



REFERENCE SYLLABUS

For

**THIRD CLASS
POWER ENGINEER'S
CERTIFICATE of QUALIFICATION
EXAMINATION**



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

GENERAL INFORMATION

Phasing out of the old 3rd class Syllabus & Implementing the New 3rd Class Syllabus

The (new) 3rd class syllabus came into existence, January 01, 2005. The British Columbia Safety Authority, (BCSA) then offered the existing (old) 3rd class examinations until July, 01, 2005, similar to the Alberta Boiler Safety Authority, (ABSA). However, to give power engineers in BC studying under the old 3rd class course material ample time to complete their 3rd class examinations, BCSA further extended the phasing out period of the old 3rd class until December 31st 2005. FYI, the majority of SOPEEC members, jurisdictions that offer Power Engineer Examinations across Canada have discontinued the old 3rd class syllabus as of December 31, 2005. BCSA is extending the time line for the old 3rd class syllabi one final time until June 30, 2006. There will be no further extensions. If you are aware of any Power Engineers still writing under the old 3rd class syllabus, please make them aware of this extension.

Following June 30, 2006, only (new) 3rd class examinations will be available. No upgrade examinations will be offered.

Candidates who have not completed the existing (old) 3rd class examinations under the old syllabus by June 30, 2006, will be required to continue writing the (new) 3rd class examination program. All examinations written and passed under the (old) 3rd class syllabus are valid and can be used to complete the 3rd class program under the (new) syllabus.

The requirements to qualify for the (old or new) 3rd class power engineer examination are outlined in the *Safety Standards Act* and applicable *Regulation*.

If you have any comments, concerns, or questions concerning the (old or new) 3rd class examination program, please feel free to telephone Fred Golar, Certification & Licensing Analyst, at 604-660-6245 or email Fred.Golar@safetyauthority.ca .

GENERAL INFORMATION



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Introduction

The Third Class Syllabus has been approved by the Association of Chief Inspectors (ACI). This syllabus is intended to assist candidates studying for the Third Class Power Engineering examinations. You may also access our web site at <http://www.safetyauthority.ca/> and the national examination web site at www.sopeec.org.

Recommended Study Program

It is recommended that, before undertaking the Third Class Power Engineer Examination, that candidates references the material contained in the old Third Class Course. Candidates would be well advised to have a good basic knowledge of mathematics, sciences, and English, and in addition to the foregoing and in order to prepare for Third Class examinations, it is recommended that they become familiar with the pertinent publications listed in the “Reference Material for Candidates of Power Engineer Examinations”, which can be 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 Engineering Certificate of Qualification Examinations. Inquiries regarding the above mentioned course materials should be directed to the Energy and Natural Resources Department at the Southern Alberta Institute of Technology (SAIT), telephone numbers (403) 284-8451 or 1-800-661-1268 and the British Columbia Institute of Technology (BCIT) at telephone number (604) 432-8390. 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 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. It is strongly recommended that candidates complete an appropriate formal course of study offered by a recognized



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Technical Institute before undertaking to write any of the "Standardized Power Engineers' Certificate of Qualification 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 Engineering Curriculum Committee (IPECC), and the Standardization of Power Engineering Examinations Committee (SOPEEC). 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. The Interprovincial Power Engineering 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. In most jurisdictions it is the students' responsibility to bring code books into the examination.

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	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.

	1 st	2 nd	3 rd	4 th



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

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

	1st	2nd	3rd	4th
Applied Engineering Mechanics First Canadian, Jensen, Chenoweth Snail & Stassen-(Latest edition) ISBN#007-032-492-1	X	X		
National Board Inspection Code LCCCN #52-44738	X	X		
Applied Thermodynamics for Engineering Technologists. T.D. Eastop (Latest edition) ISBN #0-582-09193-4	X	X	X	
Blueprint Reading and Technical Sketching for Industry Thomas P Olivo (Latest edition) ISBN#0-8273-5077-5	X	X	X	
Electric Circuits & Machines Lister, Golding (Latest edition) ISBN#0-07-552603-4	X	X	X	



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

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

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

Excerpts:

