3rd Class Curriculum

SOPEEC Syllabus, dated **January 2014**

Previous Syllabus dated **2006**

Updated **March 2014**

By BFB

Changes from the previous version will be in Blue, deletions will be in Red

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The Learning Material Reference Column currently refers to the PanGlobal materials unless otherwise stated. This document is divided by exam papers or parts, which coincide with the PanGlobal materials. The numbers in the Learning Materials Reference column refer to the chapter number in the materials and the Objective number.

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
Part "A1"			
1.	Applied Mathematics		
	Use these mathematics disciplines to complete	*Apply the rules for addition, subtraction, multiplication and division of positive and negative quantities.*	*3A1.1.1*

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
	engineering calculations: *Elementary algebra (simple equations)* *Trigonometry; mensuration (areas, volumes of plane and solid figures);* *Natural and naperian logarithms (using calculators)*	*Simplify algebraic expressions and operations involving the removal or insertion of brackets.*	*3A1.1.2*
		Apply the rules for powers and roots to the multiplication and division of quantities and expressions.	*3A1.1.3*
		Apply the rules of transposition to solve simple equations involving addition, subtraction, multiplication and division.	*3A1.1.4*
		Solve equations involving powers, roots, and fractions.	*3A1.1.5*
		Identify the types of angles and specify angle size in degrees and radians.	*3A1.2.1*
		Identify right, obtuse, and acute triangles and apply the naming convention for sides and angles.	*3A1.2.2*
		Use Pythagoras' Theorem to calculate the side lengths of a right angle triangle and solve simple problems involving right triangles.	*3A1.2.3*
		Explain the sine, cosine, and tangent of an angle and determine the values of these functions for all angles between 0º and 360º.	*3A1.2.4*
		Using sine, cosine, and tangent, find the dimensions of right triangles and solve physical problems involving right triangles.	*3A1.2.5*
		Define the Sine Rule and use these rules to determine the unknown dimensions of oblique triangles.	*3A1.2.6*

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
		Convert between Imperial and SI units of measure; convert unit magnitudes for area and volume within the SI system.	*3A1.3.1*
		Calculate the areas of triangles given altitude and height, or the lengths of the sides.	*3A1.3.2*
		Define the following quadrilaterals and calculate their areas: rectangle, square, rhomboid, rhombus, trapezoid, and trapezium.	*3A1.3.3*
		Define the following polygons and calculate their areas: hexagon, octagon.	*3A1.3.4*
		Define and calculate areas of: a circle, a segment of a circle, a sector of a circle, and an ellipse.	*3A1.3.5*
		Solve problems involving the surface areas and volumes of cylinders and spheres.	*3A1.3.6*
		Define terms and solve problems involving the surface areas and volumes of pyramids, cones, and frustums.	*3A1.3.7*
		Explain common Naperian (natural) logarithms. Using a calculator, perform mathematical operations and solve equations that contain logarithms	*3A1.1.6*
		Apply an organized, systematic approach to solving a problem and presenting the solution.	*3A1.1.7*
2.	Applied Mechanics		
	Explain theories, define terminologies, and perform problem-solving calculations involving the following		

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
	topics:		
2.a.	*Applications of forces; vector diagrams.*	*Define, coplanar and concurrent vectors, and draw space diagrams for forces and displacements.*	*3A1.4.1*
		Draw a vector diagram and use it to graphically determine the resultant and equilibrant of a force system.	*3A1.4.2*
		Use trigonometry to resolve forces into components and to calculate the resultant and equilibrant of a force system.	*3A1.4.3*
		Given a coplanar, concurrent force system, calculate any unknown forces.	*3A1.4.4*
2.b.	*Friction on level ~~and inclined~~ surfaces.*	*Define static friction, sliding friction, and coefficient of friction, use the friction formula to calculate coefficient of friction.*	*3A1.4.5*
		Explain friction angle and perform friction calculations for forces applied parallel to the horizontal plane.	*3A1.4.6*
		Calculate the coefficient of friction, object mass, and applied forces for objects moved on a horizontal surfaces that are NOT parallel to the plane.	*3A1.4.7*
2.c.	*Linear and angular velocity and acceleration.*	*Define, and show the relationships, between, distance, displacement, speed, linear velocity, and linear acceleration.*	*3A1.5.4*
		Using linear motion relationships, calculate the displacements, velocities and accelerations of bodies moving in a straight line.	*3A1.5.5*

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
		Define and calculate angular displacement, angular velocity and angular acceleration.	*3A1.5.6*
2.d.	*Work, power, and energy.*	*Define force, force due to gravity, and work. Calculate the work done in moving objects horizontally and vertically*	*3A1.5.1*
		Define power and mechanical efficiency. Calculate the power expanded when work is done, plus the power developed and mechanical efficiency of a reciprocating engine.	*3A1.5.2*
		Define potential and kinetic energy. Calculate the energies of stationary and moving objects.	*3A1.5.3*
		Calculate the work done to compress a spring *(New objective January 2014)*	*TBD*
2.e.	*Moments of force and simple machines; mechanical advantage; velocity ratio; efficiency.*	*Define moments of force.*	
		For simple machines in general, define and calculate mechanical advantage (MA), velocity ratio (VR), and efficiency.	*3A1.7.1*
		Calculate the efforts, loads, MA, VR, and efficiencies of wheel and axle systems,	*3A1.7.2*
		Calculate the efforts, loads, MA, VR, and efficiencies of various pulley systems.	*3A1.7.3*
		Calculate the efforts, loads, MA, VR, and efficiencies of a screw jack	*3A1.7.4*
		Calculate the efforts, loads, MA, VR, and efficiencies of ***levers, and inclined planes, (Added January 2014)***	*TBD*

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
2.f.	*Stress and strain; safe working stress; yield point and ultimate strength; factor of safety.*	*Define and explain, using appropriate formula where applicable, terms that apply to materials under load, including stress, tensile, compressive, shear, strain, elastic limit, ultimate load, ultimate strength, allowable working stress, factor of safety, Hooke's Law, Young's Modulus of Elasticity* ***proportional limit and breaking point****.*	*3A1.6.1*
		Use a stress/strain diagram for mild steel to define and explain: Proportional limit • ***Elastic limit*** • ***Yield Point*** • ***Ultimate stress*** • ***Breaking point***	*TBD*
		Calculate stress, strain, ultimate strength, factor of safety, and/or modulus of elasticity for materials under various load situations.	*3A1.6.2*
2.g.	*Bending of beams; equilibrium, shearing forces and bending moments.*	*Explain the types of beams, beam supports, and beam loads and state the requirements for beam equilibrium.*	*3A1.6.3*
		Calculate the reaction forces for simple and cantilever beams, with point and distributed loads.	*3A1.6.4*
		Explain the shear forces and bending moments in a beam and the compression/tension profile of a loaded beam.	*3A1.6.5*
		Calculate the sheer force at any given point in a simple or cantilever beam.	*3A1.6.6*
		Calculate the bending moment at any given point in a simple or cantilever beam.	*3A1.6.7*

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
2.h.	*Density ~~and~~ specific gravity,* ***Fluid pressure and fluid flow*** *(Additional terms added January 2014)*	*Define and state the relationships between mass density, relative density, weight density, specific weight, and specific gravity.*	*3A1.7.5*
		Given unknowns, calculate the densities, relative densities, masses and/or volumes of substances.	*3A1.7.6*
		Calculate pressures exerted by columns of fluids and convert between gauge pressure, absolute pressure, millimeters of mercury, millimeters of water.	*3A1.7.7*
		Calculate the pressure and force exerted by a liquid at various levels in a tank.	*3A1.7.8*
		Explain flow continuity and calculate simple flows and velocities of liquids in a pipe.	*3A1.7.9*
3.	Thermodynamics		
	Explain theories, define terminologies and perform problem-solving calculations involving the following topics:		
3.a.	*Temperature measurement units/scales.*	*Define and explain internal energy, heat, specific heat, heat units* ***temperature and explain the relationship between the different temperature scales.***	*3A1.8.1*
3.b.	*Expansion of solids (linear, area and volume) and liquids.*	*Explain the thermal conditions that cause expansion of solids and liquids and describe the relationship between linear, superficial (area) and volumetric expansion.*	*3A1.9.1*
		Given known conditions, calculate linear expansion or contraction, temperatures, and/or expansion coefficients for solids.	*3A1.9.2*

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
		Given known conditions, calculate superficial expansion or contraction, temperatures, and/or expansion coefficients for solids.	*3A1.9.3*
		Given known conditions, calculate volumetric expansion or contraction, temperatures, and/or expansion coefficients for solids or liquids.	*3A1.9.4*
		Calculate the stress produced in a pipe or its supports when thermal expansion is restricted.	*3A1.9.5*
3.c.	*Quantities of heat; specific heat.*	*Define and explain internal energy, heat, specific heat, heat units temperature and explain the relationship between the different temperature scales.*	*3A1.8.1*
3.d.	*Changes of State:* *sensible and latent heat;* *heat content in mixtures of water, ice and steam;* *saturated and* *superheated steam.*	*Define sensible heat and use the sensible heat equation to calculate the heat required to change the temperature of a substance, the mass of the substance, and the temperature change, if no change of state occurs.*	*3A1.8.2*
		Explain the changes of state and define latent heat, latent heat of fusion, and latent heat of evaporation.	*3A1.8.3*
		Given start and end conditions, calculate the heat required to change the states of water and other substances.	*3A1.8.4*
		Determine the final temperatures and the original masses for mixtures of ice, water, steam, and other substances.	*3A1.8.5*
		Explain the working principle of a simple calorimeter and use the calorimeter equation to determine specific heat and final temperature.	*3A1.8.6*

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
		Explain water equivalent and perform calculations involving calorimetry and heat water equivalents.	*3A1.8.7*
3.e.	*Steam tables;* *temperature-enthalpy charts;* *critical temperature and pressure;* *dryness fraction;* *equivalent evaporation,* *factor of evaporation.*	*Define and explain the following terms: saturation temperature, saturated steam, dry saturated steam, wet saturated steam, dryness fraction, superheated steam, and enthalpy.*	*3A1.10.1*
		Identify, from the pressure-based and temperature-based steam tables, the properties of saturated steam at specified conditions.	*3A1.10.2*
		Identify, from the superheated steam tables, the properties of superheated steam at specified conditions.	*3A1.10.3*
		Calculate the heat required to produce dry saturated or superheated steam at given conditions, from feedwater at given conditions.	*3A1.10.4*
		Calculate the dryness fraction of wet steam and/or the heat required to produce wet steam at a given dryness fraction.	*3A1.10.5*
		Explain the properties of steam on a temperature-enthalpy diagram.	*3A1.10.6*
		Define and calculate heat rate, equivalent evaporation and factor of evaporation for a boiler	*3A1.10.7*
3.f.	*Methods of heat transfer; conduction,* *convection,* *radiation.*	*Explain the methods of heat transfer: conduction, convection, and radiation.*	*3A1.9.6*
		Define thermal conductivity and calculate the quantity of heat conducted, the temperature difference, or the material thickness when heat is transferred through flat walls and plates.	*3A1.9.7*

