



REFERENCE SYLLABUS

FOR

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



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by a recognised technical institute before undertaking to write any of the Standardized Power 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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Safety Standards Act 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
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		



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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	
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,				



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Swanepharp (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

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



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- (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**

I. Applied Mechanics

- A. Velocity and acceleration: speed, linear velocity and acceleration; angular velocity and acceleration; relative and absolute velocity; S.I. (Metric) Units.
- 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 of annular ring and disc; radius of gyration; work done by torque.
- E. Impulse and momentum: conservation of momentum; collision of elastic bodies; angular momentum.
- F. Motion in a circular path: centripetal acceleration; centripetal and centrifugal force; balancing of rotating masses; stresses in flywheel rims; governors; simple harmonic motion.
- G. Friction: coefficient of friction; frictional force; motion on horizontal and inclined planes; the screw thread; transmission of power by belt drives.
- H. Stress and strain: tensile, compressive and shear; diagrams; modulus of elasticity; Hooke's Law; restricted expansion; factor of safety; elastic strain energy.
- I. Shearing forces and bending moments: convention of signs; conditions of equilibrium; simply supported beams and cantilevers; concentrated and distributed loading; mathematical and graphical solutions for shearing force and bending moment diagrams.
- J. Moments: moments of forces; couple; centroids and second moments of area, mathematical proof.



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- K. Stresses in beams: neutral axis; modulus of section; fundamental bending equations; deflections in beams.
- L. Torsion: fundamental torsion equations; shaft stress, torque, and power transmission; coupling bolts; close-coiled helical springs.
- M. Pressure of liquids: density; specific gravity; pressure at any depth; centre of pressure; resultant thrust; displacement.
- N. Flow of liquids: pressure head; Bernoulli's Law; Venturi meter; flow through orifices; friction in pipes; impact of water jet.

II. A.S.M.E. Codes, Calculations

A. Section I

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

- i. Cylindrical components; dished heads; unstayed flat heads and covers.
- ii. Openings in shells, headers and heads: compensation required; strength of compensation; limits of metal available for compensation.
- iii. Stayed surfaces: dimensions and locations of stay bolts; ligaments.
- iv. Safety valves and safety relief valves: size capacity.
- v. Firetube boilers; combustion chambers; furnaces and flues; stayed surfaces and stays.

B. Section VIII

Design values to be computed for the following pressure vessel parts.

- i. Shells, formed, heads, unstayed and flat heads and covers.
- ii. Vessel openings and reinforcements.
- iii. Braced and stayed surfaces.



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Part “A” Examination

**Second Paper
Afternoon session
3 ½ Hours**

I. Thermodynamics

- A. Temperature measuring devices: temperature measuring theory; bimetal and filled-system thermometers; thermocouple and radiation pyrometers; resistance thermometers; thermistors; temperature measurement by colour; instrument calibration and installation.
- B. Heat and measurement of heat: temperature scales; absolute temperature; units of heat and their relationships; S.I. (Metric) Units; specific heat; water equivalent; sensible and latent heat; heat mixtures.
- C. Expansion of liquids and solids, heat transfer: linear, surface and volumetric expansion; conduction; convection and radiation.
- D. Work and heat: mechanical equivalent of heat; laws of thermodynamics; Boyle's law; Charles' laws; Dalton's law; general gas law; characteristic constant of a gas; specific heats of gases; thermal efficiency.
- E. Expansion and compression of gases; adiabatic, isothermal and polytropic; ratios of expansion and compression; work done during expansion and compression; mathematical proofs of formulae for work done during polytropic and isothermal expansion and compression.
- F. Thermodynamics of steam: steam tables; saturated and superheated steam; heat mixtures; throttling and separating calorimeters; internal energy of steam.
- G. Entropy: entropy of water, evaporation and superheated steam; temperature-entropy diagrams and charts; computations of entropy values.
- H. Combustion: bomb calorimeter; analysis of flue gases; quantity of air required for combustion; draft calculations.
- I. Rankine cycle; boiler and plant efficiencies; heat balance testing.



