REFERENCE SYLLABUS

For

NEW THIRD CLASS

POWER ENGINEER'S

CERTIFICATE of QUALIFICATION

EXAMINATION

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

Introduction

The New Third Class Syllabus has been approved by the Association of Chief Inspectors (ACI). is syllabus is intended to assist candidates studying for the New 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 (New) Third Class Power Engineer Examination, the candidate completes a New Third Class Power Engineer's Course offered through either a British Columbia or national institute or technical college recognized by the provincial safety manager. Candidates would be well advised to have a good basic knowledge of mathematics, sciences, and English, before enrolling in an approved college, technical, vocational, or correspondence course. 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 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 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.

	1st	2nd	3rd	4th
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		
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)	X	X	X	

ISBN#0-8273-5077-5				
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.

Excerpts:

Power Engineers, Boiler, Pressure Vessel and Refrigeration Safety Regulation

Application for third class power engineer's certificate of qualification

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 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 s team 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.

Part "A" Examination

First Paper
Morning Session
3 ½ Hours

1. **Applied Mathematics:**

   Use these mathematics disciplines to complete engineering calculations:

   Elementary Algebra (simple equations); Trigonometry; mensuration (areas, volumes of plane and solid figures); natural and naperian logarithms (using calculators)

2. **Applied Mechanics:**

   Explain theories, define terminologies, and perform problem -solving calculations involving the following topics:

   a. Applications of forces, vector diagrams.

   b. Friction on level and inclined surfaces.

   c. Linear and angular velocity stet acceleration.

   d. Work, power and energy.

   e. Moments of force and simple machines; mechanical advantage; velocity ratio; efficiency.

   f. Stress and strain; safe working stress; yield point and ultimate strength; factor of safety.

   g. Bending of beams; equilibrium, shearing forces and bending moments.

   h. Density and specific gravity.

3. **Thermodynamics:**

   Explain theories, define terminologies and perform problem-solving calculations involving the following topics:

   a. Temperature measurement units/scales.

   b. Expansion of solids (linear, area and volume) and liquids.

   c. Quantities of heat; specific heat.

   d. Changes of State; sensible and latent heat; heat content in mixtures of water, ice and steam; saturated and superheated steam.

   e. Steam tables; temperature-enthalphy charts; critical temperature and pressure; dryness fraction; equivalent evaporation, factor of evaporation.

   f. Methods of heat transfer; conduction, convection, radiation.

   g. Work and heat; mechanical equivalent of heat; laws of thermodynamics.

   h. Expansion and Compression of Gases: Boyle's and Charle's laws of perfect gases, general gas

law, characteristic gas constant; isothermal, adiabatic and polytropic processes; pressure-volume diagrams; work done in cylinders; indicated horsepower; thermal efficiency.

4. **Applied Science:**

a. Basic Chemistry:

i. Molecules, atoms, elements compounds, mixtures.

ii. Structure of the atom, atomic number, atomic weight, formula weights, the mole; molar mass calculations; periodic table of the elements.

iii. Chemical formulae; balancing chemical equations.

iv Properties of acids, bases, salts.

v. Simple organic chemistry; structure of hydrocarbons.

vi. Typical industrial applications of chemistry: water treatment, combustion; corrosion.

b. Metallurgy and Engineering Materials:

i. ANSI and ASME classifications of metals; methods of steel and iron production.

ii. Properties, grades and applications of cast iron.

iii. Properties, grades and applications of steel; alloying metals and applications.

iv. Properties and applications of non-ferrous metals.

v. Properties and application s of non-metallic materials; plastics, carbon fibers, ceramics, polymers.

vi. Corrosion principles; types of corrosion, corrosion monitoring and prevention methods and devices, corrosion inspection.

c. Industrial Drawings:

Identify components and interpret symbols for the following engineering drawings:

i. Mechanical flow drawings (MFDs)

ii. Process and instrument drawings (P&IDs).

iii. Engineered construction drawings for pressure vessels and other equipment.

iv. Equipment layout.

v. Material Balance.