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
3.g.	*Work and heat;* *mechanical equivalent of heat;* *laws of thermodynamics.*		
3.h.	*Expansion and Compression of Gases:* *Boyle's and Charles' 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.*	*Explain Boyle's Law, Charles' Law, Guy Lussac's Law and the General Gas Law and use these to calculate pressure, temperature and/or volume changes for perfect gases.*	*3A1.11.1*
		Explain the Characteristics Gas Constant and use the Characteristic Gas Equation to determine the mass, the conditions, and the constant for a gas.	*3A1.11.2*
		Explain isothermal, adiabatic, and polytropic processes (expansion and compression) for a gas, state the formula for each process, and compare the processes on a pressure/volume diagram.	*3A1.11.3*
		Calculate unknown pressures, volumes and temperatures for gases during isothermal adiabatic, and polytropic processes.	*3A1.11.4*
		Explain and calculate the work done in a cylinder under constant pressure.	*3A1.11.5*
		Explain and calculate the work done in a cylinder during an isothermal expansion or compression.	*3A1.11.6*
		Explain and calculate the work done in a cylinder during an adiabatic expansion or compression.	*3A1.11.7*

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
		Explain and calculate the work done in a cylinder during a polytropic expansion or compression.	*3A1.11.8*
4.	Applied Science:		
4.a.	*Basic Chemistry:*		
4.a.i.	*Molecules,* *atoms,* *elements* *compounds,* *mixtures.*	*Define each term and explain the relationship between atoms, ions, elements, molecules, compounds, and mixtures.*	*3A1.12.1*
4.a.ii.	*Structure of the atom,* *atomic number,* *atomic weight,* *formula weights,* *the mole;* *molar mass calculations;* *periodic table of the elements.*	*Using the Periodic Table of the Elements determine the atomic numbers and the atomic masses of elements.*	*3A1.12.2*
		Explain the electronegativity and the bonding of ions.	*3A1.12.3*
4.a.iii.	*Chemical formulae;* *balancing chemical equations.*	*Explain the formation of chemical compounds, explain typical reactions and apply basic principles to the balancing of simple chemical reactions.*	*3A1.12.4*

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
		Calculate the amount of reactants of products required or produced in a chemical reaction.	*3A1.12.5*
4.a.iv.	*Properties of acids, bases, salts.*	*Define acids, bases, and salts and explain their properties.*	*3A1.12.6*
4.a.v.	*Simple organic chemistry; structure of hydrocarbons.*	*Define organic chemistry and explain, in general terms, the structure and applications of hydrocarbons and hydrocarbon derivatives.*	*3A1.12.7*
4.a.vi.	*Typical industrial applications of chemistry: water treatment, combustion; corrosion.*	*Explain typical applications of chemistry in industry, including water treatment and testing, corrosion, combustion, hydrocarbon processing, petrochemical and pulp and paper processes.*	*3A1.12.8*
4.b.	*Metallurgy and Engineering Materials:*		
4.b.i.	*ANSI and ASME classifications of metals; methods of steel and iron production.*	*Define and explain the importance and application of the following mechanical properties of materials: brittleness, hardness, ductility, malleability, plasticity, elasticity, and toughness.*	*3A1.13.1*
		Describe material testing, including tension test, Brinell and Rockwell hardness tests, Charpy and Izod impact tests.	*3A1.13.2*
		Describe the blast furnace and cupola furnace methods for iron production, and compare the characteristics of gray, white, malleable, and ductile cast iron.	*3A1.13.3*
		Describe the production of carbon and alloy steel, using the open hearth, basic oxygen and electric-arc furnace processes.	*3A1.13.7*
4.b.ii.	*Properties, grades and applications of cast iron.*	*Describe the blast furnace and cupola furnace methods for iron production, and* ***compare the characteristics of gray, white, malleable, and ductile cast iron****.*	*3A1.13.3*

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
4.b.iii.	*Properties, grades and applications of steel; alloying metals and applications.*	*Define steel and explain the compositions and characteristics of low carbon, medium carbon and high carbon steels.*	*3A1.13.4*
		Define alloy steels, and explain the benefits of each of the following alloying elements: nickel, chromium, molybdenum, vanadium, copper, lead, manganese and tungsten.	*3A1.13.5*
		Explain the purposes for hot working, cold working and heat treating of metals.	*3A1.13.6*
4.b.iv.	*Properties and applications of non-ferrous metals.*	*Describe the properties and applications of non-ferrous metals and alloys.*	*3A1.13.8*
4.b.v.	*Properties and applications of non-metallic materials;* *plastics,* *carbon fibers,* *ceramics,* *polymers.*	*Explain the basic structure, properties and applications of polymers, ceramics and composites.*	*3A1.13.9*
4.b.vi.	*Corrosion principles;* *types of corrosion,* *corrosion monitoring and prevention methods and devices,* *corrosion inspection.*	*Define corrosion terms and explain the causes and characteristics of corrosion types, including galvanic, atmospheric, stray current, biological, stress cracking, hydrogen induced, sulphide stress cracking and chloride stress cracking.*	*3A1.14.1*
		Explain specifically the nature and sources of corrosion on the water side of boilers, including caustic corrosion, hydrogen damage, and pitting.	*3A1.14.2*
		Explain the environmental factors that affect corrosion.	*3A1.14.3*

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
		Explain the principles of the following corrosion inhibitor mechanisms, including adsorbed films, passivation, cathodic precipitates, and neutralization.	*3A1.14.4*
		Describe the principles and applications of cathodic protection devices or systems, including sacrificial anodes, galvanic anodes, impressed current, and groundbeds.	*3A1.14.5*
		Describe the principles and applications of corrosion monitoring devices, including coupons, electrical resistance probes, galvanic probes, and hydrogen probes.	*3A1.14.6*
		Describe corrosion inspection procedures, including ultrasonics and radiography.	*3A1.14.7*
4.c.	*Industrial Drawings:*		
	Identify components and interpret symbols for the following engineering drawings:		
4.c.i.	*Process Flow ~~Drawings(~~Diagrams~~)~~ (PFD)*	*State the purpose of a Process Flow Diagram (PFD) (Mechanical Flow Diagram (MFD)), and identify the major information available on a typical PFD.*	*3A1.15.1*
4.c.ii.	*Process and Instrumentation ~~Drawings (~~Diagrams~~)~~ (P&IDs).*	*State the purpose of a Process & Instrumentation Diagram (P&ID), and identify the major information available on a typical P&ID. Explain the naming and symbol conventions for items found on a P&ID*	*3A1.15.2*
4.c.iii.	*Engineered construction drawings for pressure vessels and other equipment.*	*Interpret information provided on a typical, approved Construction drawing for a pressure vessel and other equipment.*	*3A1.15.4*
4.c.iv.	*Equipment layout.*	*State the purpose and identify the components of a typical Equipment Layout Drawing.*	*3A1.15.5*

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
4.c.v.	*Material Balance.*	*State the purpose and interpret information provided on a Material Balance Drawing.*	*3A1.15.3*
Part “A2”			
3A2.5.	Industrial Legislation and Codes:		
3A2.5.a.	*General knowledge of the purpose, content and application of the boiler and pressure vessel codes and regulations, including the Power Engineers' Regulations in the student's jurisdiction.*	*Explain the purpose and the legislated authority of the “Boiler Branch” jurisdictions in Canada.*	
		Recognize the naming conventions of the various jurisdictions and explain how power engineers interact with their own jurisdiction.	
		Describe the general content of a typical “Boiler and Pressure Vessel Act” and its associated “Regulations”.	
		Explain the adoption of codes and standards by jurisdictions in Canada and identify the main standards that have been adopted with respect to boilers and pressure equipment.	
		Explain the purpose and scope of the National Board of Boiler Inspectors (NBBI).	
		Describe the general procedure and regulations that must be followed in order to construct, or install, and place into service a new boiler or pressure vessel in Canada.	
3A2.5.b.	*State the purpose and describe the general content of each of the following codes:*		

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
3A2.5.b.i.	*ASME Section I - Power Boilers*	*Rules for construction of power boilers.*	
	ASME Section IV - Heating Boilers	*Rules for construction of heating boilers*	
	ASME Section V - Nondestructive Examination		
	ASME Section VI - Suggested Rules for Care of Heating Boilers		
	ASME Section VII – Recommended Guidelines for the Care of Power Boilers		
	ASME Section IX - Welding & Brazing Qualifications		
3A2.5.b.ii.	*CSA Standard B.51 – Boiler, Pressure Vessel & Pressure Piping Code*	*Describe the scope and general content of the CSA B51* ***Boiler, Pressure Vessel & Pressure Piping Code*** *~~for the construction and inspection of boiler and pressure vessels~~.*	
	CSA Standard B.52 - Mechanical Refrigeration Code	*Describe the scope and general content of the CSA B52 Mechanical Refrigeration Code*	
3A2.5.b.iii.	*National Board Inspection Code*		
3A2.6.	Code Calculations, ASME Section I: *Demonstrate an understanding of concepts in the following calculations (using SI units)*		

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
3A2.6.a.	*Designed thickness and allowable pressures of boiler tubes, drums,* and blank *dished ~~and hemispherical~~ heads.* *(Blank inserted and hemispherical removed, January 2013)*	*Given the tube material specification numbers, and other necessary parameters, use the formulae in PG-27.2.1 to calculate either the minimum required wall thickness or the maximum allowable working pressure for a boiler tube.*	*3A2.2.1*
		Given the material specification, construction method, and other necessary parameters, use the formulae PG-27.2.2 to determine the required thickness and or maximum working pressure for boiler drums, headers, or piping.	*3A2.2.2*
		Given the required specifications and operating conditions, use formulae PG-29.1 to calculate the required thickness of a seamless, unstayed dished head.	*3A2.2.3*
		Given the required specifications and operating conditions, use formulae in paragraphs PG-29.11 and PG-29.12 to calculate the minimum required thickness of an unstayed, full hemispherical head.	*3A2.2.4*
3A2.6.b.	*Sizes and capacities of boiler safety valves.*	*Using ASME Section I, Paragraphs PG-67 to PG-73, identify code information with respect to pressure relief valves and, using Table A-44, calculate the required pressure relief valve capacity for a given boiler.*	*3A2.2.5*
7.	Fuels and Combustion:		
7.a.	*Requirements for efficient combustion of boiler fuels; complete and incomplete combustion.*	*Explain/define complete combustion, incomplete combustion, combustion products, and write balanced combustion equations.*	*3A2.3.1*
		Explain the purpose and benefits of excess air and calculate the theoretical and excess air required for the complete combustion of a given fuel.	*3A2.3.2*
7.b	*Classification, properties and combustion characteristics of coal, fuel oil and natural gas; other (non-fossil) fuels .*	*Describe the properties, classifications and combustion characteristics of coal*	*3A2.3.5*
		Describe the properties, classifications and combustion characteristics of Fuel oil	*3A2.3.6*

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
		Describe the properties, classifications and combustion characteristics of natural gas	*3A2.3.7*
		Explain the use and combustion characteristics of alternatives to traditional fossil fuels, including biomass, coke, and oil emulsions.	*3A2.3.8*
7.c	*Fuel analysis; proximate, ultimate, fuel heat value; calorimetry.*	*Explain proximate analysis, ultimate analysis, and heating value of a fuel and describe the use of calorimetry to determine calorific value.*	*3A2.3.3*
		Given the ultimate analysis of a fuel, use Dulong's Formula to calculate the heating value of the fuel.	*3A2.3.4*
7.d	*Combustion chemistry; combustion equations for coal, oil, and gas; molar masses for combustion products.*		*3A2.3.9*
7.e	*Combustion calculations; oxygen, air and excess air required, given fuel analysis.*		*3A2.3.9*
vi.	*Flue gas analysis methods and devices; CO; CO2 and 02.*	*Explain the analysis of flue gas for the measurement of O_2, CO, and CO_2 in relation to combustion efficiency. Describe typical, automatic flue gas analyzers.*	*3A2.3.9*
vii.	*Control of emission standards: NOx, SO2, particulates.*	*Explain the formation, monitoring and control of nitrogen oxides (NO_X), sulphur dioxide, and particulates.*	*3A2.3.10*
8.	Piping:	.	