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Part “A” Examination

**Third Paper
Morning session
3 ½ Hours**

I. Boilers

- A. Evolution and development of the modern steam generator.
- B. Boiler classification; types of boilers; applications; design details; steam generator ratings.
- C. Methods of heat transfer; steam generation and boiler circulation; steam separation and purity.
- D. Boiler fittings, including safety devices, drum internals and soot blowers.
- E. Boiler details; superheaters and reheaters; desuperheaters; attemperators; economizers; water wall arrangements; air heaters; blow-down systems; flash tanks; steam separators.
- F. Methods of installations and support: foundations; settings; methods of tubing; top drum erection; shop and field assembly.
- G. Maintenance: mechanical and chemical cleaning; inspection; upkeep and repairs; hydrostatic test; safety precautions.

II. Control Instrumentation

- A. Modes of automatic control; two position; proportional; proportional-plus-reset.
- B. Pressure measuring devices: Bourbon-tubes, helical and spiral elements; diaphragm elements; monometers; inverted-bell elements; spring and bellows; calibration and installation of pressure measuring instruments.
- C. Flow measuring devices: primary elements for differential pressure flowmeter; mechanical and electric meter bodies; installation of differential pressure flowmeter; variable-area flowmeter; positive-displacement flowmeter; open-channel flow measurement.
- D. Liquid level measurement and control: level measuring instruments; electric and pneumatic level transmission; electric and magnetic-type level-limit devices; remote water level indicators.



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- E. Final control elements: types and low-lift characteristics of control valves; construction details of control valves; power operators, solenoid, pneumatic-diaphragm, power cylinder, electric motor.
- F. Boiler feedwater control system.
- G. Superheated steam temperature control; steam pressure reducing and desuperheating control systems.

III. Piping

- A. Piping materials and methods of manufacture.
- B. Commercial pipe sizes; symbols and identification for piping and fittings; S.I. (Metric) Units.
- C. Strength of piping; high temperature effects.
- D. Methods of connecting piping; appropriate Code procedures; inspection; leak tests.
- E. Support; expansion allowances; cold springing; drainage; insulation.
- F. Theory and effects of water hammer.
- G. Layouts of piping in Power and Pressure Plants.



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Part "A" Examination

**Fourth Paper
Afternoon session
3 ½ Hours**

I. Fuels and Combustion

- A. Combustion chemistry; chemical and analysis of fuels.
- B. Fuels: classification; heat values; properties; fuel handling; fuel burning systems; S.I. (Metric) Units.
- C. Furnace types and designs; refractories; arches; separately fired reheat furnace.
- D. Firing equipment: pulverisers; oil and gas burners; storage and heating of oil; ash and slag disposal; ash fusion temperature.
- E. Draft: F.D. and I.D. fans; gas by-pass and recirculation.
- F. Control Instrumentation:
 - i. Classification of systems; methods of operation; pneumatic, electric and hydraulic media; control systems and installations for gas, oil and coal firing.
 - ii. Flue-gas analysis: Orsat; Carbon dioxide recorders; oxygen analysis; smoke density recorders.
 - iii. Combustion safeguards: purge and fan-failure interlock systems; flame-failure control systems; photo electric tubes; ultra violet tubes; rectifier rods.
 - iv. Packaged boiler-control systems: programming sequence; limiting devices and alarms.

II. 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.



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- C. Internal treatment of boiler water: control of scale, foam and embrittlement; chelating agents; sludge conditioning; pH control; deaeration; carryover; blowdown; chemical feed systems; steam and return line corrosion; neutralizing and filming amines; silica turbine blade deposits.
- D. Analytical methods and equipment:
 - i. Instruments: embrittlement detectors; steam purity; total solids meters; methods of steam sampling; measurement of pH; conductivity measuring systems.
 - ii. Water analysis and interpretation of analytical results.
- E. Cooling water treatment; slime and algae control.
- F. Industrial waste treatment: effects caused by waste discharge; mechanical, chemical and biological methods of waste treatment.