Power Engineers, Boiler, Pressure Vessel and Refrigeration Safety Regulation

Application for third class power engineer's certificate of qualification



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- 17** (1) An applicant for a third class power engineer's certificate of qualification must
- (a) hold a second class marine engineer (motor) certificate of competency, or
 - (b) hold a fourth class power engineer's certificate of qualification or a standardized fourth class power engineer's certificate of qualification and have been employed, while in possession of a fourth class power engineer's certificate of qualification, for a period of not less than
 - (i) 24 months as a power engineer in a position requiring a fourth class power engineer's certificate of qualification in a power plant that has a boiler capacity that exceeds 50 m²,
 - (ii) 36 months as a shift engineer of a low pressure steam plant that has a boiler capacity that exceeds 300 m²,
 - (iii) 36 months as a chief engineer of a fluid plant or low pressure thermal fluid plant that exceeds 500 m² boiler capacity,
 - (iv) 36 months as a maintenance engineer of a power plant that has a boiler capacity that exceeds 50 m²,
 - (v) 36 months of relevant experience as an assistant chief engineer of a power plant that has a boiler capacity that exceeds 500 m², or
 - (vi) 48 months as a power engineer in a fluid plant, or a thermal fluid plant that has a boiler capacity that exceeds 500 m² of boiler capacity.
- (2) If an applicant has successfully completed a third 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 6 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.
- (4) Despite subsection (1) (b), an individual may apply for a third class power engineer's



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certificate of qualification if the individual (a) holds a diploma issued after completing a 2 year full time day program in third class power engineering that has been approved by a provincial safety manager, and (b) has been employed for at least 6 months in a power plant that has a boiler capacity of not less than 100 m².

- (5) A one time 3 month credit towards the qualifying time requirement specified in subsection (4) (b) will be granted to candidates who have received boiler plant computer simulation training at an educational or vocational facility approved by a provincial safety manager.

What a third class power engineer may do

18 A third 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 500 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,
- (c) chief engineer of any unfired plant, or
- (d) shift engineer of a power plant or high pressure thermal fluid plant that has a boiler capacity of 1 000 m² or less.



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Part "A" Examination

**First Paper
Morning Session
3 ½ Hours**

I. Applied Mathematics

Logarithms, elementary algebra and trigonometry, simple equations, mensuration.

II. Applied Mechanics

- (A) Application of forces; Newton's Laws of Motion; vector diagrams.
- (B) Forces due to friction.
- (C) Velocity and acceleration.
- (D) Work, power and energy.
- (E) Moments of force and simple machines.
- (F) Relationships between load, stress and strain; yield point and ultimate strength.
- (G) Factor of safety and safe working stress.
- (H) Bending of beams; shearing forces and bending moments.
- (I) Density and specific gravity.

III. Thermodynamics

- (A) Measurement of temperature in Fahrenheit, Rankine, Centigrade, and Kelvin scales.
- (B) Expansion of solids: linear, surface and volumetric.
- (C) Expansions of liquids and gases.
- (D) Quantity of heat: specific heat, S.I. (Metric) quantities.
- (E) Change of state: sensible and latent heat; heat content in mixtures of water, ice and steam; saturated and superheated steam.
- (F) Thermodynamics of steam: steam tables; Mollier and temperature-enthalpy charts; critical temperature and pressure; dryness fraction; equivalent evaporation, factors of evaporation.
- (G) Methods of heat transfer: conduction, convection, radiation.
- (H) Work and heat: mechanical equivalent of heat; laws of thermodynamics; Boyle's and Charles' laws of perfect gases, general gas laws, characteristic constant of a



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gas.

(I) Expansion and compression of gases: isothermal, adiabatic; pressure-volume diagrams; indicated horsepower; thermal efficiency.

IV. Applied Science

- (A) Basic Chemistry
 - (i) Elements, compounds and mixtures; molecules and atoms.
 - (ii) Chemical balancing equations, chemical formulae.
 - (iii) Structure of the atom, atomic number, atomic weight, formula weights, the mol.
 - (iv) Acids, bases, salts.
 - (v) Carbon and carbon compound.
- (B) Engineering Materials
 - (i) Mechanical properties.
 - (ii) Materials used in construction; selection of materials.
 - (iii) Alloying elements, case hardening.
 - (iv) Nonferrous metals.
- (C) Mechanical Drawing
 - (i) Geometrical construction of plane figures.
 - (ii) Projecting, dimensioning and sectioning simple figures.
 - (iii) Types of screw threads and securing keys.



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Part "A" Examination

**Second Paper
Afternoon Session
3 ½ Hours**

I. Industrial Legislation

- (A) A thorough knowledge of The *Safety Standards Act* and a working knowledge of the Regulations under that Act.
- (B) General background knowledge of the reasons for adopting the present Regulations.