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
8.a	*Codes and standards for pressure piping: ASME, ~~ANSI,~~ CSA, ASTM; identification and sizes of piping; B31.1, power piping vs B31.3 ~~pressure~~ process piping.*	*Identify and explain the general scope of the CSA, ASME, ANSI, ASTM codes and standards with respect to piping and pipe fittings. Differentiate between power piping (Code B31.1) and ~~pressure~~ process piping (Code 31.3).*	*3A2.4.1*
		Using pipe specifications and the ASME code Sections I and II you will able to identify the size of pipe required for a particular installation, process or operating condition.	*3A2.4.3*
8.b	*Ferrous piping materials and methods of manufacture; specifications and service ratings; non-ferrous materials.*	*Explain methods of pipe manufacture; size specifications and service ratings, and the materials specifications and applications ferrous pipe.*	*3A2.4.2*
		Explain the materials, code specifications and applications of common, non-ferrous metal piping and cast iron.	*3A2.4.4*
8.c	*Non-metallic piping: materials and applications.*	*Explain the materials, construction and approved application of common non-metallic pipe.*	*3A2.4.7*
8.d	*Strength of piping; effects of temperature on piping.*	*Explain the effects of temperature on piping; explain the mechanisms and the dangers of expansion in piping systems, including attached equipment.*	*3A2.4.8*
8.e	*Piping connection methods: threaded, flanged, welded; design, materials, selection and installation of gaskets.*	*Describe screwed, welded, and flanged methods of pipe connection and identify the fitting used for each method.*	*3A2.4.5*
		Describe the construction, designs, and materials of flange gaskets and explain the confined, semi-confined, and unconfined flange styles.	*3A2.4.6*
8.f	*Designs and applications of expansion devices, supports and anchors.*	*State the purpose and explain the designs, locations and applications of simple and offset U-bend expansion bends.*	*3A2.4.9*

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
		Describe designs, locations, care and maintenance of slip, corrugated, bellows, hinged, universal, pressure-balanced, and externally pressurized expansion joints.	*3A2.4.10*
		Describe design, location, operation of pipe support components, including hangers, roller stands, variable spring hangers, constant load hangers, anchors, and guides	*3A2.4.11*
8.g	*Types of steam traps;* *trap sizing and selection;* *trap installation configurations;* *trap inspection and maintenance;* *trap flow calculation.*	*Explain the dynamics, design, and components of steam/condensate return systems for steam lines and condensing vessels. Explain roles and locations of separators and traps.*	*3A2.5.1*
		Describe the design, operation and application of ball float, inverted bucket, thermostatic, bi-metallic, impulse, controlled disc, and liquid expansion steam traps.	*3A2.5.2*
		Explain the selection, sizing and capacity of steam traps and explain the factors that determine efficient trap operation.	*3A2.5.3*
		Explain the procedures for commissioning, testing, and maintenance of steam traps.	*3A2.5.4*
8.h	*Water hammer: effects; causes; design and operational preventions.*	*Explain and compare condensate-induced and flow-induced water hammer in steam and condensate lines.* *Explain the typical velocities, pressures and damage that can be created in steam/condensate lines due to water hammer.*	*3A2.5.5*
		Describe specific trap and condensate return arrangements that are designed to prevent water hammer in steam and condensate lines.	*3A2.5.6*

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
		State precautions that must be observed to prevent water hammer and describe a typical steam system start-up procedure that will prevent water hammer.	*3A2.5.7*
8.i	*Insulation:* • *purposes;* • *benefits;* • *characteristics;* • *common materials and their uses;* • *methods of application;* • *cladding;* • *care of insulated piping systems;* • *calculations using coefficient of thermal conductivity.*	*State the purposes of insulation for piping and process equipment and explain the properties required for a good insulating material.* *Explain thermal conductivity, K-Factor and R-Value.*	*3A2.5.8*
		Identify the most common industrial insulating materials, describe the composition and characteristics of each, and explain in what service each would be used.	*3A2.5.9*
		Describe common methods for applying insulation to piping and equipment, including wrap and clad, blanket, insulated covers and boxes. *Explain the care of insulation and cladding and the importance of maintaining good condition.*	*3A2.5.10*
8.j	*Common and specialty valves: purpose, design, operation and applications; valve flow configurations; valve trim; actuator types.*	*Explain the factors that determine the suitability and applications of the major valve styles; gate, globe, ball, plug, butterfly and needle.*	*3A2.6.1*
		Explain the factors that determine the selection of valve materials, and describe examples of typical valve body and trim materials. How are common control valves identified?	*3A2.6.2*
		Describe the configurations and applications for gate valves, including gate designs (solid, split, flexible, sliding), stem configurations (rising, non-rising, outside screw-and-yoke, inside screw), and bonnet designs (flanged, screwed, welded).	*3A2.6.3*
		Describe the designs and applications of globe valves, including conventional disc, composition disc, plug-type disc, and angle valves. Describe high-pressure plug-type control valves.	*3A2.6.4*

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
		Describe the designs, application and operation of single-seated and double-seated balance valve. Explain caged trim for balanced control valves.	*3A2.6.5*
		Describe the designs and applications of typical plug valve designs, including tapered and cylindrical plug, four way, eccentric, and jacketed.	*3A2.6.6*
		Describe the designs and configurations for mixing and diverter valves.	*3A2.6.7*
		Describe the designs and operation of diaphragm valves.	*3A2.6.8*
		Describe design and operation of butterfly valves, including vertical, horizontal, swing-through, lined, and high-performance.	*3A2.6.9*
		Describe the design, application, and operation of gear, motor, air-diaphragm, and air-piston actuators for valves.	*3A2.6.10*
9.	Electrotechnology:		
9.a.	*Direct Current Theory:*		
9.a.i	*Electron theory;* • *theory of magnetism;* • *magnetic field;* • *force on conductor.*	*Explain the production of electron flow in a circuit and define circuit voltage, amperage and resistance.*	3A2.7.1
		Describe the terms: magnetism, magnetic field, temporary and permanent magnets, magnetic flux, reluctance, and magnetization of a coil. *(IPECC Motion 13.3c.6, January 2014)*	TBA

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
		Describe Weber's molecular theory of magnetism *(IPECC Motion 13.3c.6, January 2014)*	TBA
9.a.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.*	*Explain electromagnetic induction and how it produces generator action and motor action.*	3A2.7.2
		(Describe Faraday's and Lenz's Laws of Induction.)	TBA
		Explain self-induction and mutual induction of a coil. *(IPECC motion 13.3.c.7, January 2014)*	TBA
9.b	*Direct Current Machines:*		
9.b.i	*Generators:* • *operating principles,* • *construction,* • *commutation,* • *speed and voltage control;* • *types (shunt, series and compound)*	*Describe the design and operating principles of a DC generator or motor, clearly stating purposes of the armature, commutator, winding and poles.*	*3A2.7.3*
		Explain how back EMF, armature reaction, and torque are created and their influence on a DC generator.	*3A2.7.4*
		Given the speed, flux, number of poles, and number of conductors, calculate the back EMF created by a DC generator.	*3A2.7.4*
		Explain separate and self excitation and describe the voltage/load characteristics of shunt, series and compound generators.	*3A2.7.5*
		State where the various types would be used.	*3A2.7.5*
		Explain how excitation of a DC generator is controlled.	*3A2.7.5*

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
9.b.	*Motors:* • *principle of operation,* • *torque development and measurement,* • *armature reaction,* • *interpoles,* • *speed control,* • *methods of starting,* • *types (shunt, series, and compound),* • *protection devices.*	*Explain the speed/load characteristics of shunt, series and compound DC motors, define and calculate percent speed regulation and explain how speed is controlled in DC motors.*	*3A2.7.6*
		Explain DC motor torque characteristics and describe the starting mechanisms for DC motors.	*3A2.7.7*
9.c..	*Alternating Current Theory:*		
9.c.i.	• *Generating an alternating EMF;* • *sinusoidal wave forms;* • *phase relationships.*	*Explain the creation of single phase and three-phase alternating power; define cycle, frequency and phase relationships (voltage/current) for AC sine waves.*	*3A2.8.1*
9.c.ii	• *Resistance in AC circuits;* • *inductive and capacitive reactance;* • *impedance;* • *power and power factor;* • *single and multi-phase circuits.*	*Define the following terms and explain their relationships in an ac circuit: capacitance, inductance, reactance, impedance, power factor, alternator ratings (kVA and kW).*	*3A2.8.2*
9.d	*Alternating Current Machines:*		
9.d.i.	*Alternators:*	*Describe the stator and rotor designs, operation, and application for salient pole and cylindrical rotor alternators.*	*3A2.8.3*

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
	• *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)*	*Describe water, air and hydrogen cooling systems for large generators.*	*3A2.8.4*
		Explain parallel operation of alternators and state the requirements for synchronization. *Describe manual and automatic synchronization.*	*3A2.8.5*
9.d.ii.	*Motors:* • *principle and operation of induction and synchronous motors;* • *construction;* • *speed and slip;* • *starting methods for induction motors;* • *speed control;* • *variable speed starting,* • *step-starting*	*Describe the design, applications and operating principles for large three phase squirrel cage and wound rotor induction motors.*	*3A2.8.6*
		Describe the design and operating principle of synchronous motors.	*3A2.8.7*
		Explain variable speed control, variable speed starting, and step starting for large induction motors.	*3A2.8.8*
9.d.iii.	*Transformers:* • *operating theory;* • *types (design and construction),* • *losses and efficiency;* • *methods of cooling;* • *safety and fire protection*	*Explain the principles and applications of power transformation.*	*3A2.8.9*
		Perform transformer calculations.	*3A2.8.9*
		Describe the designs and components of typical core and shell type transformers, including cooling components.	*3A2.8.10*
9.e	*AC Systems, Switchgear, Safety:*		