III. Pumps

- A. Theory of pumping; pump performance characteristics.
- B. Uses and selection of pumps.
- C. Types: centrifugal; rotary; gear; reciprocating; heavy duty pumps used in gas processing plants.
- D. Installation; maintenance; operation.
- E. Constructional details including: impeller types; packing boxes; mechanical seals; shaft alignment; thrust balancers; tachometers.
- F. Boiler feed pump re-circulation control.
- G. Feed and circulation systems; design and operation; feed heaters; drain coolers.



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Part "B" Examination

**Fifth Paper
Morning session
3 ½ Hours**

I. Prime Movers

- A. Thermodynamic Cycles
 - i. Ideal cycles: Carnot; Rankine; Otto; Diesel; Brayton; thermal efficiencies; pressure-volume and temperature-entropy diagrams; S.I. (Metric) Units.
 - ii. Energy flow calculations; efficiency limits of heat engines.
- B. Steam Turbines
 - i. Principles of operation of impulse and reaction turbines; classification of steam turbines.
 - 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; casing expansion and anchorage.
 - iv. Control: governors; governor systems; control valves; grid type extraction valves; casing relief valves; grid type extraction valves; casing relief valves; over-speed trips; turbine supervisory equipment.
 - v. Operation: starting up and shutting down; quick starting; normal operation; flow diagrams; efficiencies; heat rate; water rate; turbine performance.
 - vi. Maintenance: overhauls and repairs; shaft alignment; bearing, thrust, blade and packing clearance; blade fouling and erosion; removing turbine deposits; cleaning after erection; preventive maintenance.
 - vii. Theory: nozzles; velocity diagrams; angle of entry and velocity calculational work done on blades and horse power; blade characteristics.
 - viii. Dynamometers.
- C. Internal Combustion Engines.



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- i. Spark ignition engines: principles of operation of two and four stroke gas and gasoline engines; construction; carburetor; magneto.
 - ii. Compression ignition engines: principles of two and four stroke oil burning, gas and dual-fuel engines; constructional details.
 - iii. Fuels: classification; properties; impurities; methods of purifying and clarifying; injection systems; ignition systems; scavenging and supercharging arrangements.
 - iv. 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.
 - v. Cooling: piston and jacket cooling water systems; cooling water treatment and removal of deposits; lubricating oil systems.
- D. Gas Turbines**
- i. Principle of operation; types of gas turbines.
 - ii. Open and closed cycle systems; regeneration; intercooling and reheating.
 - iii. Dual shaft machines; free-piston gas generators.
 - iv. Construction: rotors; blading; compressors; combustors; combustion chambers.
 - v. Operation and control: starting up and shutting down; normal running procedure; control systems; safety devices.
- E. Condensing Equipment**
- i. Condensers: types and constructional details; backwashing and cleaning; leak testing.
 - ii. Condenser ancillary equipment: air ejectors; cooling water systems, intakes and intake screens; cooling towers and ponds; atmospheric exhaust valves; circulating pumps; condensate pumps.
- II. Fire Prevention and Plant Safety**
- A. Plant Safety**



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- i. Plant safety department; safety personnel.
 - ii. Types of accidents; causes and prevention.
 - iii. Harmful gases; treatment for personnel exposed to harmful gas; gas masks; compressed air or oxygen breathing apparatus; gas detectors; gas ejectors.
 - iv. Handling and storage of chemicals.
 - v. Radiation hazards: radioactive materials and penetrating power; facilities for using radiographic sources; protection from radiation; personnel dosimeters; radiation survey meters.
 - vi. General safety equipment: mechanical guards; protective clothing; safety harnesses; noise survey meters.
 - vii. Lifting gear: cranes; ropes; chains; slings; hooks.
 - viii. Electric shock: causes and preventive measures; testing conductors; grounding; treatment for personnel exposed to electric shock.
 - ix. Artificial respiration: Holger Nielson and Schafer methods; mouth-to-mouth resuscitation; pneolators; resuscitators.
- B. Fire Prevention**
- i. Classes of fires; selection of fire protective equipment.
 - ii. Types of fire fighting equipment; operation and construction.
 - iii. Handling and storage of flammable materials.
 - iv. Emergency drill; steps taken in the event of fire.
 - v. Fire fighting training for personnel.



