



REFERENCE SYLLABUS

For

SECOND 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 2nd Class Syllabus

On January 01, 2005, a revised second class syllabus for Power Engineer examinations came into effective. This revised second class syllabus brought about major changes in the layout of the second class examinations.

This change is so substantial that examination papers already successfully completed at the second class certificate level under the (old) second class syllabi can not be integrated into the revised second class program.

However, to assist in this transition, the examinations for both the (old & revised) second 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) second class syllabus, ample time to finish up their examinations and earn their certificate of qualification.

For your information there will be a transition period from January 01, 2005 to December 31, 2005. During this transition period, candidates will have the option of starting examinations under either the (old or revised) syllabus for second class. By January 1, 2006, all applicants who have not successfully completed at least one examination paper under the (old) second class syllabus will be required to start writing second class examinations under the new revised second class program.

If you have any comments, concerns, or questions concerning the revised second 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 has been approved by the Standardization of Power Engineers Examinations Committee (SOPEEC) and the Association of Chief Inspectors (ACI). It is intended to assist candidates studying for the Second Class Power Engineer's Certificate of Qualification Examinations.

Please also access our website at <http://www.safetyauthority.ca/> and the national examination website at www.sopeec.org.

The requirements to qualify for a Second Class Examination are outlined in the *Safety Standards Act* and the *Power Engineers, Boiler, Pressure Vessel and Refrigeration Safety Regulation*.

Application to Undertake Examination

In order to be registered for an examination and receive a confirmation examination date a candidate must submit an application and the prescribed fee and have the application approved prior to the registration cut off date. Please access our website to view the Power Engineer Examination Schedule.

Examination Instructions

The Second Class Certificate of Qualification certification consists of six (6) examination papers. Each paper consists of seven (7) questions, of which only the first five (5) attempted will be marked. (Note: Part B, Paper One (1) also consists of seven (7) questions, but included in these seven (7) questions, is a mandatory drawing question which must be attempted.



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A candidate is allowed to bring into the examination room any of the ASME Codes except sections VI and VII. Normally only section I and VIII Division 1 are required for the 2nd class.

A dictionary, (scientific dictionaries are not permitted)

Non – programmable calculator. If your calculator is programmable, you must reset it in the company of the examiner so that the examiner is sure that all memories are clear. Or the examiner may request that you remove the battery to erase all memory. This may be done during your examination time, so be aware that you may have less time to complete your exam. Also, if your calculator fails to function after reset or battery removal, the examiner is not responsible, and you may be at a significant disadvantage.

Drawing instruments, Pens and pencils.

Note: The items referenced above must be shown to the examiner for approval.

The following exam material is provided by the BC Safety Authority:

- Safety Standards Act & Regulations
- CSA B-51 Boiler, Pressure Vessel & Pressure Piping Code
- CSA B-52 Mechanical Refrigeration Code
- Four Figure Tables & Constants
- Steam & Refrigeration Tables

The candidate must show picture I.D. at the examination.



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Recommended Study Programme

It is strongly recommended that Candidates complete an approved formal course of study offered by a recognized technical Institute or training provider, before undertaking to write any of the "Standardized Power Engineers' Certificate of Qualification Examinations".

In addition to the foregoing and in order to prepare for the BCSA examinations, 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 institutes, colleges, or from the SOPEEC website

Candidates would be well advised to have a good basic knowledge of Mathematics, Science, and English, before enrolling in an approved college, technical, vocational, or correspondence course.

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 or First Class Power Engineering Certificate of Qualification Examinations. Inquiries regarding the above mentioned course materials should be directed to Pan Global, Power engineering Training Systems, 1301 – 16th Ave., N.W. Calgary, Alberta T2M 0L4, toll free 1-866-256-8193, fax 403-284-8863 or email customer_service@powerengineering.ca .

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 they may



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change annually. Therefore, it is suggested that candidates use the codes located at their company library or at public libraries to obtain the necessary information.

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 SOPEEC and the Interprovincial Power Engineering Curriculum Committee (IPECC). It is intended to assist candidates in achieving an excellent working knowledge of related topics, and to contribute to attaining passing grades on the standardized examinations.