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
9.e.i.	• *Components,* • *layout, and operation of a typical industrial AC power system.*	*Using a one-line electrical drawing, identify the layout of a typical industrial AC power system with multiple generators, and explain the interaction of the major components.*	*3A2.9.1*
9.e.ii.	*Components of an AC generator panel.*	*Explain the function of the typical gauges, meters, and switches on an AC generator panel.*	*3A2.9.2*
9.e.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.*	*Explain the purpose and function of the circuit protective and switching equipment associated with an AC generator: fuses, safety switches, circuit breakers, circuit protection relays, automatic bus switchover, grounding and lightning arrestors.*	*3A2.9.3*
9.e.iv.	*UPS/Inverter Systems:* • *purpose,* • *components,* • *operation;* • *battery design and* • *maintenance.*	*Explain the components and operation of a typical Uninterruptible Power Supply (UPS) system.*	*3A2.9.4*
9.e.v	*Electrical safety for operators.*	*Explain safety procedures and precautions that must be exercised when working around and operating electrical system components.* *Explain Grounding*	*3A2.9.5*
3A2.10.	Electrical Calculations:		

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
	Explain theories and perform calculations for:		
3A2.10.a.	• *Current,* • *voltage,* • *resistance in series and parallel circuits;* • *using Ohm's Law and Kirchhoff's Laws;* • *Wheatstone Bridge.*	*Use Ohm's Law and Kirchhoff's Laws to calculate current, resistance or voltage drop in series or parallel multi-resistor circuits.*	*3A2.10.1*
		Calculate unknown resistances using a Wheatstone Bridge circuit.	*3A2.10.2*
~~3A2.10.b.~~	~~*Temperature coefficient of resistance.*~~ *IPECC motion 13.3.s.8, June 2013*	~~*Explain resistance change with temperature change.*~~	
3A2.10.b.	• *Work,* • *energy,* • *power:* • *relationship between electrical, mechanical and heat units.*	*Explain and perform calculations involving electrical power, work and energy.*	*3A2.10.3*
3A2.10.c.	*Sinusoidal Wave Forms:* • *maximum, average and root mean square root values;* • *frequency;* • *phase.*	*Calculate the frequency, period and phase angle for an AC sine wave.*	*3A2.10.4*
		Define terms and calculate the peak-to-peak, root mean square, and maximum values for ac voltage and current.	*3A2.10.5*
3A2.10.d.	*AC Circuits:* • *inductive reactance,*	*Given required parameters, calculate the inductive reactance, capacitive reactance, total reactance, and impedance for an ac circuit, plus circuit frequency and current flow.*	*3A2.10.6*

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
	• *capacitive reactance,* • *impedance,* • *KVA;* • *power factor*	*Calculate real power, imaginary power and power factor for an ac circuit.*	*3A2.10.7*
		Given the load, voltage and power factor of a 3-phase generator, calculate the kVA and kW ratings of the generator.	*3A2.10.8*
3A2.10.e.	• *Relationship between poles,* • *frequency,* • *speed for AC machines*		*TBA*
3A2.10.f.	*Transformer calculations; step up and step down*		*TBA*
11.	Control Instrumentation:		
11.a	*Control loops and strategies:*		
11.a.i	*Applications of* • *pneumatic,* • *electric and* • *electronic (digital) control systems;* • *components and operation of typical control loops*	*Describe the operation, components and terminologies for a typical control loop.*	*3A2.11.1*
		Describe the operation and components of a purely pneumatic control loop. Explain the function of each component.	*3A2.11.2*
		Describe the operation and components of an analog/electronic control loop. Explain the function of each component.	*3A2.11.3*
		Describe the operation and components of a digital control loop. Explain the function of each component	*3A2.11.4*

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
11.a.ii	• *On-off,* • *proportional,* • *reset,* • *derivative control strategies*	*Explain the purpose, operation, and give examples of on-off, proportional, proportional-plus-reset, and proportional-plus-reset-plus-derivative control.*	*3A2.11.5*
		Define proportional band and gain.	*3A2.11.5*
11.a.iii.	• *Feed forward,* • *feedback,* • *cascade,* • *ratio,* • *split-range,* • *select control*	*Describe and give examples of feed forward, feedback, cascade, ratio, split-range, and select control.*	*3A2.11.6*
11.a.iv.	• *Alarm and shutdown functions in a control loop;* • *operator interfaces with control loops*	*Explain, with examples, the purpose and incorporation of alarms and shutdowns into control loop/system.*	*3A2.11.7*
		Explain the interactions that occur and the interfaces that exist between an operator and the various components of a control loop/system, including the components of a controller interface.	*3A2.11.8*
11.b	*Instrument and Control Devices:* *design and principles of common* • *temperature,* • *pressure,* • *flow, and* • *level instruments*	*Describe the design, operation and applications for the following temperature devices: bimetallic thermometer, filled thermal element, thermocouple, RTD, thermistor, radiation and optical pyrometers.*	*3A2.12.1*
		Describe the design, operation and applications for the following pressure devices: bourdon tubes, bellows, capsules, diaphragms, and absolute pressure gage.	*3A2.12.2*
		Describe the design, operation and applications for the following flow devices: orifice plate, venture tube, flow nozzle, square root extractor, pilot tube, elbow taps, target meter, variable area, nutating disc, rotary meter and magnetic flowmeter.	*3A2.12.3*

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
		Describe the design, operation and applications for the following level devices: atmospheric and pressure bubbles, diaphragm box, differential pressure transmitter, capacitance probe, conductance probes, radiation and ultrasonic detectors and load cells.	*3A2.12.4*
11.c	*Distributed and Logic Control Systems:*		
11.c.i	• *Components,* • *layout,* • *functions of distributed control system*	*Explain distributed control and describe the layout and functioning of a typical distributed control system.*	*3A2.13.1*
		Explain the function of each major components of the system.	*3A2.13.1*
11.c.ii.	*DCS operator interface components;* • *trending;* • *data logging;* • *alarms and* • *shut-downs.*	*Identify and explain the functions of the major components of the operator interface unit (OIU), including controller interfaces, displays, alarms and shutdown.*	*3A2.13.2*
11.c.iii.	*Programmable logic controllers:* • *purpose,* • *design,* • *components;* • *applications;* • *ladder diagrams.*	*State typical applications and explain the purpose and functioning of a programmable logic controller, including the operator interfaces. Explain a ladder logic diagram.*	*3A2.13.3*
11.c.iv.	*Supervisory control and data acquisition systems (SCADA) as used in* • *process control: purpose and*	*State the purpose and explain the general functioning of a communication and data acquisition system (eg. SCADA) as it relates to process control.*	*3A2.13.4*

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
	• *general functions:*		
12.	Industrial Safety and Fire Protection:		.
12.a	*Safety Management Programs:*		
12.a.i.	*Introduction to OH&S Acts in general*	*Explain the general intent, power and scope of Occupational Health and Safety (OH&S) legislation*	*3A2.14.1*
12.a.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;*	*Explain the intent and scope of a workplace OH&S program and state the responsibilities of company, employees, and the OH&S Committee within the program.*	*3A2.14.2*
		Define and give examples of typical workplace hazards and describe a system of hazard identification and control.	*3A2.14.3*
		Explain the purpose of work permits and describe typical hot and cold work permit systems.	*3A2.14.4*
		Explain the purpose of equipment lockout, describe lockout devices, and describe a typical equipment lockout procedure.	*3A2.14.5*
		Define and identify confined spaces and describe a typical confined space permit and entry procedure.	*3A2.14.6*
		Explain the hazards of excavation and describe typical excavation procedures and permits.	*3A2.14.7*

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
		Explain the purpose and describe the typical components of an emergency response plan.	*3A2.14.8*
		State the purpose of WHMIS, explain the use of labels and material safety data sheets, and explain the responsibilities of employer and employee.	*3A2.14.9*
		Explain the purpose, requirements, and procedures for incident and accident investigation and reporting.	*3A2.14.10*
12.b.	*Fire Protection Systems:*		
12.b.i.	• *Classes of fire;* • *extinguishing methods*	*Explain the classifications of fires and describe the extinguishing media that are appropriate for each classification.*	*3A2.15.1*
12.b.ii.	*Components and operation of industrial fire detection and alarm system*	*Describe the components and operation of a typical fire detection and alarm system in an industrial setting.*	*3A2.15.2*
12.b.iii.	*Sprinkler systems (dry and wet standpipe); pre-action and deluge; design and operation*	*Describe the design and operation of a typical standpipe system.*	*3A2.15.3*
		Describe the wet pipe, dry pipe, pre-action and deluge designs for sprinkler systems.	*3A2.15.4*
12.b.iv.	• *Fixed fire systems:* • *firewater pump,* • *loops,* • *hydrants;* • *vessel deluge system;* • *foam systems*	*Describe the layout, components and operation of a typical firewater system with fire pump and hydrants.*	*3A2.15.5*
		Explain seasonal considerations for a firewater system.	*3A2.15.5*
		Describe the construction and operation of a typical fire hydrant.	*3A2.15.6*

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
		Explain the purpose and describe a typical deluge water system for hydrocarbon storage vessels.	*3A2.15.7*
		Explain the purpose and describe a typical foam system for process buildings and tanks.	*3A2.15.8*
12.b.v.	*Industrial fire response*	*Describe a typical fire response procedures for an industrial setting.*	*3A2.15.9*
Part “B1”			
13.	Boilers		
13.a.	*Boiler Classification:*		
13.a.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*	*Explain the difference between package, shop assembled, and field-erected watertube boiler.* *Explain how boilers are rated.*	*3B1.1.1*
		Explain the process of water circulation in a watertube boiler and the factors that influence circulation.	*3B1.1.2*
		Identify examples of and describe the A, O, and D design configurations and explain the water and gas circulation patterns for each.	*3B1.1.3*
		Define integral furnace.	*3B1.1.3*
		Define a steam-generating unit, identify oil and gas-fired units, and explain the components, heating surfaces, and flow patterns through a typical unit.	*3B1.1.4*

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
		State typical temperatures throughout the unit.	*3B1.1.4*
		Differentiate between critical and super-critical boilers.	*3B1.1.5*
		Explain the purpose and advantage of forced circulation and describe the flow through a typical controlled circulation boiler.	*3B1.1.6*
		Explain the purpose and design of a once-through boiler.	*3B1.1.7*
13.a.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*	*Describe typical designs, components and operating strategies for once-through, steam flood boilers.*	*3B1.2.1*
		Describe typical designs, components and operating strategies for Fluidized Bed boilers.	*3B1.2.2*
		Describe typical designs, components and operating strategies for Heat Recovery Steam Generators.	*3B1.2.3*
		Describe typical designs, components and operating strategies for Black Liquor Recovery boilers used in pulp mills.	*3B1.2.4*
		Describe typical designs, components and operating strategies for Refuse boilers used in waste disposal.	*3B1.2.5*
		Describe typical designs, components and operating strategies for waste heat, biomass boilers.	*3B1.2.6*
b.	*Boiler Construction:*		
13.b.i.	*Designs, fabrication, construction methods, and Code requirements for:* • *shells,*	*Explain bottom and top support and describe the support techniques for various components of a large boiler, including lateral supports for furnace walls.* *Explain allowances for expansion*	*3B1.3.1*