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Part "B" Examination

**Sixth Paper
Afternoon session
3 ½ Hours**

I. Metallurgy

- A. Nonferrous metals: properties, composition and uses of the principle of nonferrous metals.
- B. Iron and steel: methods of manufacture; blast furnace; pig iron, cast iron, wrought iron, furnaces and converters for steelmaking; acid and basic processes; carbon steel; alloy steels; uses of oxygen in steelmaking.
- C. The structure of metals: atoms; elements; crystalline structure of metals; grains and grain boundaries.
 - i. Mechanical properties; effects on mechanical properties of low temperatures, elevated temperatures, hot or cold plastic work; S.I. (Metric) Units.
 - ii. Physical properties: thermal properties; electrical conductivity; magnetic properties.
 - iii. Corrosion properties.
- D. Alloying elements in iron; iron-carbon equilibrium diagram; alloy steels; stainless steels and high-chromium alloys; cladding steels.
- E. Heat treatment of metals: normalizing; annealing; spheroidizing; hardening; tempering; quenching.

II. Testing of Materials

- A. Tensile testing machine; Brinell and Rockwell hardness testing machines; Charpy and Izod notch impact testing machines.
- B. Procedures of effecting tensile, hardness and impact tests; forms of specimens tested.
- C. Metallographic examinations.
- D. Creep resistance, corrosion resistance and fatigue tests.

III. Welding



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- A. Definitions of welding terms; welding symbols.
- B. Welding methods and processes: metal, shielded and submerged arc; T.I.G.; M.I.G.; electrical resistance; gas welding; brazing; soldering.
- C. Shielding of the welding processes; shielding slags; deoxidizers; fluxes; covered electrodes; flux-cored electrodes; argon; helium; carbon dioxide.
- D. Heat control and heat-treating: pre- and interpass heating; temperature control; postweld heat treatment; weldment cooling rates.
- E. Qualification of welding and welds: purpose; significance of welding positions; retesting.
- F. Weldment defects: dimensional defects; structural discontinuities; defective properties.
- G. Nondestructive testing: visual inspection; magnetic particle inspection; liquid penetrant testing; radiographic examination; ultrasonic inspection; proof tests; leak tests.

IV. Power Plant Erection and Developments

- A. Foundations: test boring; piling; footings; types of building foundations; small engine and large turbine foundations.
- B. Lining up and erecting small machines, large turbine installations, and internal combustion engines.
- C. Commissioning: auxilliary services; boilers; turbines; alternators; internal combustion engines; performance tests.
- D. Regenerative feed heating cycle; closed feed systems; feed heaters; deaerators; evaporators.
- E. Reheat cycle; binary vapour cycle; combined gas turbine and steam cycle.

V. Lubrication

- A. Principles of lubrication: action of lubricants on bearing surfaces; oil supply methods and applications.
- B. Liquid, semi-solid, and solid lubricants; properties; specifications; selection.



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- C. Plant lubrication programme: lubrication survey; types of lubricating systems, air compressor, gas turbine, internal combustion engine, steam turbine; lubricating oil pumps; governing systems for alternators with hydrogen seals.
- D. Engine lubricating oil maintenance: causes of deterioration; additives; oil purification equipment.
- E. Types of ball and roller bearings and their lubrication; bearing seals.



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Part "B" Examination

**Seventh Paper
Morning session
3 ½ Hours**

I. Industrial Administration

- A. A thorough understanding of the *Safety Standards Act* & regulations as applied to the field of the certified Power Engineer in industry.
- B. Installations: factors governing plant designs and layouts; contract specification; 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 programmes; air pollution control.