Candidates who are entering into the Power Engineering field should realize 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. 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



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that they use Code books from their company library or from public libraries to assist with their studies.

| | 1 st | 2 nd | 3 rd | 4 th |
|---|-----------------|-----------------|-----------------|-----------------|
| 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.



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| | 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 | | |
| 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 | |
| | | | | |



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| | | | | |
|--|---|---|---|---|
| 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, Swaneharp (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.



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Excerpts:

Power Engineers, Boiler, Pressure Vessel and Refrigeration Safety Regulation

Application for second class power engineer's certificate of qualification

15 (1) An applicant for a second class power engineer's certificate of qualification must

- (a) hold a first class marine engineer (motor) certificate of competency, or
- (b) hold a third class power engineer's certificate of qualification or a third class power engineer's standardized certificate of competency and have been employed, while in possession of a third class power engineer's certificate of qualification, for a period of not less than
 - (i) 30 months as a chief engineer of a power plant that has a boiler capacity that exceeds 150 m²,
 - (ii) 30 months as a chief engineer of a low pressure steam plant that has a boiler capacity that exceeds 500 m²,
 - (iii) 36 months as a shift engineer or as an assistant chief engineer of a power plant that has a boiler capacity that exceeds 250 m²,
 - (iv) 48 months as an assistant shift engineer or maintenance engineer of a power plant that has a boiler capacity that exceeds 1 000 m²,
 - (v) 60 months as an assistant engineer of a power plant that has a boiler capacity that exceeds 1 000 m² performing duties approved by a provincial safety manager as providing suitable experience, or



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(vi) one half of the period set out in subparagraph (i) or (ii) in the position and in the size and type of plant set out in that subparagraph, and have been employed for a period of not less than 48 months as a maintenance engineer.

(2) If an applicant has successfully completed a second class power engineering course that has been approved by a provincial safety manager, the required periods of employment referred to in subsection (1) (b) (i) to (v) are reduced by 9 months.

(3) If an applicant holds an engineering degree acceptable to a provincial safety manager, the required periods of employment for the positions and types of plants set out in subsection (1) (b) (i) to (v) are reduced by one half.

[am. B.C. Reg. 475/2004, Sch. 4, s. 2.]

What a second class power engineer may do

16 A second class power engineer's certificate of qualification entitles the holder to be

- (a) chief engineer of a power plant that has a boiler capacity of 1 000 m² or less,
- (b) chief engineer of any low pressure steam plant, fluid plant, low pressure thermal fluid plant or low temperature low pressure fluid plant, or
- (c) shift 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; inducted 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; 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. 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.

II. A.S.M.E. Code, Section I, Calculations



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- A. Design values to be computed for the following boiler pressure parts:
- i. Cylindrical components; dished heads; unstayed flat heads and covers.
 - ii. Openings and compensation: openings in shells, headers and heads; compensation required; strength of compensation.
 - iii. Stayed surfaces: dimensions and locations of stay bolts; ligaments.
 - iv. Safety valves and safety relief valves: size and capacity.
 - v. Firetube Boilers:
 1. Combustion chambers and furnaces: plain circular furnaces; circular flues; Adamson ring reinforced and corrugated furnaces.
 2. Stayed surfaces: maximum spacing of stays; areas of heads to be stayed; stresses in diagonal stays.

III. 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.
- 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 solids meters; methods of steam sampling; measurement of pH.
 - ii. Water analysis and interpretation of analytical results.
- E. Industrial waste treatment: effects caused by waste discharge; mechanical, chemical and biological methods of waste treatment.



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Part "A" Examination

**Second Paper
Afternoon session
3 ½ Hours**

I. Thermodynamics

- A. 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.
- 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: 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.
- F. Combustion: bomb calorimeter; analysis of flue gases; quantity of air required for combustion; draft calculations.
- G. Boiler efficiency; heat balance testing.

II. Fuels and Combustion

- A. Combustion chemistry; chemical 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.
- D. Firing equipment: pulverisers; oil and gas burners; storage and heating of oil; ash and slag disposal.
- E. Draft: F.D. and I.D. fans; gas by-pass and recirculation.