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
	• *drums,* • *tubes (include attachment methods),* • *nozzles;* • *headers;* • *handholes/manholes*	*. Explain the purpose, design, locations and installation methods for boiler casing insulation, refractory, and cladding.*	*3B1.3.2*
		Describe the methods used to fabricate boiler tubes.	*3B1.3.3*
		Describe the preparation, fabrication, and testing of boiler drums.	*3B1.3.4*
		Describe methods of attaching tubes to drums and headers, including expanding and welding, and explain where each method would be used.	*3B1.3.5*
		Describe acceptable nozzle attachment methods, including reinforcements; describe inspection openings.	*3B1.15.4*
		Explain code requirements for, and describe the designs and installation of, manholes and handholes, including welded handholes.	*3B1.3.6*
		Explain procedures for removing and installing covers.	*3B1.3.6*
13.b.ii.	*Field assembly of a large watertube boiler*	*Describe the field assembly of a large boiler or stem generating unit.*	*3B1.3.7*
13.b.iii.	*Boiler metals - applications and purpose*		
13.c.	*Boiler Heat Transfer Components:*		
13.c.i.	• *Watertube boiler settings (brickwork and refractory),*	*Describe baffle designs and locations and explain their significance to boiler heat transfer.*	*3B1.4.1*

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
	• *baffles;* • *integral furnace designs and waterwalls:* • *studded tubes;* • *water-cooled walls:* • *fin-tube,* • *tangent-tube,* • *flat-stud tube*	*Describe the designs of integral furnace sidewall and header arrangement, including tube-and-tile, tangent tube, and membrane.*	*3B1.4.2*
13.c.ii.	*Superheaters:* • *primary,* • *secondary,* • *convection,* • *radiant,* • *integral and separately-fired;* • *operating characteristics;*	*Define primary, secondary, convection, radiation, platen, and pendant as they apply to superheaters.*	*3B1.4.3*
		Describe the locations of superheaters within a steam generator and state the operating characteristics of convection and radiant superheaters.	*3B1.4.3*
		Explain the purpose and design of a separately-fired superheater.	*3B1.4.4*
13.c.iii.	*Reheater designs*	*Explain the purpose and describe the locations of reheaters.*	*3B1.4.5*
		Explain the position of and flow through the reheater in relation to the superheaters.	*3B1.4.5*
13.c.iv.	*Economizers:* • *integral and separate;* • *tube styles,* • *advantages/ disadvantages*	*Describe designs and locations for integral and separate economizers.*	*3B1.4.6*
13.c.v.	*Air Heaters:* • *plate,* • *tubular,* • *rotary regenerative designs;*	*Describe the designs, operation, and location of plate, tubular, and rotary regenerative air heaters.*	*3B1.4.7*

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
	• *heater corrosion control;* • *advantages/disadvantages*		
13.c.vi.	*Sootblowers:* • *stationary and retractable,* • *locations,* • *shot cleaning*	*Explain operating care and considerations that must be given to the various heat transfer sections of the boiler.*	*3B1.4.8*
		Explain a typical water and gas temperature profile through a large steam generating unit.	*3B1.4.9*
		Describe sootblowing systems and describe the procedures for operating sootblowers.	*3B1.9.8*
13.d.	*High Pressure Boiler Fittings*		
	Design, installation/location, operation, testing and Code requirements for each of the following boiler fittings:		
13.d.i.	• *Water columns and gauge glasses;* • *types of remote level indicators;* • *illumination;* • *safety shut-off*	*Describe common designs, connections and components of high-pressure water columns and flat gauge glasses, including illumination and quick shut-off devices and bulls-eye glasses.*	*3B1.5.3*
		Explain testing and maintenance of a high pressure gauge glass.	*3B1.5.3*
13.d.ii.	*Safety valves; setting*	*Describe the design, installation, operation, and setting of a high-pressure safety valve.*	*3B1.5.1*
		Explain the Code requirements for size, capacity and location of safety valves on a boiler.	*3B1.5.1*
13.d.iii.	*Low-water fuel cut-offs; float and probe designs*	*Describe the float and probe designs for low-water level cutoffs and explain how these are tested.*	*3B1.5.4*

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
13.d.iv.	*Steam outlet fittings and non-return designs*	*Describe boiler steam outlet arrangements and fittings including gate, angle, and globe stop valves and globe, Y, angle, and spring-cushioned non-return valves.*	*3B1.5.5*
13.d.v.	• *Pressure gauges;* • *feedwater connections;* • *vents;* • *and blowdown valve designs;* • *blowdown procedures;* • *blowdown tank*	*Describe the code requirements for boiler pressure gauges, including attachment and locations.*	*3B1.5.2*
		Describe manual blowdown piping arrangements.	*3B1.5.6*
		Describe the design and operation of sliding disc, seatless sliding plunger, seat and disc, and combination valves.	*3B1.5.6*
		Explain manual blowdown procedures.	*3B1.5.6*
		Describe the requirements for a blowdown tank.	*3B1.5.6*
13.d.vi.	*Drum Internals:* • *baffles,* • *scrubbers,* • *separators,* • *driers,* • *piping circulation and* • *separation of steam and water*	*Explain the components of the steam drum internals of a watertube boiler.*	*3B1.5.7*
		Describe the design and operation of various steam separation devices, including baffles, primary and secondary separators, and scrubbers.	*3B1.5.7*
13.e.	*Fuel, Draft, and Flue Gas Systems*		

13.e.i.	• ~~*Coal*~~ ***Solid Fuel*** *firing equipment:*
	  ○ *mechanical,*
	  ○ *underfeed,*
		Describe a ~~*coal*~~ *solid fuel supply system from stockpiles to burners for a typical pulverized* ~~*coal*~~ *solid fuel furnace.*
		(IPECC 13.3.s.12, January 2014)
			3B1.6.5

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
	○ *crossfeed and* ○ *overfeed stokers;* • *pulverizers –* ○ *impact,* ○ *ball,* ○ *ball-race and* ○ *bowl mills;* • *burner and furnace designs –* ○ *turbulent* ○ *vertical,* ○ *tangential,* ○ *cyclone;* • ***solid fuel** feed systems;* • *ash handling systems - hydro and air,* • *bottom ash*	*Describe the design and operation of a pulverized coal burner and explain turbulent vertical, tangential, and cyclone furnaces.*	*3B1.6.6*
		Describe the designs and operation of underfeed, crossfeed, and overfeed furnaces for burning solid fuels.	*3B1.6.8*
		Describe the design and operation of ball, impact, ball-race, and bowl mill pulverizers3	*3B1.6.7*
13.e.ii.	*Oil burning equipment:* • *oil burner designs –* • *steam,* • *air and* • *mechanical atomizing;* • *components of large oil burner systems;* • *start-up/shut-down of large oil burners;* • *cleaning and* • *maintenance*	*Describe a complete fuel oil supply system from storage tanks to burners and explain the function of each system component.*	*3B1.6.3*
		Describe the design and operation of air, steam, and mechanical atomizing burners.	*3B1.6.4*
13.e.iii.	*Gas burning equipment:* • *burner designs*	*Describe a complete fuel gas supply system from fuel gas header to burner and explain the function of each component, including control and shut-off valves, auto-vents, and instruments.*	*3B1.6.1*

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
	• *spud,* • *multi-spud and* • *ring; burner* • *gas supply system;* • *start-up sequence for gas burner;* • *high-efficiency,* • *low NOx burners;*	*State the typical operating pressures.*	*3B1.6.1*
		Describe the design and operation of spud and ring burners, and explain high efficiency, low NO_X designs.	*3B1.6.1*
13.e.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*	*Define and explain the applications and designs of natural, forced, induced and balanced draft.*	*3B1.7.1*
		Explain how draft is measured, monitored, and controlled in a large, balanced draft boiler.	*3B1.7.2*
		Explain the position of control dampers.	*3B1.7.2*
		Describe typical draft fan designs, single and double inlet arrangements, and explain methods used to control fan output.	*3B1.7.3*
		Explain the start-up and running checks that must be made on draft fans.	*3B1.7.4*
		Describe typical windbox and sir louvers arrangements and distinguish between primary and secondary air.	*3B1.7.5*
13.e.v.	*Flue gas clean-up methods and equipment:* • *precipitators,* • *filters,* • *ash handling systems;* • *SO2 recovery systems*	*Describe the design and operation of flue gas particulate clean-up equipment, including mechanical and electrostatic precipitators and baghouse filters.*	*3B1.7.6*
		Describe the design and operation of ash handling systems, including hydro and air systems, bottom ash systems, and scraper conveyor systems.	*3B1.7.7*

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
		Describe the designs and operation of SO_2 recovery systems, including lime and wet gas scrubbing.	*3B1.7.8*
13.f.	*Boiler Operation and Maintenance*		
13.f.i.	*Manual start-up and shut-down procedure for large, industrial boilers.*		
13.f.ii.	*Initial start-up (commissioning) of a new boiler*	Explain the steps involved in the commissioning of a new boiler or before starting a boiler after major repairs, including: a) hydrostatic test b) external and internal inspections c) drying out refractory d) boiling out e) testing shutdowns and safety devices	*3B1.9.1*
13.f.iii.	*Routine and emergency operations*	Explain routine tasks and visual monitoring that the operator must perform on a large operating boiler.	*3B1.9.6*
13.f.iv.	*Causes and prevention of boiler furnace and pressure explosions*	*Explain the procedures and precautions that an operator must exercise to avoid furnace and pressure-side explosions.*	*3B1.9.7*
13.f.v.	*Chemical and mechanical boiler cleaning methods; boiling out*	*Describe typical equipment and procedures for cleaning the water side of a boiler:* *a) mechanically* *b) chemically*	*3B1.9.5*
13.f.vi.	*Methods of cleaning and preparing a boiler for inspection*	*Describe the proper shut down and preparation of a boiler for internal inspection*	*3B1.9.3*
		Describe the wet and dry methods when laying up a boiler for an extended ti me, including nitrogen blanketing.	*3B1.9.2*

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
13.f.vii.	*Inspection: fire and water sides; safety*	*Describe a thorough inspection of the water and furnace sides of a boiler.*	*3B1.9.4*
13.f.viii.	*Hydrostatic test*		
14.	Boiler control Systems		

14.a.	*Boiler Water Level Control:*
	components,
	• *purpose and operation of*
	  ○ *single-element,*
	  ○ *two element, and*
	  ○ *three-element*
	• *control systems;*
	• *explain swell and shrinkage*
		Describe on-off and single element control of boiler feedwater.	*3B1.8.1*