II. Codes

- A.S.M.E. Section I - Power Boilers
- A.S.M.E. Section IV - Heating Boilers
- A.S.M.E. Section VI - Recommended Rules for Care and Operation of Heating Boilers
- A.S.M.E. Section VII - Recommended Rules for Care and Operation of Power Boilers
- C.S.A. Standard B-51 - Boiler, Pressure Vessel and Pressure Piping
- C.S.A. Standard B-52 - Mechanical Refrigeration Code

III. Boiler Calculations A.S.M.E. Code, Section I

Values to be computed for the following boiler pressure parts.

- (A) Piping, drums headers and dished heads: minimum required plate thickness, maximum allowable working pressure, maximum allowable stress value, joint efficiency.
- (B) Unstayed flat heads and covers: minimum required plate thickness, maximum allowable working pressure, maximum allowable stress value, factor C.
- (C) Stayed surfaces: minimum required plate thickness, maximum allowable working pressure, maximum pitch of stays, Factor C.
- (D) Plain circular furnaces and circular flues: minimum required thickness of flue or furnace wall, maximum allowable working pressure.
- (E) Corrugated furnaces: minimum required thickness of furnace wall, maximum allowable working pressure, Factor C.

IV. Fuels and Combustion



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(A) Combustion

- (i) Essentials for economic boiler operation.
- (ii) Classification of fuels: coals, fuel oil, natural gas.
- (iii) Fuel analysis: proximate, ultimate, fuel heat value.
- (iv) Combustion chemistry: combustion balancing equations, air and excess air, products.
- (v) Flue gas analysis: Carbon Dioxide and Oxygen recorders and application of results; smoke prevention.

V. Piping

- (A) Materials for and identification of piping and fittings.
- (B) Strength of piping; commercial pipe sizes; high temperature effects on piping.
- (C) Methods of connecting pipe: screwed, flanged and welded connections; gasket material and applications.
- (D) Piping expansion: expansion bends; slip and corrugated expansion joints.
- (E) Piping supports: strap, roller and constant support hanger; roller stands; anchors.
- (F) Piping drainage: baffle and centrifugal steam separators; mechanical, thermostatic and thermodynamic steam traps; strainers, causes and prevention of water hammer.
- (G) Pipe insulation: material types and characteristics; methods of installation.
- (H) General layout of piping arrangements in power plants.

VI. Electrotechnology

- (A) Direct Current Theory
 - (i) Primary and secondary batteries: internal resistance; specific gravity; battery capacity; construction and maintenance.
 - (ii) Magnetism: magnets and magnetic materials; molecular theory of magnetism; magnetism field; force on conductor; magnetomotive force.
 - (iii) Electromagnetic induction: induced EMF; Faraday's and Lenz's Laws of Induction; Fleming's right-hand rule; self-induction in a coil; mutual induction.
- (B) Direct Current Machines



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- (i) Generators: principle of operation; construction; multi-coil armatures; methods of field excitation; magnetization curve; commutation, speed and voltage control; efficiency and losses; types, shunt, series and compound.
- (ii) Motors: principle of operation; torque development and measurement; armature reaction; interpoles; speed control; methods of starting; types, shunt, series and compound, protection devices.
- (C) Alternation Current Theory
 - (i) Generation of an alternation EMF: sinusoidal wave forms; phase relationships.
 - (ii) Resistance in an A.C. circuit: inductive and capacitive reactance; impedance; power and power factor; single phase circuits.
- (D) Alternating Current Machines
 - (i) Alternator: principle of operation; construction; voltage regulation; synchronizing; parallel operation; taking off the line; switchboard arrangement.
 - (ii) Motors: principle of operation of induction and synchronous motors; construction; speed and slip; methods of starting induction motors.
 - (iii) Transformers: Theory of operation; types of construction; losses and efficiency, methods of cooling.
- (E) The Electron Theory
 - (i) Flow of electricity.
 - (ii) Measurement of current, voltage and resistance.
 - (iii) Voltmeter and ammeter connections.
 - (iv) Circuit-protective and switching equipment: fuses, safety switches; circuit breaker; grounding; lightning arresters.

VII. Electrical calculations

- (A) Potential difference; current; Ohm's Law.
- (B) Series and Parallel circuits; Kirchhoffs' Laws; the Wheatstone Bridge.
- (C) Effect of temperature on resistance; temperature coefficient of resistance.
- (D) Work, energy, power: Joule, coulomb, watt, kilowatt hour.
- (E) Relationship between electrical, mechanical and heat units.