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F. Control instrumentation:

- 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; Orsat, Carbon Dioxide and Oxygen recorders.
- iii. Combustion safeguards: purge and fan-failure interlock systems; flamefailure control systems; photo electric tubes; rectifier rods.
- iv. Packaged boiler-control systems: programming sequence; limiting devices and alarms.



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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. Methods of heat transfer; circulation; steam generator ratings.
- C. Boiler classification; types and applications of Firetube and watertube boilers.
- D. Boiler fittings, including safety devices, drum internals, soot blowers.
- E. Boiler details: water walls; superheaters; desuperheaters; attemperators; economizers; air heaters; blow-down systems; flash tanks.
- F. Methods of installation and support: foundations; settings; methods of tubing; top drum erection; shop and field assembly.
- G. Insulation: duct and baffle arrangements; boiler casings.
- H. Operation: start up and shut down; boiling out; drying out refractory; lay-up procedure; safety precautions.
- I. Maintenance: mechanical and chemical cleaning; inspection; upkeep and repairs; hydrostatic test; safety precautions.

II. Piping

- A. Piping materials and methods of manufacture.
- B. Commercial pipe sizes; symbols and identification for piping and fittings.
- 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.

III. Control Instrumentation

- A. Modes of automatic control; two position; proportional; proportional-plus-reset.
- B. Pressure measuring devices, primary elements: Bourdon tubes; helical and spiral



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elements; diaphragm; manometer; spring and bellows; inverted-bell.

C. Temperature measuring instruments: bimetal and filled system thermometers; thermocouple and radiation pyrometers; resistance thermometers; thermistors.

D. Flow measurements with differential pressure flow meters:

i. Primary elements: orifice plate; flow nozzle; venturi tube; pilot tube; flownozzle pipes.

ii. Indicating mechanisms: manometer; Ledoux-bell; ring-balance; forcebalance; electric.

iii. Meter connections.

E. Liquid level measurement and control: ball-float; displacement-type; hydrostatic head; electric and pneumatic level transmission; electric and magnetic type levellimit devices; remote water-level indicators.

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

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

H. Superheated steam temperature control; steam pressure reducing and desuperheating control systems.

IV. Pumps

A. Theory of pumping; pump performance characteristics.

B. Uses and selection of pumps.

C. Types: centrifugal; rotary; gear; reciprocating.

D. Installation; maintenance; operation.

E. Constructional details including: impeller types; packing boxes; mechanical seals; shaft alignment; thrust balancers; tachometers.

F. Feed and circulating systems; design and operation; feed heaters; drain coolers.



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Part "B" Examination

**Fourth Paper
Afternoon session
3 ½ Hours**

I. Prime Movers

A. Thermodynamic Cycles:

- i. Ideal cycles: Carnot; Rankine; Otto; Diesel; Brayton.
- ii. 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; expansion and anchoring; reducing gears.
 - 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; blade characteristics.
- C. Internal Combustion Engines:
- 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; construction details.



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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. Coolings: 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 procedures; 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.

II. Fire Prevention and Plant Safety

A. Plant Safety:

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 breathing apparatus; gas detectors; gas ejectors.



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- iv. Radiation hazards: radioactive materials and penetrating powers; protection from radiation.
 - v. General safety equipment: mechanical guards; protective clothing; safety harnesses; noise survey meters.
 - vi. Lifting gear: cranes; ropes; chains; slings; hooks.
 - vii. Artificial respiration: Holger-Nielson and Schafer methods; mouth-to-mouth resuscitation.
- 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.



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Part "B" Examination

**Fifth Paper
Morning session
3 ½ Hours**

I. Industrial Legislation

A thorough understanding of the *Safety Standards Act* & regulation as applied to the field of the certified Power Engineer in industry.

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.

C. Principles of air compression: effects of altitude, temperature, humidity.

III. Refrigeration and Air Conditioning

A. Refrigeration:

i. Principles and methods of refrigeration; compression and absorption systems; S.I. (Metric) Units.

ii. Refrigerants: types; properties; classification; uses.