		Explain swell and shrinkage in a boiler.	*3B1.8.2*
		Describe the components and operation of a two-element feedwater control system, explaining the interaction of the controllers.	*3B1.8.2*
		Describe the components and operation of a three-element feedwater control system.	*3B1.8.3*
14.b.	*Combustion control:*		
14.b.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,*	*Describe the components and operation of a direct combustion control system.*	*3B1.8.4*
		Describe the components and operation of a 'steam-flow-airflow' combustion control system.	*3B1.8.5*
		Describe the components and operation of a 'fuel flow-airflow' combustion control system.	*3B1.8.6*

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
	• *multi-element control*	*Describe the components and operation of an 'airflow-fuel flow' combustion control system.*	*3B1.8.7*
		Describe the components and operation of a multi-element combustion control system.	*3B1.8.8*
14.b.ii.	*Safety devices and interlocks*		
14.b.iii.	*Flame failure detection:* *continuous,* *intermittent,* *interrupted pilots;* *photo-electric cells*		
14.b.iv.	*Automatic, programmed boiler start-up and shut-down sequence*	*Describe the automatic, programmed start-up sequence for a gas-fired boiler.*	*3B1.8.10*
14.c.	*Steam temperature control: desuperheating control* *attemperation,* *gas recirculation,* *gas bypass,* *tilting burners*	*Describe steam temperature control methods and equipment, including attemperation (desuperheating), gas recirculation, gas bypass, and tilting burners.*	*3B1.8.9*
15.	Feedwater Treatment		

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
15.a.	*Feedwater impurities and their effects on boiler operation*		
15.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 (multi-effect evaporators),* • *reverse osmosis*	*Describe the design and explain the terms, purpose and operation for a clarifier, using coagulation and flocculation.*	*3B1.11.1*
		Describe the design and explain the terms, purpose and operation of a gravity and pressure filters. .	*3B1.11.2*
		Describe the design and explain the terms, purpose and operation, including chemical reactions for a cold lime softener.	*3B1.11.3*
		Describe the design and explain the terms, purpose and operation of a hot lime softener.	*3B1.11.4*
		Explain the principles of ion exchange softening in general, identifying the common anions and cations in untreated water.	*3B1.11.5*
		Describe the design, components, and operation of a sodium Zeolite softening system including chemical reactions.	*3B1.11.6*
		Describe the design, components, and operation of a hydrogen Zeolite softening system including chemical reactions.	*3B1.11.7*
		Describe the design, components, and operation of a dealkalization system including chemical reactions.	*3B1.11.8*
		Describe the design, components, and operation of a demineralizers system, including mixed bed and degasification.	*3B1.11.9*

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
		Describe the design, components and operation of evaporators for external water treatment *(IPECC motion 13.3.c.9, January 2014)*	*TBA*
		Explain the principle and operation of a reverse osmosis system.	*3B1.11.10*
		Describe the design, principle, and operation controls of a typical deaerator.	*3B1.11.11*
15.c.	*Internal Boiler Water Treatment:*		
15.c.i.	*Causes, effects and controls for boiler internal water problems*	*Explain the causes and effects of boiler scale; explain the most common internal methods of scale control, including phosphate treatment, chelate treatment, sludge conditioning and dispersion*	*3B1.10.1*
15.c.ii.	*PH control magnetite layers, acidic and caustic corrosion*	*Explain the causes and effects of boiler and condensate return line corrosion; explain treatment methods for acidic, caustic, oxygen, and carbon dioxide corrosion, including sulphite, hydrazine, and amine treatment.*	*3B1.10.2*
15.c.iii.	*Sludge conditioning and dispersion; modern sludge dispersants*		
15.c.iv.	*Chemical deaeration oxygen corrosion; sulphite programs; hydrazine*		
15.c.v.	*Carryover priming, misting, foaming*	*Explain the mechanical and chemical causes, effects and types of carryover; explain methods of carryover control, including the use of antifoam and blowdown.*	*3B1.10.3*
15.c.vi.	*Dissolved solids blowdown control; conductance; simple and heat recovery blowdown systems; automatic blowdown systems*	*Describe the design and explain the operation of simple blowdown, heat recovery, and automatic blowdown systems.*	*3B1.10.4*

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
15.c.vii.	*Return line corrosion neutralizing and filming amines*	*Explain the causes and effects of boiler and condensate return line corrosion; explain treatment methods for acidic, caustic, oxygen, and carbon dioxide corrosion, including sulphite, hydrazine, and amine treatment.*	*3B1.10.2*
15.c.viii.	*Scale control phosphate and chelate programs*		
15.d.	*Chemical feed systems: shot and continuous feed systems; chemical feed pumps*	*Describe typical chemical feed systems, including pot feeders, continuous feed with day tanks, and continuous feed with pump tanks.*	*3B1.10.6*
15.e.	*Feedwater and boiler water testing methods: automatic sampling systems and monitors; boiler and steam system parameters and test locations*	*Explain, in general terms, the sampling and testing strategies for boiler internal conditions; describe typical sampling and automatic monitoring equipment.*	*3B1.10.5*
16.	Pumps		
16.a.	*Theory of pumping: define and explain pump head terms, perform pump head and pressure calculations, explain cavitation*	*Explain the relationship between the height of a liquid, the density of the liquid and the pressure exerted at the bottom of the liquid.*	*3B1.13.1*
		Perform simple calculations involving this relationship.	*3B1.13.1*
		Define equivalent head and calculate equivalent heads for water and other liquids.	*3B1.13.2*
		Define static head, static suction lift, static discharge head, total static head, pressure head, and calculate each of these for a given pump arrangement.	*3B1.13.3*
		Define and calculate friction head and velocity head.	*3B1.13.4*
		Define dynamic suction head, dynamic suction lift, dynamic discharge head, total dynamic head, and calculate each of these for a given pump arrangement.	*3B1.13.5*

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
		Explain vapor pressure, cavitation, and net positive suction head.	*3B1.13.6*
		Calculate the required suction pressure for a water pump, given the manufacturers required NPSH.	*3B1.13.6*
16.b.	*Reciprocating pumps:* *pump drivers;* *single and double-acting designs;* *plunger type;* *diaphragm type;* *pump protection*	*Explain the principle of operation and describe the components of typical piston and plunger reciprocating pumps.*	*3B1.12.1*
16.c.	*Centrifugal pumps:*		
16.c.i.	*Classification and principles of operation for volute, diffuser and turbine pumps; axial and mixed flow*	*Explain the designs and operating principles of volute and diffuser centrifugal pumps, including impeller designs.*	*3B1.12.3*
		Describe centrifugal pump arrangements, including vertical, horizontal, single and double suction, opposed impellers, multi-staging, split and barrel casings.	*3B1.12.4*
		Describe the design and applications of axial and mixed flow pumps.	*3B1.12.5*
16.c.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*	*Describe the design and components of a multistage centrifugal pump, clearly stating the purpose and general design of: wearing rings, shaft sleeves, seals, bearings and lubrication components, vents and drains.*	*3B1.12.6*
		Explain design features that eliminate thrust in large centrifugal pumps	*3B1.12.7*
16.c.iii.	*Operation: starting and stopping, priming*	*Explain priming, start-up, capacity control and operating cautions for centrifugal pumps*	*3B1.12.9*

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
16.c.iv.	*Typical pump installation; auto-recycle valve*	*Describe systems used to maintain minimum fl ow through a centrifugal pump.*	*3B1.12.8*
16.d.	*Rotary pumps: design and operation of gear, lobe, screw*	*Explain the designs and operating principles of the external gear, internal gear, sliding vane, lobe, and screw type rotary pumps.*	*3B1.12.2*
17.	Welding Procedures and Inspection:		
17.a.	*Welding Processes (overview): describe and state where each of these processes would be used - metal arc, shielded arc, submerged arc, gas (TIG), MIG*	*Describe the equipment, procedures and applications of shielded metal arc welding (SMAW).*	*3B1.14.1*
		Describe the equipment, procedure and applications of submerged arc welding (SAW).	*3B1.14.2*
		Describe the equipment, procedure and applications of gas tungsten arc welding (GTAW).	*3B1.14.3*
		Describe the equipment, procedure and applications of gas metal arc welding (GMAW).	*3B1.14.4*
17.b.	*Electrodes: classification, types and uses; where and why each would be used*	*Explain the classification of arc welding electrodes.*	*3B1.14.1*
17.c.	*Fabrication and repairs: weld preparation; preheating, performing a boiler tube repair, postweld heat treatment (stress relieving)*	*Explain weld preparation and terminology of a butt weld; explain preheating and postweld heat treatment*	*3B1.14.5*
17.d.	*Causes and effects of common weld defects*	*Describe common defects in welds, including undercut, lack of penetration, porosity, slag inclusion, and cracking.* *Explain how each occurs and the effect on the integrity of the weld.*	*3B1.14.6*

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
17.e.	*Weld inspection procedures: non-destructive examination techniques; destructive examination techniques*	*Explain the equipment and procedures for dye penetrant, magnetic particle, radiographic, and ultrasonic inspection of a weld; explain the potential weld defects revealed by each test.*	*3B1.14.7*
17.f.	*Welding Procedure and Welder's Performance Qualifications per ASME Code, Sect. 9*	*Explain the requirements and process for Weld Procedure and Welder Performance Qualification, per the ASME Code, Section 9.*	*3B1.14.8*
18.	Pressure Vessels:		
18.a.	*Explain design, construction, operation and repair regulation of pressure vessels, including stamping and nameplate details*	*Define "pressure vessel" and explain, in general terms, how pressure vessels are regulated in design, construction and repair (including purpose of Section VIII, ASME).*	*3B1.15.1*
		Explain the stamping/nameplate requirements for pressure vessels and identify terms and specifications on a typical nameplate.	*3B1.15.2*
18.b.	*Head, nozzle, manway designs*	*Describe the weld locations on a typical pressure vessel and identify head designs, including ellipsoidal, torispherical, hemispherical, conical, and toriconical.*	*3B1.15.3*
		Describe acceptable nozzle attachment methods, including reinforcements; describe INSPECTION OPENINGS ~~manway cover designs~~.	*3B1.15.4*
18.c.	*Loads and stresses on pressure vessels*	*Explain the loads that contribute to stresses in pressure vessels, including pressure, thermal, attachments, static, wind, seismic, and cyclic loads.*	*3B1.15.5*
18.d.	*Typical components/fittings on a pressure vessel*	*Explain the components and fittings of a typical pressure vessel.*	*3B1.15.6*
18.e.	*Safe operating and maintenance consideration, including hydro and pneumatic testing; inspection*	*Explain operating and maintenance considerations for the safe operation of pressure vessels, including the appropriate use of hydrostatic and pneumatic testing.*	*3B1.15.7*