Part "A" Examination

Second Paper
Afternoon Session
3 ½ Hours

5. **Industrial Legislation and Codes:**

a. General knowledge of the purpose. content and application of the boiler and pressure vessel codes and regulation, including the Power Engineers' Regulations in the student's jurisdiction.

b. State the purpose and describe the general content of each of the following codes:

i. ASME Section I - Power Boilers

ASME Section IV - Heating Boilers

ASME Section V - Nondestructive Examination

ASME Section VI - Suggested Rules for Care of Heating Boilers

ASME Section VII - Suggested Rules for Care of Power Boilers

ASME Section IX - Welding & Brazing Qualifications

ii. CSA Standard B.51 - For Construction and Inspection of Boilers and Pressure Vessels

CSA Standard B.52 - Mechanical Refrigeration Code

iii. National Board Inspection Code

6. **Code Calculations, ASME Section I:**

Use Code formulae and information to calculate the following (using SI units):

i. Designed thickness and allowable pressures of boiler tubes, drums, dished and hemispherical heads.

ii. Sizes and capacities of boiler safety valves.

7. **Fuels and Combustion:**

i. Requirements for efficient combustion of boiler fuels; complete and incomplete combustion.

ii. Classification, properties and combustion characteristics of coal, fuel oil and natural gas; other (non-fossil) fuels.

iii. Fuel analysis; proximate, ultimate, fuel heat value; calorimetry.

iv. Combustion chemistry; combustion equations for coal, oil, and gas; molar masses for combustion products.

v. Combustion calculations; oxygen, air and excess air required, given fuel analysis.

vi. Flue gas analysis methods and devices; CO; CO_2 and 0_2

vii. Control of emission standards: NOx, SO_2, particulates.

8. **Piping:**

i. Codes and standards for pressure piping: ASME, ANSI, CSA, ASTM; identification and sizes of piping; B31.1, B31.3; power piping vs. pressure piping.

ii. Ferrous piping materials and methods of manufacture; specifications and service ratings; non-ferrous materials.

iii. Non-metallic piping: materials and applications.

iv. Strength of piping; effects of temperature on piping

v. Piping connection methods: threaded, flanged, welded; design, materials, selection and installation of gaskets.

vi. Designs and applications of expansion devices, supports and anchors.

vii. Types of steam traps; trap sizing and selection; trap installation configurations; trap inspection installation configurations; trap inspection and maintenance; trap flow calculation.

viii. Water hammer: effects; causes; design and operational preventions.

ix. Insulation: purposes; benefits; characteristics; common materials and their uses; methods of application; cladding; care of insulated piping systems; calculations using coefficient of thermal conductivity.

x. Common and specialty valves: purpose, design, operation and applications; valve flow configurations; valve trim; actuator types.

9. **Electrotechnology:**

a. Direct Current Theory:

i. Electron theory; theory of magnetism; magnetic field; force on conductor.

ii. 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:

i. Generators: operating principles, construction, commutation, speed and voltage control; 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. Alternating Current Theory:

i. Generating an alternating EMF; sinusoidal wave forms; phase relationships.

ii. Resistance in AC circuits; inductive and capacitive reactance; impedance; power and power factor; single and multi-phase circuits.

d. Alternating Current Machines:

i. Alternators: principle of operation, construction, voltage regulation, excitation methods, parallel operation, synchronizing procedures; automatic synchronizers, taking off the line, switchboard components (meters, breakers, machine protection relays)

ii. Motors: principle and operation of induction and synchronous motors; construction; speed and slip; starting methods for induction motors; speed control; variable speed starting, stepstarting

iii. Transformers: operating theory; types (design and construction), losses and efficiency; methods of cooling; safety and fire protection

e. AC Systems, Switchgear, Safety:

i. Components, layout, and operation of a typical industrial AC power system

ii. Components of an AC generator panel

iii. Circuit protective and switching equipment: fuses, safety switches; circuit breakers; circuit protection relays; automatic bus switchover (emergency supply to normal supply); grounding; lightning arresters.