II. Refrigeration and Air Conditioning

- A. Refrigeration
 - i. Principles and methods of refrigeration; compression systems; absorption systems; steam-jet system; thermoelectric refrigeration; hermetic cycles; cascade systems; heat pump systems; S.I. (Metric) Units.
 - ii. Refrigerants: types; properties; classifications; uses.
 - iii. Refrigeration plants: types; layouts; installation details.
 - iv. Plant equipment: compressors; condensers; evaporators; liquid receivers; oil separators; absorbers; generators; heat exchangers; rectifiers; driers; scale traps; piping and fittings; cold room construction.



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- v. Operation of refrigerating plants: starting up and shutting down; charging; hand and automatic purging; automatic expansion valves; compressor lubrication; brine solutions; leak testing.
- vi. Trouble shooting and maintenance: correcting operational troubles; repairing or replacing defective parts; freon cloud and floc points; “copper plating”.
- vii. Safety and control: Code requirements; safety fittings; compressor and refrigerant system instrumentation and controls; cooling water system controls.
- viii. Computations of capacities and performances of refrigerating plants; ideal and practical refrigerant cycles; theoretical piston displacement and horsepower; heat pump effect.

B. Air Conditioning

- i. Terminologies and definitions in psychrometrics; psychrometric chart and tables; heat transfer; heating load; cooling load.
- ii. Heating systems: steam; hot water; high temperature water; heating systems equipment.
- iii. Cooling systems: central, combined heating and cooling systems; chilled-water absorption system; cooling systems equipment.
- iv. Air distribution; air cleaning; humidifying and dehumidifying equipment.
- v. Instrumentation and control of; humidity, air temperature, cooling systems; air-washer systems, outdoor air dampers.

III. Types and Arrangements of Industrial Plants

A. Terminologies and definitions common to the petroleum and gas industries.

B. Gas Processing Plants

- i. Composition of natural gas: contents; structure and classes of hydrocarbons; types; properties; uses for products of natural gas.
- ii. Field operations and equipment: well head equipment and operating procedures; prevention of hydrates; indirect and direct fired heaters; types and constructions of separating equipment; field flares.



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- iii. Gas sweetening processes: liquid sweetening processes, amine, sulphinol, and hot potassium carbonate; solid regenerative processes, iron sponge and molecular sieve; flow diagrams; process stages; process operation difficulties.
 - iv. Process vessels and equipment; product treating and storage.
 - v. Sulphur recovery plants: sulphur recovery stages; flow diagram; waste heat boilers.
 - vi. Safety in gas plants: types of accidents and hazards; toxic gases; chemical handling; fire protection; high pressures and temperature; electrostatic charges; general plant safety operations and equipment; emergency systems.
- C. Pulp and paper mills: mechanical and chemical manufacturing processes; flow diagrams; safe operations of black liquor recovery boilers.



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Part "B" Examination

**Eighth Paper
Afternoon session
3 ½ Hours**

I. Electrotechnology

- A. The Electron Theory of flow of electricity; structure of the atom; electron speed along a conductor; the electron-volt; S.I. (Metric) Units.
- B. D.C. Theory
 - i. D.C. circuits: Ohm's Law; series and parallel circuits; circuit laws; distribution circuits; work, power, and energy; grouping of cells.
 - ii. Conductors and insulators: resistance and resistivity; the circular mil, wire gauges and conductors; temperature coefficient of resistance; heat and electrical energy; mechanical equivalent of heat.
 - iii. Electrochemistry: electrolysis; operation and maintenance of primary and secondary cells.
 - iv. Electromagnetism: magnetic field around a current-carrying conductor, force on conductor; the magnetic circuit; magnetomotive force; electromagnets; saturation.
 - v. Electromagnetic induction: magnitude and direction of induced E.M.F.; Fleming's right-hand rule; Lenz's law; hysteresis.
 - vi. Inductance in a D.C. circuit: unit of inductance; flux-linkages; mutual inductance.
- C. A.C. Theory
 - i. The sine wave: generation of an alternating E.M.F.: root mean square values; vector representation of sinusoidal quantities.
 - ii. Resistance, inductance and capacitance in single-phase series and parallel circuits: inductive reactance, capacitive reactance, and impedance; resonance.
 - iii. Power in A.C. circuits: true and apparent power; practical importance of power factor; power factor correction.