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
B2			
19	Prime Movers		
19.a.	*Steam Turbines:*		
19.a.i.	*Impulse and reaction principles; nozzles; blade shapes;*	*Explain impulse turbine operating principles.*	*3B2.1.1*
		Describe convergent and divergent nozzles, and the pressure-velocity profiles through an impulse section.	*3B2.1.1*
		Explain reaction turbine operating principles and describe the pressure-velocity profiles through reaction blading.	*3B2.1.2*
19.a.ii.	*Turbine arrangements: staging and compounding: principles and p-v diagrams for pressure, velocity and pressure-velocity compounding*	*Explain pressure, velocity, and pressure-velocity compounding of impulse turbines.*	*3B2.1.3*
		Describe the pressure-velocity profiles and the purposes and applications of each.	*3B2.1.3*
19.a.iii.	*Turbine components:* *purpose,* *design,* *operation of the following:* *casings,* *disc and drum rotors,* *dummy pistons,*	*Describe the designs of typical turbine casing and state the purpose and location of casing fittings, including drains and sentinel valves.*	*3B2.1.5*
		Describe the designs and principles of casing/shaft seals.	*3B2.1.5*
		Describe the designs and applications of disc and drum rotors.	*3B2.1.6*
		Describe methods of rotor and casing blade attachment and explain blade-sealing arrangements.	*3B2.1.6*

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
	journal and thrust bearings, *barring gear,* *blade and shaft sealing* *glands,* *couplings,* *interceptor valves on reheat turbines*	*Explain thrust in a large turbine and describe methods to offset thrust, including thrust bearings, dummy pistons, and thrust-adjusting gear.*	*3B2.1.7*
		Identify typical designs and components for small and large industrial turbines. Explain typical size/capacity rating specifications and explain typical applications.	*3B2.1.8*
		Explain the use and design of reducing gears attached to steam turbines.	*3B2.1.9*
		Describe typical lube oil systems for small and large steam turbines.	*3B2.2.1*
		Explain the purpose and describe the design and operation of barring gear and jacking oil systems on a large turbine.	*3B2.2.2*
		Describe a condensing turbine circuit and explain typical operating parameters.	*3B2.2.3*
19.a.iv.	*Explain purpose and arrangements of condensing, bleeder, topping, extraction, cross and tandem compounded turbines*	*Explain the purpose, general operating principles and arrangement for each of the following turbine types: condensing, condensing-bleeder, backpressure, extraction, topping, mixed-pressure, cross-compounded ~~and~~ tandem compounded double flow and reheat..*	*3B2.1.4*
19.a.v.	*Turbine governor types; speed-sensitive, pressure-sensitive, nozzle, throttle, bypass; mechanical, mechanical hydraulic, electronic-hydraulic; droop and isochronous operation*	*Explain and state the applications, where applicable, of the following governor types: speed-sensitive, pressure-sensitive, nozzle, throttle, and bypass.*	*3B2.2.4*
		Explain governor droop and isochronous control.	*3B2.2.4*
		Explain the operation and the major components of the three main speed-sensitive governor systems: mechanical, mechanical-hydraulic, and electronic-hydraulic.	*3B2.2.5*

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
		Explain the operation and describe the components of typical mechanical and electronic overspeed trip systems.	*3B2.2.6*
19.a.vi.	*Starting and shutting down condensing and extraction turbines*	*Explain the sequence followed for the cold start-up and the shutdown of a non-condensing steam turbine.*	*3B2.2.7*
		Explain the sequence followed for the cold star-up and the shutdown of a condensing and extracting steam turbine.	*3B2.2.8*
19.a.vii.	*Steam turbine condensers: types, air-cooled, water-cooled, Panier style; condenser auxiliaries; condenser operation; feedwater heater system*	*Explain the purposes of a turbine condenser in a steam plant cycle and describe a typical condensing circuit, with operating temperatures and pressures.*	*3B2.3.1*
		Explain the design, operation and applications of the jet condenser, including the ejector type.	*3B2.3.2*
		Explain the design, operation and applications of the surface condenser, including air-cooled and water-cooled, down flow and central flow.	*3B2.3.3*
		Describe construction details for surface condensers, including shells, tube attachment, supports, and allowances for expansion.	*3B2.3.4*
		Explain the effects of air in a condenser and describe the design and operation of single and two-stage air ejectors.	*3B2.3.5*
		Explain the detection of condenser air leaks. *Explain vacuum pumps*	*3B2.3.5*

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
		Explain the devices and operating considerations used to protect a condenser against high backpressure, high condensate level, and cooling water contamination. *Describe a cooling water leak test.*	*3B2.3.6*
		Describe the operating conditions and corresponding design considerations for condensate extraction pumps and cooling water pumps.	*3B2.3.7*
		Describe a feed water heater system in conjunction with a steam condenser and explain the designs of low-pressure and high-pressure feed water heaters.	*3B2.3.8*
19.b.	*Gas Turbines:*		
19.b.i.	*Applications, advantages and disadvantages of gas turbines*	*Explain gas turbine advantages and disadvantages, background and industrial application.*	*3B2.4.1*
		Identify the types of gas turbines, their major components and describe the operating principles of a simple gas turbine.	*3B2.4.1*
19.b.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*	*Explain single and dual shaft arrangements for gas turbines.*	*3B2.4.2*
		Describe open cycle and closed cycle operation.	*3B2.4.2*
		Describe a typical open cycle gas turbine installation, including buildings or enclosures, intake and exhaust systems, and reducing gear.	*3B2.4.3*
		Explain the efficiency and rating of gas turbines and describe the purpose and applications of gas turbine cycle improvement, including intercooling, regenerating, reheating and combined cycle.	*3B2.4.4*

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
			3B2.
			3B2.
19.b.iii.	*Main gas turbine components: radial and axial compressors, combustor arrangements and operation, turbine rotor designs*	*Describe various aspects of compressor design and centrifugal and axial types of compressors.*	*3B2.4.5*
		Describe the types, operation, components and arrangements of combustors.	*3B2.4.6*
		Describe turbine section design and operation especially with respect to blading and materials.	*3B2.4.7*
19.b.iv.	*Gas turbine support systems: fuel supply systems; lubrication; barring gear; steam injection; intake and exhaust components*	*Describe and explain the operation and routine maintenance of a typical fuel gas supply system for a gas turbine.*	*3B2.5.2*
		Describe and explain the operation and routine maintenance of a typical fuel oil supply system for a gas turbine.	*3B2.5.3*
		Describe the types of bearings used in a gas turbine and explain the components, operation, protective devices and routine maintenance of a typical lube oil system *.*	*3B2.5.1*
		Explain the control of NO_X from a gas turbine and describe the purpose and operation of water/steam injection and dry low NO_X systems.	*3B2.5.4*

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
		Explain the purpose, location and operation of the gas turbine starting motor and turning gear.	*3B2.5.5*
		Describe the compressor intake and the turbine exhaust components.	*3B2.5.6*
19.b.v.	*Supervisory, protective, and control systems*	*Explain the types and functions of the control systems and instrumentation needed for gas turbine operation.*	*3B2.4.8*
19.b.vi.	*Starting and stopping procedures and sequences; turbine washing*	*Describe the preparation and complete start-up and loading sequence for a gas turbine.*	*3B2.5.7*
		Describe the shutdown sequence and procedure for a gas turbine.	*3B2.5.8*
		Explain the purpose and describe typical on-line and off-line waterwash procedures for gas turbine blades.	*3B2.5.9*
19.c.	*Internal Combustion Engines:*		
19.c.i.	*Gasoline engines: spark ignition defined, two-stroke cycle, four-stroke cycle, carburetion; carburetor design and operation, spark ignition components, fuel injection*	*Explain the principles of spark ignition and compression ignition.* *Describe the operating cycles for two-stroke and four-stroke designs.*	*3B2.6.1*
		Identify and state the purpose of the major mechanical components of an internal combustion engine	*3B2.6.2*
		Describe carburetor, fuel injection, battery ignition, and magneto ignition systems for a spark ignition engine.	*3B2.6.3*

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
19.c.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*	*Describe individual pump, distributor, and common rail fuel injection systems for a diesel engine.*	*3B2.6.4*
		Explain the monitoring, protection and control devices on a large industrial diesel, including shutdowns and governing.	*3B2.6.9*
		Explain a typical start-up procedure for a large industrial diesel engine, plus the routine monitoring requirements of a running engine.	*3B2.6.10*
19.c.iii.	*Engine support systems: fuel systems, lubrication, governing, starting systems and methods, magneto system, cooling systems, supercharging and turbo-charging*	*Explain the purpose and describe the operation of supercharges and turbochargers.*	*3B2.6.5*
		Describe and explain the operation of a typical cooling system for an industrial ICE.	*3B2.6.6*
		Describe and explain the operation of a typical lubrication system for an industrial ICE.	*3B2.6.7*
		Describe engine-starting devices/systems for diesel and gas engines.	*3B2.6.8*
19.c.iv.	*Thermodynamic heat engine cycles: explain the Otto, Diesel and Brayton cycles*		
20.	Cogeneration:		
	a. Purpose, advantages, components of cogeneration systems;	*Define cogeneration and explain its purpose, advantages, and applications.*	*3B2.7.1*

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
	b. *simple and combined cycle,*	*Explain the components and operation of simple-cycle cogeneration systems.*	*3B2.7.2*
		Explain the components and operation of combined-cycle, gas/steam turbine cogeneration systems.	*3B2.7.3*
	c. *using gas turbines and internal combustion engines;*	*Explain the components and operation of a fully fired, combined-cycle cogeneration system.*	*3B2.7.4*
	d. *single and dual shaft arrangements;*	*Explain single-shaft and dual-shaft combined-cycle power plants.*	*3B2.7.5*
	e. *control strategies and components;*	*Explain the control strategies and components, for both power and steam production, including diverter and duct burner operation.*	*3B2.7.6*
	f. *environmental considerations;*	*Explain the environmental considerations and techniques in the operation of a cogeneration system.*	*3B2.7.7*
	g. *heat recovery boilers and water heaters;*	*Describe the various designs of heat recovery steam generators (HRSGs) and explain their industrial applications.*	*3B2.7.8*
		Describe typical cogeneration systems that use internal combustion engines (gas or diesel) and heat recovery water heaters (HRWHs).	*3B2.7.9*
	h. *operating procedures*	*Explain a typical start-up procedure for a combined cycle cogeneration system.*	*3B2.7.10*
	i. *typical industrial cogeneration applications*		
21.	Compressors:		