iv. UPS/Inverter Systems: purpose, components, operation; battery design and maintenance.

v. Electrical safety for operators

10. **Electrical Calculations:**

Explain theories and perform calculations for:

a. Current, voltage, resistance in series and parallel circuits; using Ohm's Law and Kirchhoff's Laws; Wheatstone Bridge.

b. Temperature coefficient of resistance.

c. Work, energy, power: relationship between electrical, mechanical and heat units.

d. Sinusoidal Wave Forms: maximum, average and root mean square root values; frequency; phase.

e. AC Circuits: inductive reactance, capacitive reactance, impedance, KVA; power factor

f. Relationship between poles, frequency, speed for AC machines

g. Transformer calculations; step up and step down

11. **Control Instrumentation:**

a. Control loops and strategies:

i. Applications of pneumatic, electric and electronic (digital) control systems; components and operation of typical control loops; .

ii. On-off, proportional, reset, derivative control strategies

iii. Feed forward, feedback, cascade, ratio, split-range, select control

iv. Alarm and shutdown functions in a control loop; operator interfaces with control loops

b. Instrument and Control Devices: design and principles of common temperature, pressure, flow, and level instruments

c. Distributed and Logic Control Systems:

i. Components, layout, functions of distributed control system

ii. DCS operator interface components; trending; data logging; alarms and shut-downs.

iii. Programmable logic controllers: purpose, design, components; applications; ladder diagrams.

iv. Supervisory control and data acquisition systems (SCADA) as used in process control: purpose and general functions:

12. **Industrial Safety and Fire Protection:**

a. Safety Management Programs:

i. Introduction to OH&S Acts in general

ii. Workplace OH&S Programs: setting up a program; purpose and interaction with WCB; company and employee responsibilities; typical components of an OH&S program: safety committees, hazard identification, incident investigation, personal safety equipment; work permit systems (equipment lock-out, confined space entry, hot and cold work, excavations); WHMIS (overview); emergency response plans;

b. Fire Protection Systems:

i. Classes of fire; extinguishing methods

ii. Components and operation of industrial fire detection and alarm system

iii. Sprinkler systems (dry and wet stand); pre-action and deluge; design and operation

iv. Fixed fire systems: firewater pump, loops, hydrants; vessel deluge system; foam systems

v. Industrial fire response

Part "B" Examination

Third Paper
Morning Session
3 ½ Hours

Essay, Sketch and Describe Examination

13. **Boilers**

a. Boiler Classification:

i. Definitions and designs of typical Watertube Boilers: multi-drum bent tube; D, A, O configurations; packaged, once-through, forced circulation, critical vs. super-critical boilers

ii. Special Boiler Designs: describe the design, components and operation of the following designs: fluidized bed boilers, heat recovery steam generators (HRSG), black liquor boilers, waste heat boilers, refuse boilers, Bio-mass, high-pressure/high-temperature hot water boilers

b. Boiler Construction:

i. Designs, fabrication, construction methods, and Code requirements for: shells, drums, tubes (include attachment methods), nozzles; headers; handholes/manholes

ii. Field assembly of a large watertube boiler

iii. Boiler metals – applications and purpose

c. Boiler Heat Transfer Components:

i. Watertube boiler settings (brickwork and refractory), baffles; integral furnace designs and waterwalls: studded tubes; water-cooled walls: fin-tube, tangent-tube, flat -stud tube

ii. Superheaters: primary, secondary, convection, radiant, integral and separately-fired; operating characteristics;

iii. Reheater designs

iv. Economizers: integral and separate; tube styles, advantages/ disadvantages

v. Air Heaters: plate, tubular, rotary regenerative designs; heater corrosion control; advantages/disadvantages

vi. Sootblowers: stationary and retractable, locations, shot cleaning

d. High Pressure Boiler Fittings:

