a. Piping material identification and selection, appropriate Code procedures, inspection, leak tests.

b. Strength of piping; high temperature effects.

c. Support; expansion allowances; cold springing; drainage; insulation.

d. Theory and effects of water hammer.

e. Layouts of piping in Power and Pressure Plants.

13. Mechanical Drawing:

a. Pictorial drawing; geometrical constructions.

b. Orthographic, auxiliary, isometric and oblique drawings.

c. Sectioning and dimensioning.

d. Flow diagrams; piping drawings; charts.

e. Industrial Drawings, types and interpretation.

14. Power Plant Systems

a. Feed water systems; layout and operation. regenerative feed heating cycle; closed feed systems; feed heaters; deaerators.

b. Steam Piping systems.

c. Fuel systems; layout and operation.

d. Steam Condensate system; layout and operation.

e. Cooling water systems; layout and operation.

f. Waste handling systems; layout and operation.

g. Integration of powerplant water systems.

15. Control Instrumentation:

a. Electrical and Electronic Pressure measuring devices and component placement/installation.

b. Electrical and Electronic Temperature measuring instruments and component placement/installation.

c. Flow measurements with differential pressure flow meters:

   i. Primary elements: orifice plate; flow nozzle; venturi tube; pitot tube; flow-nozzle pipes.

   ii. Indicating mechanisms: manometer; ring balance; force balance; electric.

   iii. Component placement/installation.

d. Liquid level measurement and control and component installation: ball-float; displacement-type; hydrostatic head; electric and pneumatic level transmission; electric and magnetic type level-limit devices; remote water-level indicators.

e Final control elements: types and flow characteristics of control valves; construction details of control valves; power operators ---solenoid, pneumatic-diaphragm, power cylinder, electric motor.

f. One, two and three element boiler feedwater control systems.

g. Superheated/reheated steam temperature control; steam pressure reducing and desuperheating control systems.

h. Modes of automatic control; two position (; proportional; proportional-plus-reset and proportional-plus-reset-plus-rate.

i. Control Systems: Distributed Control Systems, Programmable Logic Controller,

16. Fuels and Combustion:

a. Combustion chemistry; chemical analysis of fuels.

b. Fuels: classification; heat values; properties; fuel handling;

c. Combustion: bomb calorimeter; analysis of flue gases; quantity of air required for combustion; draft calculations.

d. Furnace types and designs; refractories; arches; separately fired reheat furnace.

e. Firing equipment: pulverizers; oil and gas burners; storage and heating of oil; ash and slag disposal; ash fusion temperature, fuel burning systems.

f. Draft: systems and equipment.

g. Combustion Control:

i. Classification of systems; methods of operation; pneumatic, electric and hydraulic mediums; control systems and installations for gas, oil and coal firing.

ii. Flue-gas analysis; CO_2, O_2 and combustibles recorders.

iii. Combustion safeguards: purge and fan-failure interlock systems; flame-failure control systems; photo electric tubes; rectifier rods.

iv. Packaged boiler-control systems: programming sequence; limiting devices and alarms.

17. Environmental Protection

a. Monitoring equipment and troubleshooting procedures: continuous emissions monitoring systems; wastewater monitoring; data interpretation; troubleshooting

b. Specific environmental controls and equipment: integrated environmental controls; technical knowledge and efficient operating practices and monitoring for the following:

i. flue gas desulphurization
ii. selective catalytic reduction
iii. NOx reduction
iv. flue gas chemical conditioning
v. baghouses and precipitators

c. Significance of measured parameters:

i. Air quality particulates, stack opacity, SO_2 and NOx concentration and mass flow, mercury, O_2, CO_2, hydrocarbons
ii Wastewater - iron, phosphorous, biological oxygen demand, chemical oxygen demand, hydrocarbons, temperature, flow, pH, nitrogen

18. Electrotechnology:

a. A.C. Theory:

i. The sine wave: generation of an alternating electromotive force; root mean square values; vector representation of sinusoidal quantities, peak, peak to peak.

ii. Resistance, inductance and capacitance in single-phase A.C. circuits; inductive reactance; capacitive reactance, impedance, resonance.

iii. Power in A.C. circuits; true and apparent power; practical importance of power factor; power factor correction.

iv. Three-phase circuits: delta and star connected alternators and loads, current and voltage relationships; three-phase power.

b. D.C. Machines:

i. Generators: principle of operation; construction; commutation; armature reaction; interpoles; compensating windings; lap and wave wound armatures; generator types and characteristics; parallel operation; voltage regulation; theory of self-excitation; efficiency and power losses; selection of generators and applications; parallel operation; ratings.

ii. Motors: principle of motor action; torque development; Fleming's left-hand rule; back electromotive force: voltage, current and speed computation; motor types and characteristics; starting arrangements; dynamic and regenerative braking; speed control; efficiency and power losses.

c. A. C. Machines:

i. Alternators: types; construction of stators, rotors and exciters; stator windings; relationship between speed, frequency and number of pole pairs; cooling systems; shaft sealing systems; voltage regulators; synchronizing; parallel operation; power factor control, voltage drops in armatures; rating, efficiency and power losses.

ii. Single-phase motors: universal, shaded pole and split-phase types; repulsion-start and reluctance-start types; capacitance starting method.

iii. Polyphase induction motors; principle of operation; rotating magnetic field; slip and rotor speed; stator and rotor construction; starting methods.

iv. Synchronous motors: general facts concerning synchronous motors; stator and rotor construction, starting methods.

v. Transformers: principle of transformer action; ratings; efficiency and losses; short and open circuit tests; types of construction; methods of cooling; connections; parallelling; instrument transformers.

vi. Protection of electrical systems: alternator stator and rotor protection devices; motor protection devices; transformer safety fittings.

vii. Circuit-protective equipment; interrupting capacity; fuses; switches; circuit-breakers; relays.

19. Principles of Air and Gas Compression:

a. Applications of air and gas compression: effects of altitude, temperature, humidity.

b. Reciprocating, axial, centrifugal and rotary compressors: operation, applications; construction; regulation and control; drive selection criteria and preventive maintenance.

c. Ancillary equipment: valves; coolers; receivers; oil and water separators; filters; unloaders; safety/relief valves; instruments; piping layouts, dryers.

20. Industrial/Commercial Refrigeration:

a. Applications of refrigeration: compression and absorption systems; thermoelectric refrigeration; hermetic cycles; cascade systems; heat pump systems.

b. Refrigerating plants: types; layouts; installation details.

c. Plant equipment: compressors; condensers; evaporators; liquid receivers; oil separators; absorbers; generators; heat exchangers; rectifiers; driers; scale traps; piping and fittings; cold room construction.

d. Operation of refrigerating plants: starting up and shutting down; charging; hand and automatic purging; automatic expansion valves; compressor lubrication; brine solutions; leak testing; trouble shooting.

e. Safety and control: Code requirements; safety fittings; compressor and system instrumentation and controls; cooling water system controls.

f. Computations of capacities and performances of refrigerating plants; ideal and practical refrigerant cycles; theoretical piston displacement; heat pump effect; theoretical power; pressure-enthalpy charts.