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- (F) Heating effect of the electric current.
- (G) Electrical conductors: circular and square mil; wire gauge.
- (H) Sinusoidal wave forms: Maximum, average and root mean square values; frequency; phase.
- (I) A.C. circuits: resistive, inductive and capacitive; inductive reactance, capacitive reactance, impedance; power factor.
- (J) A.C. machines: relationship between number of poles, frequency and speed.
- (K) Step up and step down transformers.

VIII. Control Instrumentation

- (A) Applications of pneumatic, electric and electronic operated automatic control systems.
- (B) Pressure measuring devices: bourbon tube, manometer, diaphragm, bellows.
- (C) Temperature measuring instruments: glass-stem, remote indicating bulb, and bimetallic thermometers; thermoelectric and optical pyrometers.
- (D) Flow measurement:
 - (i) Flowmeters: variable area, nutating disc, rotary, orifice, venturi.
 - (ii) Indicating mechanisms: monometer, ledoux bell, float manometer, bellows, force balance unit, the integrator.
- (E) Level measuring instruments: float cage units, float manometer.

IX. Fire Prevention and Plant Safety

- (A) General Plant Safety
 - (i) Safety Committee.
 - (ii) Types of accidents: safety measures; safe storage of flammable materials; housekeeping.
 - (iii) Safety equipment: eye, ear, head and respiratory protection requirements.
 - (iv) Precautions taken before entering pressure vessels or boiler for cleaning or repairs.
 - (v) Knowledge of the harmful gases; effects and identification.
- (B) Fire Protection
 - (i) Classes of fires.
 - (ii) Ways to extinguish fires; steps taken in the event of a fire.



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- (iii) Construction and operation of fire fighting equipment.
- (C) First Aid
 - (i) Treatment for electric shock.
 - (ii) Artificial respiration; Holger-Nielson methods, mouth-to-mouth resuscitation.

X. Types and arrangements of Industrial Plants

- (A) Terminologies and definitions common to the petroleum and gas industries.
- (B) Gas Processing Plants:
 - (i) Composition, structure and properties of the hydrocarbons.
 - (ii) Safety in gas plants, emergency systems.
 - (iii) Gas processing: system and equipment; separation sweetening, dehydration, fractionation, condensate stabilization, sulphur recovery, product treating and storage.
- (C) Terminologies and definitions common to the pulp and paper mills.
- (D) Pulp and paper mills: mechanical and chemical manufacturing processes; flow diagrams.



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Part “B” Examination

**Third Paper
Morning Session
3 ½ Hours**

Essay, Sketch and Describe Examination

I. Boilers

- (A) Boiler Classification
 - (i) Boiler development and terminology.
 - (ii) Types of firetube boilers: horizontal return tubular, locomotive, firebox, scotch, multi-pass, packaged.
 - (iii) Types of watertube boilers: straight-tube design, multidrum bent-tube design; packaged “D”, “A” and “O” types; once through, large steam generating units.
 - (iv) Comparisons of firetube and water tube boilers.
- (B) Boiler Construction
 - (i) Shell and drum fabrication: tube manufacture.
 - (ii) Boiler assembly: attachment of tubes, stays and braces.
 - (iii) Access and inspection openings.
 - (iv) Field erection.
- (C) Boiler Details
 - (i) Foundations and supports.
 - (ii) Settings: brickwork, solid wall and sectionally supported wall, water-cooled, fin-welded, tangent-tube and flat-stud tube walls.
 - (iii) Casing and baffle arrangements.
 - (iv) Superheaters and reheater: integral, separately fired, steam temperature control; desuperheaters, attemperation.
 - (v) Economizers: integral and separate, advantages and disadvantages.
 - (vi) Air heaters: plate, tubular, rotary regenerative, corrosion control, advantages and disadvantages.
- (D) Firing Methods



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- (i) Coal firing equipment: mechanical stokers, underfeed, crossfeed, overfeed; pulverizers, impact, ball mill, ball race mill, bowl mill; mill feeders; coal grindability; burner types and furnace arrangements, turbulent, vertical, tangential, cyclone; coal and ash handling, dust collectors.
- (ii) Oil burning equipment: types of burner; steam atomizing, mechanical atomizing, rotary cup.
- (iii) Gas burning equipment: Multi-spud and ring type burners.
- (iv) Draft equipment: types of chimneys; natural, forced and induced draft fans, construction, control, hydraulic and variable speed couplings.
- (v) Precautions when firing with oil or gas.
- (vi) Change over procedure from gas to oil firing.
- (E) Boiler Operation and Maintenance
 - (i) Starting up and shutting down procedures.
 - (ii) Starting up a new boiler for the first time.
 - (iii) Routine and emergency operations.
 - (iv) Causes and prevention of boiler furnace and pressure explosions.
 - (v) Chemical and mechanical boiler cleaning methods, boiling out a new boiler.
 - (vi) Method of cleaning and preparing a boiler for inspection.
 - (vii) Inspection: fire and water sides, safety precautions.
 - (viii) Hydrostatic test.
- (F) Boiler Fittings