Design, installation/location, operation, testing and Code requirements for each of the following boiler fittings:

i. Water columns and gauge glasses; types of remote level indicators; illumination; safety shutoff

ii. Safety valves; setting

iii. Low-water fuel cut -offs; float and probe designs

iv. Steam outlet fittings and non-return designs

v. Pressure gauges; feedwater connections; vents; and blowdown valve designs; blowdown procedures; blowdown tank

vi. Drum Internals: baffles, scrubbers, separators, driers, piping circulation and separation of steam and water

e. Fuel, Draft, and Flue Gas Systems:

i. Coal firing equipment: mechanical, underfeed, crossfeed and overfeed stokers; pulverizers - impact, ball, ball-race and bowl mills; burner and furnace designs - turbulent vertical, tangential, cyclone; coal feed systems; ash handling systems - hydro and air, bottom ash

ii. Oil burning equipment: oil burner designs - steam, oil and mechanical atomizing; components of large oil burner systems; start-up/shut-down of large oil burners; cleaning and maintenance

iii. Gas burning equipment: burner designs – spud, multi-spud and ring; burner gas supply system; start-up sequence for gas burner; high-efficiency, low NOx burners;

iv. Draft equipment: natural, forced, induced, balanced draft; draft fan designs, control methods; fan performance curves; draft measurement; windbox and air louvers; primary and secondary air

v. Flue gas clean-up methods and equipment: precipitators, filters, ash handling systems; SO_2 recovery systems

f. Boiler Operation and Maintenance:

i. Manual start -up and shut-down procedure for large, industrial boilers;

ii. Initial start-up (commissioning) of a new boiler

iii. Routine and emergency operations

iv. Causes and prevention of boiler furnace and pressure explosions

v. Chemical and mechanical boiler cleaning methods; boiling out

vi. Methods of cleaning and preparing a boiler for inspection

vii. Inspection: fire and water sides; safety

viii. Hydrostatic test

14. **Boiler Control Systems:**

a. Boiler Water Level Control: components, purpose and operation of single-element, two-element, and three-element control systems; explain swell and shrinkage

b. Combustion control:

i. Design and operation of each of the following combustion control systems: direct pressure control of fuel and air, steam flow–air flow control, fuel flow–air flow control, air flow–fuel flow, multi-element control

ii. Safety devices and interlocks

iii. Flame failure detection: continuous, intermittent, interrupted pilots; photo-electric cells

v. Automatic, programmed boiler start-up and shut-down sequence

c. Steam temperature control: desuperheating control, attemperation, gas recirculation, gas bypass, tilting burners

15. **Feedwater Treatment:**

a. Feedwater impurities and their effects on boiler operation

b. External, feedwater treatment: Explain the purpose, physical and/or chemical operating principles, system/equipment design and operation for each of the following: settling, coagulation and filtering, hot and cold lime-soda softening, hot phosphate softening, sodium and hydrogen zeolite softening, demineralization, dealkalization, mechanical deaeration, evaporation (multieffect evaporators), reverse osmosis

c. Internal Boiler Water Treatment:

i. Causes, effects and controls for boiler internal water problems

ii. pH control – magnetite layers, acidic and caustic corrosion

iii. Sludge conditioning and dispersion; modern sludge dispersants

iv. Chemical deaeration – oxygen corrosion; sulphite programs; hydrazine

v. Carryover – priming, misting, foaming

vi. Dissolved solids – blowdown control; conductance; simple and heat recovery blowdown systems; automatic blowdown systems

vii. Return line corrosion – neutralizing and filming amines

viii. Scale control – phosphate and chelate programs

d. Chemical feed systems: shot and continuous feed systems; chemical feed pumps

e. Feedwater and boiler water testing methods: automatic sampling systems and monitors; boiler and steam system parameters and test locations