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

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

v. 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.

vi. Safety and control: Code requirements; safety fittings; compressor and system instrumentation and controls.

vii. Computations of capacities and performances of refrigerating plants; heat



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pump effect; theoretical horsepower; pressure-enthalpy charts.

B. Air Conditioning:

- i. Fundamentals: terminologies and definitions in psychometrics: heat transfer; heating load; cooling load.
- ii. Space heating and cooling systems and equipment: steam heating; hot water heating; high temperature water heating; central and unit heating; chilled-water cooling; combined heating and cooling systems.
- iii. Humidity and temperature control instrumentation.

IV. 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: constituents; structure and classes of hydrocarbon; types; properties.
- ii. Field operations and equipment; well head equipment and operating procedures; indirect and direct fired heaters; separators, types and construction.
- iii. Gas sweetening processes: liquid sweetening processes, ammine, 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 temperatures; electrostatic charges; general plant safety operations and equipment; emergency systems.

C. Pulp and paper mills: mechanical and chemical manufacturing processes; flow



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diagrams; safe operation of black liquor recovery boilers.

V. Mechanical Drawing

- A. Pictorial drawing; geometrical constructions.
- B. Orthographic, auxiliary, isometric and oblique drawings.
- C. Dimensioning and sectioning.
- D. Graphical representations for welding.
- E. Flow diagrams; piping drawings; charts.



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Part "B" Examination

**Sixth Paper
Afternoon session
3 ½ Hours**

I. Electrotechnology

A. The Electron Theory on flow of electricity; structure of the atom; electron speed along a conductor; S.I.(Metric) Units.

B. D.C. Theory:

i. D.C. circuits: Ohm's Law; series and parallel circuits; circuit laws; ammeters and voltmeters; 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: direction of magnetic field due to an electric current; force on conductor carrying an electric current in a magnetic field.

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 leakage; 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 A.C. series circuits; inductive reactance, capacitive reactance, impedance, resonance.

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

D. Basic Electronics:



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- i. Electron tube types, vacuum tube, thermionic tube, thermionic emission; photoelectric emission; secondary emission; field emission.
- ii. Fundamental knowledge of semi-conductor devices: germanium and silicon; transistors.
- iii. Motors: principle of motor action; torque development; Fleming's left-hand rule; back E.M.F: voltage, current and speed computation; motor types and characteristics; starting arrangements; dynamic and regenerative braking; speed control; efficiency and power losses.

E. A.C. Machines:

- i. Alternators: types; construction of stators, rotors and exciters; relationship between speed, frequency and number of pole pairs; cooling systems; shaft sealing systems; voltage regulators; synchronizing; parallel operation; power factor control, rating, efficiency and power losses.
- ii. Single-phase motors: universal, shaded pole and split-phase 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 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.

F. Conversion of Electrical Power:

- i. Rotary convertors: action and construction of the synchronous convertor.
- ii. Rectifiers: action and construction of the mercury-arc, solid-state and semiconductor



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types of rectifier.

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

II. Metallurgy and Welding

A. Nonferrous metals: properties, composition and uses; copper; brasses; bronzes; aluminum; white metal.

B. Iron and steel: methods of manufacture; blast furnace; pig iron, cast iron, wrought iron; furnaces and converters for steel-making; acid and basic processes; carbon steel; oxygen steelmaking.

C. Mechanical, physical and thermal properties of ferrous metals.

D. Welding methods and processes: metal, shielded and submerged arc; gas; definitions of welding terms; welding symbols.

E. Fluxes, slags and gases for shielding: fluxes and coatings; bare electrode; covered electrodes.

F. Heat control and heat treating: pre and interpass heating; temperature control; postweld heat treatment; weldment cooling rates.

G. Qualification of welding and welders: purpose; significance of welding positions; retesting.

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

I. Nondestructive testing: visual inspection; magnetic particle inspection; liquid penetrant testing; proof tests; leak tests.

III. Lubrication

A. Principle of lubrication: action of lubricant on bearing surfaces; oil supply methods and applications.

B. Liquid semi-solid and solid lubricants: properties; specifications; selection.

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



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pumps.

D. Turbine oil maintenance: causes of deterioration; additives; oil purification equipment.

E. Types of ball and roller bearings and their lubrication; bearing seals.