Thorough knowledge of all boiler fittings including the following:

 - (i) Construction, installation, operation and testing of the water gauge and water column.
 - (ii) Construction, installation, operation, testing and setting of the safety valves.
 - (iii) Construction, installation, operation and testing of the low-water fuel cut-off.
 - (iv) Pressure gauges; feedwater connections; stop, vent, water gauge and blowdown valves; blowdown tank.
 - (v) Drum internals: baffles, scrubbers, separators, driers, piping, circulation of steam and water.



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(vi) Soot-blowers; stationary and retractable, locations, shot cleaning.

II. Boiler Control Systems

- (A) Feedwater control: single, two and three element feedwater regulator.
- (B) Combustion control: direct pressure control of fuel and air, steam flow-air control, fuel flow-air control, multi element control, safety devices and interlocks, flame failure detection, principle of operation of a programmed control on an automatic packaged type boiler.
- (C) Steam temperature control: automatic control of desuperheating, attemperation, gas recirculation, gas by-pass and tilting burners.

III. Heating and Air Conditioning

- (A) Heating Boilers and Accessories
 - (i) Types of boilers: cast iron sectional, steel plate, packaged, module type cast iron.
 - (ii) Heating boiler fittings required by the Regulations.
 - (iii) Heating boiler controls: construction, testing and maintenance; programmed control sequence, starting up and shutting down.
 - (iv) Accessories: radiators; convectors; unit heaters; pipe coils; unit ventilators; air vents; radiator valves and traps; reducing valves; receiver and vacuum pumps; piping, fittings; hangers and insulation; condensate return traps.
 - (v) Heating boiler operation and maintenance: laying up for extended periods; water treatment.
- (B) Heating Systems
 - (i) Heating systems: steam heating; hot water heating; steam to hot water convertor; high temperature hot water.
 - (ii) Operation of heating systems: filling; starting; cleaning out; control; use of anti-freeze.
 - (iii) System equipment: expansion tanks and circulating pumps.
- (C) Air Conditioning
 - (i) Definitions: dew point; relative humidity; dry and wet bulb temperatures.
 - (ii) Air conditioning systems: induction; dual duct; combined heating and air conditioning.



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(iii) System auxiliary equipment: air cleaners; humidifiers.

IV. Feedwater Treatment

- (A) Impurities in fresh water, and their harmful effects.
- (B) Chemical reactions in water treatment; pH values.
- (C) Definitions of: precipitation; in solution; in suspension; scale; corrosion; pitting; priming; foaming; coagulation; ion exchange.
- (D) Methods of feedwater treatment: settling, coagulation and filtering; lime-soda hot and cold process softening; sodium and hydrogen zeolite softening; demineralization; mechanical deaeration; evaporation.
- (E) Internal treatment methods of boiler water: prevention of scale, foam, caustic embrittlement and return line corrosion; pH control; sludge conditioning; chemical deaeration; blowdown control; chemical feed systems.
- (F) Feedwater and boiler water testing methods: hardness; alkalinity; dissolved solids; sodium sulphite; phosphate; pH value.

V. Pumps

- (A) Theory of pumping.
- (B) Reciprocating Pumps
 - (i) Steam driven: simplex, duplex, operation, slide valve setting, lost motion, packing, lubrication, maintenance.
 - (ii) Power driven: types of drives, necessity for relief valves.
- (C) Centrifugal Pumps
 - (i) Classification and principles of operation: volute, diffuser, turbine and rotary pumps.
 - (ii) Construction and parts: single and multi-stage, impeller types, wear rings, shaft sealing arrangements, balance disc, types of drives.
 - (iii) Operation: starting and stopping, priming, lubrication.
- (D) Injectors
 - Construction and operation.