16. **Pumps**

a. Theory of pumping: define and explain pump head terms, perform pump head and pressure calculations, explain cavitation

b. Reciprocating pumps: pump drivers; single and double-acting designs; plunger type; diaphragm type; pump protection

c. Centrifugal pumps:

i. Classification and principles of operation for volute, diffuser and turbine pumps; axial and mixed flow

ii. Construction and components: single and multi-stage;impeller types; wear rings; shaft sealing arrangements - stuffing box, lantern ring, mechanical seals; balance disc, drum; opposed impellers

iii. Operation: starting and stopping, priming

iv. Typical pump installation; auto-recycle valve

d. Rotary pumps: design and operation of gear, lobe, screw

17. **Welding Procedures and Inspection:**

a. Welding Processes (overview): describe and state where each of these processes would be used - metal arc, shielded arc, submerged arc, gas (TIG), MIG

b. Electrodes: classification, types and uses; where and why each would be used

c. Fabrication and repairs: weld preparation; preheating, performing a boiler tube repair, postweld heat treatment (stress relieving)

d. Causes and effects of common weld defects

e. Weld inspection procedures: non -destructive examination techniques; destructive examination techniques

f. Welding Procedure and Welder's Performance Qualifications per ASME Code, Sect. 9

18. **Pressure Vessels**

b. Explain design, construction, operation and repair regulation of pressure vessels, including stamping and nameplate details

c. Head, nozzle, manway designs

d. Loads and stresses on pressure vessels

e. Typical components/fittings on a pressure vessel

f. Safe operating and maintenance consideration, including hydro and pneumatic testing; inspection

Part "A" Examination

Fourth Paper
Afternoon Session
3 ½ Hours

19. **Prime Movers:**

a. Steam Turbines:

i. Impulse and reaction principles; nozzles; blade shapes;

ii. Turbine arrangements: staging and compounding: principles and p-v diagrams for pressure, velocity and pressure-velocity compounding

iii. Turbine components: purpose, design, operation of the following: casings, disc and drum rotors, dummy pistons, journal and thrust bearings, barring gear, blade and shaft sealing glands, couplings, interceptor valves on reheat turbines

iv. Explain purpose and arrangements of condensing, bleeder, topping, extraction, cross and tandem compounded turbines

v. Turbine governor types; speed-sensitive, pressure-sensitive, nozzle, throttle, bypass; mechanical, mechanical hydraulic, electronic-hydraulic; droop and isochronous operation

vi. Starting and shutting down condensing and extraction turbines

vii. Steam turbine condensers: types, air-cooled, water-cooled, Panier style; condenser auxiliaries; condenser operation; feedwater heater system

b. Gas Turbines:

i. Applications, advantages and disadvantages of gas turbines

ii. Basic cycle and improvements: open and closed cycles defined, regeneration, dual shaft arrangement, intercooling and reheating, typical gas turbine operating parameters and efficiency, combined steam and gas turbine cycles

iii. Main gas turbine components: radial and axial compressors, combustor arrangements and operation, turbine rotor designs

iv. Gas turbine support systems: fuel supply systems; lubrication; barring gear; steam injection; intake and exhaust components

v. Supervisory, protective, and control systems

vi. Starting and stopping procedures and sequences; turbine washing

c. Internal Combustion Engines:

i. Gasoline engines: spark ignition defined, two-stroke cycle, four-stroke cycle, carburetion;

carburetor design and operation, spark ignition components, fuel injection

ii. Diesel engines: compression ignition defined, two-stroke cycle, four -stroke cycle, scavenging, fuel injection; fuel injectors; purpose and design of the major mechanical/structural components of a diesel engine; starting and maintenance procedures

iii. Engine support systems: fuel systems, lubrication, governing, starting systems and methods, magneto system, cooling systems, supercharging and turbo-charging

iv. Thermodynamic heat engine cycles: explain the Otto, Diesel and Brayton cycles