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- iv. Three-phase circuits: delta and star connected alternators and loads, current and voltage relationships; three-phase power.
- D. Electrical Instruments
 - i. Galvanometers; permanent-magnet moving-coil instrument.
 - ii. Power measurement: ammeter; voltmeter; wattmeter; power-factor meter.
 - iii. Resistance measurement: megger insulation tester; ohmmeter.
- E. Electronics
 - i. Electron tube types: vacuum and gas-filled; thermionic, mercury-pool and photoemissive; diodes, triodes, tetrodes, and pentodes, action of grid.
 - ii. The cathode-ray oscilloscope; the thyration; the ignition.
 - iii. Semi-conductors: germanium and silicon; PN junctions; applications.
 - iv. Transistors: characteristics; amplification; applications.
- F. D.C. Machines
 - i. Generators: principles of operation; construction; communication; types of armature windings; armature reaction; interpoles, compensating windings; generator types and characteristics, theory of self-excitation; selection of generators and applications; parallel operation; efficiency and power losses; ratings.
 - ii. Motors: principle of motor action; torque development; motor classification; back E.M.F.; voltage, current and speed computation; starting arrangements; dynamic and regenerative braking; speed control; reversing directions; selection of motors; types and characteristics; efficiency and power losses; ratings.
- G. Electrical Instruments
 - i. Galvanometers; permanent-magnet moving-coil instrument.
 - ii. Power measurement: ammeter; voltmeter; wattmeter; power-factor meter.
 - iii. Resistance measurement: megger insulation tester; ohmmeter.



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H. Electronics

- i. Electron tube types: vacuum and gas-filled; thermionic, mercury-pool and photoemissive; diodes, triodes, tetrodes and pentodes, action of the grid.
- ii. The cathode-ray oscilloscope; the thyration; the ignitron.
- iii. Semi-conductors: germanium and silicaon; PN junctions; applications.
- iv. Transistors: characteristics; amplification; applications.

I. A.C. Machines

- i. Alternators: types and characteristics; construction of stators; rotors and exciters; stator windings; cooling systems; shaft sealing systems; relationship between speed, frequency and number of pole pairs; voltage regulators; synchronizing; parallel operation; power factor control; voltage drops in armatures; phasor diagram; rating, efficiency and power losses.
- ii. Single-phase motors: universal, shaded-pole, split-phase, repulsion-start, and reluctance-start types, capacitance starting methods.
- 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; principle of operation; applications; construction; exciters; starting methods; power factor adjustment.
- v. Transformers: principle of transformer action; ratings; efficiency and losses; short and open circuit test; types of construction; methods of cooling; connections; parallelling; instrument transformers.
- vi. Protection of A.C. machines: alternator stator and rotor protection devices; motor protection devices; transformer safety fittings.

J. Conversion of Electrical Power

- i. Convertors: action and construction of the synchronous convertor; frequency convertors; phase convertors.



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- ii. Rectifiers: mercury-arc rectifiers; ignitors; thyratons; thermionic oscillators; solid-state and semi-conductor types of rectifier; silicon controller rectifiers.
- K. Circuit-protective equipment: interrupting capacity; fuses; switches; circuit-breakers; relays.

II. Compressors

- A. Reciprocating and rotary compressors: types; operation; construction; regulation and control; preventive maintenance.
- B. Ancillary equipment: valves; coolers; receivers; oil and water separators; filters; unloaders; safety valves; instruments; piping layouts and plant installation.
- C. Principles of air compression: effects of altitude; temperature; humidity.

III. Nuclear Power Production

- A. Basic nuclear technology: the atom; nuclear fission; chain reaction; breeding control; essential components of a nuclear reactor.
- B. Definitions of terms: atomic weight; atomic number; mass number; isotopes; heavy hydrogen; heavy water; fissile material; fertile material fission products; fuel burn-up; half-life; critical mass; moderators; coolants.
- C. Classification of fuels and reactors; life of nuclear fuels.
- D. examples of reactor systems: graphite moderated gas cooled; he heavy water; boiling