VI. Welding

- (A) Welding processes: metal, shielded and submerged arc; gas.
- (B) Electrodes: classification, types and uses.
- (C) Fabrication: plate preparation, single and double butt welds, preheat, stress relieving, testing inspection.
- (D) Safety practices.
- (E) Welding procedure and performance qualifications.



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Part "A" Examination

Fourth Paper
Afternoon Session
3 ½ Hours

I. Prime Movers

- (A) Steam Engines
 - (i) Advantages and disadvantages of steam engines.
 - (ii) Engines: parts and their functions, terminology, classification, arrangements.
 - (iii) Engine operation: valve setting and adjustment, governing, starting up and shutting down.
 - (iv) Engine lubrication: methods, the mechanical lubricator.
 - (v) Indicated and brake horsepower, the prony brake.
- (B) Steam Turbines
 - (i) Advantages and disadvantages of steam turbines.
 - (ii) Principles of the impulse and reaction turbines: shapes of blades.
 - (iii) Impulse turbine staging: pressure, velocity and pressure-velocity compounding.
 - (iv) Turbine types and applications.
 - (v) Turbine parts: casings, rotors, dummy pistons, bearings, thrusts, glands, governors, overspeed trip, safety devices.
 - (vi) Starting up and shutting down.
 - (vii) Plant auxiliaries: heat exchanger, condensers, condenser auxiliaries, feedwater heaters, deaerator, evaporator, cooling towers.
- (C) Gas Turbines
 - (i) Advantages and disadvantages of gas turbines; applications.
 - (ii) Basic cycle and improvements; regeneration, dual shaft arrangement intercooling and reheating, the closed cycle, combined steam and gas turbine cycles.
 - (iii) Turbine parts: compressors, combustors, safety devices.
 - (iv) Starting up and shutting down.
- (D) Internal Combustion Engines
 - (i) Classification of engines: types of fuels, methods of ignition working cycle.



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- (ii) Gasoline engine: two and four stroke cycles, carburettor, spark and magneto ignition.
- (iii) Diesel engine: two and four stroke cycles, fuel injection, fuel systems, operation and maintenance.
- (iv) Internal combustion engines: lubrication, governing, starting and cooling methods, supercharging.
- (v) Typical diesel engine construction: cylinders, frame and crankcase, bedplate, crankshaft, flywheel, connecting rods, pistons and rings, cylinder liners, heads and valves, camshaft, crankcase safety fittings, flame proofing.

II. Air Compressors

- (A) Theory of Air Compression:
 - (i) Uses of compressed air.
 - (ii) Terminology and definitions.
 - (iii) Effect of altitude and moisture.
 - (iv) Compressor calculations; displacement, volumetric efficiency.
 - (v) Multi-stage compression.
- (B) Classification of Air Compressors.
- (C) Positive Displacement Compressors:
 - (i) Reciprocating; principle operation, methods of drive, compressor parts.
 - (ii) Free piston; principle of operation.
 - (iii) Types of rotary units, construction and principles of operation; sliding vane, rotary lobe, rotary screw.
- (D) Dynamic Compressors:
 - (i) Centrifugal and axial flow units, construction and principles of operation; and
 - (ii) cause and prevention of surging.
- (E) Compressor starting and stopping procedures.
- (F) Compressor Auxiliaries:
 - (i) Intercoolers and aftercooler; air receivers.
 - (ii) Compressor control; start and stop, variable and constant speed; safety devices.
 - (iii) Compressor lubrication, internal and external.



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(iv) Installation and piping layouts.

III. Refrigeration

- (A) Principle and applications of mechanical refrigeration; refrigeration capacity rating.
- (B) Refrigeration mediums: physical properties; characteristics, applications.
- (C) Compression System:
 - (i) Principle and basic systems.
 - (ii) Ammonia, flooded evaporator, direct and indirect systems.
 - (iii) System components, compressors, condensers, liquid receiver, evaporators, oil separator, piping and accessories.
- (D) Absorption System:
 - (i) Principle and basic system.
 - (ii) Ammonia and water vapour absorption systems.
- (E) Comparison of absorption and compression systems.
- (F) Refrigeration Auxiliaries:
 - (i) System controls: expansion valves, low-side float, high-side float, capillary tube.
 - (ii) Compressor controls: temperature and pressure actuated.
 - (iii) Condenser cooling water control.

IV. Lubrication

- (A). Lubrication oils, synthetic oils.
- (B) Characteristics of greases.
- (C) Oil viscosity, pour point.
- (D) Prime mover lubricating oils.
- (E) Bearings and bearing lubrication.
- (F) Filters and filter materials.