20. **Cogeneration:**

Purpose, advantages, components of cogeneration systems; simple and combined cycle, using gas turbines and internal combustion engines; single and dual shaft arrangements; control strategies and components; environmental considerations; heat recovery boilers and water heaters; operating procedures; typical industrial cogeneration applications

21. **Compressors:**

a. Theory of Compression:

i. Adiabatic and isothermal compression; pressure volume relationships; compression ratio, capacity, multi-staging; effect of altitude and moisture

ii. Applications for compression, including air and gas.

b. Positive Displacement Compressors: design, operating principles

i. Reciprocating compressors: clearance volume; indicator diagrams; calculations for displacement and volumetric efficiency.

ii. Free piston compressor

iii. Rotary Compressors: sliding vane, lobe, and screw types (industrial screw type in detail, including control panel)

c. Dynamic Compressors:

i. Design and operation of centrifugal and axial flow compressors; application as blowers

ii. Compressor surge: causes and prevention; P-V curve; surge line, anti-surge system and Control

d. Starting and stopping procedures for positive displacement and dynamic compressors

e. Compressor Auxiliaries:

i. Intercoolers/aftercoolers; moisture separators

ii. Compressor control systems and devices: start and stop, variable and constant speed; safety devices

iii. Lubrication: internal and external

iv. Compressor installation and piping layouts

f. Compressed air system components:

i. Typical system layout; air receivers (wet and dry) fittings and operation; filters

ii. Air dryers: system design, flows, operation; dewpoint monitoring

22. **Refrigeration:**

a. Refrigerant classifications, properties, characteristics;

b. Compression systems:

i. Principle of compression refrigeration; typical system temperatures and pressures for simple refrigeration systems

ii. Multi-stage systems: 2-stage with duplex compressors; 2-stage with booster compressor; low-temperature multi-stage

iii. Direct vs. indirect systems

iv. Typical refrigeration applications

c. Absorption system: ammonia absorption system description and operating parameters

d. Refrigeration system 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. Safety devices and controls: pressure relief devices, high-pressure cut-out, low-pressure lube oil cut-out

e. CSA B52 Regulations: overview of the code for the safe operation, installation and repair of refrigeration equipment

f. System Operation: leak testing, charging, purging, troubleshooting (condenser, regulator, refrigerant strength, compressor discharge temperature); effects of moisture in system; effects of oil in the refrigerant; oil removal using oil separators, oil traps, oil still; operating and maintaining brine systems

23. **Special Industrial Equipment:**

Describe the general applications, designs, components, operation for the following:

a. Heat exchangers: double pipe designs; shell-and-tube configurations, head designs, reboiler and feedwater heater fittings; plate frame; overhead aerial coolers; aerial steam condensers, including operation and control

b. Cooling towers: natural draft, atmospheric, hyperbolic; mechanical draft designs; operation and control

c. Fired Heaters: multi-burner vertical designs; burner components and styles; fuel supply and control; interlocks and safety devices; indirect-fired heaters; horizontal designs; start-up and shutdown procedures

24. **Wastewater Treatment:**

a. Purpose of WWT; typical wastewater pollutants and systems

b. Theory and equipment for specific treatment process: removal of suspended solids (screening, floatation, sedimentation); removal of colloidal solids (chemical coagulation, flocculation, clarification); biological treatment (activated sludge, rotating biological contactors, trickling filters)

c. Operating parameters, controls and tests: nutrients, BOD, COD, pH, settleability

d. Safety in wastewater treatment plants

25. **Plant Maintenance and Administration:**

Explain the purpose, typical design and administration of the following plant functions:

a. Communication and accountability structures

b. Scheduled and preventative maintenance programs

c. Record keeping; logbooks; logsheets

d. Project control; critical path (applied to a complete boiler turnaround, as an example)

e. Operating standards and procedures

f. Training and development practices; job skill profiles

g. Environmental practices and supervision