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
21.a.	*Theory of Compression:*		
21.a.i.	*Adiabatic and isothermal compression; pressure volume relationships; compression ratio, capacity, multi-staging; effect of altitude and moisture*	*Explain compressor terminologies, including compression ratio, capacity, staging, intercooling and aftercooling.*	*3B2.8.1*
		Explain the effects of moisture in compressed gases.	*3B2.8.1*
		Explain the effects of altitude on the compression process.	*3B2.8.1*
21.a.ii.	*Applications for compression, including air and gas.*		
21.b.	*Positive Displacement Compressors: design, operating principles*	*Describe the operation and common arrangements of reciprocating compressors, including single-acting, double-acting, tandem arrangements.*	*3B2.8.2*
		Identify the components of a reciprocating compressor and describe the operation of plate and channel valves.	*3B2.8.3*
21.b.i.	*Reciprocating compressors: clearance volume; indicator diagrams; calculations for displacement and volumetric efficiency.*		*3B2.*
~~ii.~~	~~*Free piston compressor*~~ *Removed from syllabus January 2014*		
21.b.ii.	*Rotary Compressors: sliding vane, lobe, and screw types (industrial screw type in detail, including control*	*Describe the design and explain the operating principles of rotary compressors, including sliding vane, rotary lobe, and rotary screw.*	*3B2.8.5*

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
	panel)	*Identify the components for a packaged industrial screw compressor.*	*3B2.8.6*
21.c.	*Dynamic Compressors:*		
21.c.i.	*Design and operation of centrifugal and axial flow compressors; application as blowers*	*Describe designs and principles of centrifugal compressors/blowers, including single and multi-stage designs.*	*3B2.8.7*
21.c.ii.	*Compressor surge: causes and prevention; P-V curve; surge line, anti-surge system and control*	*Explain the design and operation of an anti-surge system for a dynamic compressor.*	*3B2.9.2*
21.d.	*Starting and stopping procedures for positive displacement and dynamic compressors*	*Explain the start-up procedure for a positive displacement compressor.*	*3B2.9.7*
		Explain the start-up procedure for a dynamic compressor/blower.	*3B2.9.8*
21.e.	*Compressor Auxiliaries:*		
21.e.i.	*Intercoolers/aftercoolers; moisture separators*	*Describe the designs of water and air-cooled aftercoolers and intercoolers, with separators.*	*3B2.9.3*
21.e.ii.	*Compressor control systems and devices: start and stop, variable and constant speed; safety devices*	*Describe the control devices and strategies for air compressors, including start-stop, variable speed, constant speed, describe pilot and unloader devices.*	*3B2.9.1*
21.e.iii.	*Lubrication: internal and external*	*Describe internal and external lubrication systems for reciprocating compressors. (Other compressor lubrication systems explained with the compressors)*	*3B2.8.4*
21.e.iv.	*Compressor installation and piping layouts*		*3B2.*
21.f.	*Compressed air system components:*		

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
21.f.i.	*Typical system layout; air receivers (wet and dry) fittings and operation; filters*	*Describe the design, fittings, and operating consideration for air receivers.*	*3B2.9.6*
		Describe the components, arrangement, and parameters of a typical, complete instrument air system, including wet and dry receivers, dryers.	*3B2.9.4*
21.f.ii.	*Air dryers: system design, flows, operation; dewpoint monitoring*	*Describe the components and operating principles and sequences of instrument air dryers.*	*3B2.9.5*
		Explain dewpoint monitoring of air systems.	*3B2.9.5*
22.	Refrigeration:		
22.a.	*Refrigerant classifications, properties, characteristics*	*Explain the required properties of a refrigerant and describe the six group classifications for refrigerants.*	*3B2.10.1*
		Identify the properties of common refrigerants.	*3B2.10.1*
22.b.	*Compression systems:*		
22.b.i.	*Principle of compression refrigeration; typical system temperatures and pressures for simple refrigeration systems*	*Explain the ammonia refrigeration cycle, explaining the purpose of each major component and stating typical pressures and temperatures in the system.*	*3B2.10.2*
22.b.ii.	*Multi-stage systems: 2-stage with duplex compressors; 2-stage with booster compressor; low-temperature multi-stage*	*Describe and explain the operation of a two-stage, duplex compressor system with brine cooler.*	*3B2.10.4*
		Describe and explain the operation of a two-stage refrigeration system with a rotary booster compressor.	*3B2.10.5*

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
		Describe and explain the operation of a low-temperature multi-stage refrigeration system.	*3B2.10.6*
22.b.iii.	*Direct vs. indirect systems*	*Explain direct and indirect refrigeration.*	*3B2.10.3*
		Describe a centrifugal compression system, using chilled water.	*3B2.10.3*
22.b.iv.	*Typical refrigeration applications*		
22.c.	*Absorption system: ammonia absorption system description and operating parameters*	*Explain the components and operating principle of an ammonia absorption system.*	*3B2.10.7*
22.d.	*Refrigeration system auxiliaries:*		
22.d.i.	*System controls: expansion valves, low-side float, high-side float, capillary tube*	*Explain the purpose, design and operation of the following controls on a compression refrigerating system: expansion valve, low-side float, high-side float.*	*3B2.11.1*
22.d.ii.	*Compressor controls: temperature and pressure-actuated*	*Describe compressor controls (temperature and pressure-actuated),.*	*3B2.11.1*
22.d.iii.	*Condenser cooling water control*	*and condenser cooling water control*	*3B2.11.1*
22.d.iv.	*Safety devices and controls: pressure relief devices, high-pressure cut-out, low pressure lube oil cut-out*	*Explain the purpose of the following refrigeration system safety devices: high-pressure cutout, oil pressure cutout and pressure relief devices.*	*3B2.11.2*
22.e.	*CSA B52 Regulations: overview of the code for the safe operation, installation and repair of refrigeration*	*Explain refrigeration safety and environmental issues.*	*3B2.11.8*

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
	equipment		
22.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*	*Explain leak testing of a system and describe the procedure for adding refrigerant.*	*3B2.11.6*
		Explain the effects of oil in ammonia and Freon systems and describe the location and operation of an oil separator and oil still.	*3B2.11.3*
		Explain how oil is manually drained from these systems.	*3B2.11.3*
		Explain the effects and location of non-condensable gases.	*3B2.11.4*
		Describe the operation of manual and automatic purge devices.	*3B2.11.4*
		Explain the effects of moisture in a refrigeration system and describe its removal.	*3B2.11.5*
		Explain the principles of brine control in an indirect system and explain the procedures for charging and controlling brine strength.	*3B2.11.7*
23.	Special Industrial Equipment:		
	Describe the general applications, designs, components, operation for the following:		
22.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*	*Describe double pipe heat exchangers, including jacketed pipe, U-tube, and concentric pipe designs.*	*3B2.12.1*
		Describe shell-and-tube heat exchangers including fixed straight tube and U-tube designs.	*3B2.12.2*

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
	control	*Describe common front and rear head designs, shell flow configurations, and explain the purpose of baffles.*	*3B2.12.2*
		Explain the operation and the typical fittings/equipment on the steam/condensate side of a reboiler and a feed water heater.	*3B2.12.3*
		Describe the design and operation of a plate-and-frame exchanger.	*3B2.12.4*
		Describe the design and components of overhead, aerial coolers, including fan and cooler arrangements.	*3B2.12.5*
		Explain cooler control.	*3B2.12.5*
		Describe the design and components, including controls, of an overhead, aerial condenser.	*3B2.12.6*
		Explain condenser operation, control and precautions when used to condense excess steam.	*3B2.12.6*
23.b.	*Cooling towers: natural draft, atmospheric, hyperbolic; mechanical draft designs; operation and control*	*Describe the design and explain the operation of natural draft cooling towers, including atmospheric and hyperbolic styles.*	*3B2.12.7*
		Describe the design and operation of mechanical draft cooling towers, including forced draft, induced draft counterflow, and induced draft crossflow.	*3B2.12.8*
23.c.	*Fired Heaters: multi-burner vertical designs; burner components and styles; fuel supply and control; interlocks and safety devices; indirect-fired heaters;*	*Describe the common process applications for direct-fired heaters.*	*3B2.13.1*
		Explain direct-fired heater designs and classifications.	*3B2.13.1*

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
	horizontal designs; startup and shutdown procedures	*Describe the design, identify the tube banks and explain the fluid and combustion gas flows through a multi-burner, vertical fired heater.*	*3B2.13.2*
		Describe typical burner designs and configurations, identifying burner components, including air registers, pilots, and flame scanners.	*3B2.13.3*
		Describe burner operation.	*3B2.13.3*
		Describe the fuel gas supply system to the burners and explain the purpose of the major fittings.	*3B2.13.4*
		Describe the monitoring, control, and shutdown devices on a typical heater.	*3B2.13.5*
		Explain heater start-up procedure, including the lighting of additional burners once flame is established.	*3B2.13.6*
		Explain heater shutdown procedure.	*3B2.13.6*
		Describe the design, components and operation of a typical horizontal, indirect-fired heater such as a salt bath heater.	*3B2.13.7*
		Explain start-up and shutdown procedures for and indirect-fired heater.	*3B2.13.8*
24.	Wastewater Treatment		
24.a.	*Purpose of WWT; typical wastewater pollutants and systems*	*State the purpose of wastewater treatment, list typical waste liquids, and explain the legislation and permitting, including parameters, for the disposal of wastewater.*	*3B2.14.1*

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
		Sketch an industrial wastewater treatment system and describe the processes that occur at each stage of treatment.	*3B2.14.2*
24.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)*	*Describe the equipment and process involved in the removal of suspended solids from wastewater, including screening, floatation, and sedimentation.*	*3B2.14.3*
		Describe the equipment and process involved in the removal of colloidal solids from wastewater, including chemical coagulation, flocculation, and clarification.	*3B2.14.4*
		Describe the equipment and process involved in the biological removal of solids from wastewater, including activated sludge, rotating biological contactors, and trickling filters.	*3B2.14.5*
24.c.	*Operating parameters, controls and tests: nutrients, BOD, COD, pH, settleability*	*Describe the control strategy for a wastewater treatment system.*	*3B2.14.6*
		Define and explain the control of and sampling points for the main control parameters, including nutrients, BOD, COD, pH, and settleability.	*3B2.14.6*
24.d.	*Safety in wastewater treatment plants*		
25.	Plant Maintenance and Administration:		
	Explain the purpose, typical design and administration of the following plant functions:		
25.a.	*Communication and accountability structures*	*Explain typical communication and accountability structures within a large facility, including the responsibilities for external communication.*	*3B2.15.1*

Syllabus Section#	Syllabus Statement	Objectives	Learning Materials Reference
25.b.	*Scheduled and preventative maintenance programs*	*Describe the typical components and responsibilities of scheduled and preventive maintenance management programs.*	*3B2.15.2*
25.c.	*Record keeping; logbooks; logsheets*	*Explain the importance and extent of record keeping and describe the quality and content requirements for operating logbooks and records.*	*3B2.15.3*
25.d.	*Project control; critical path (applied to a complete boiler turnaround, as an example)*	*Using a complete boiler turnaround and inspection as an example, describe project management using two methods, Gantt Chart and critical path.*	*3B2.15.4*
25.e.	*Operating standards and procedures*	*Explain the importance of procedures in the operation of a facility and describe the application of well-written procedures to personnel training and daily operation.*	*3B2.15.5*
25.f.	*Training and development practices; job skill profiles*		
25.g.	*Environmental practices and supervision*	*Explain typical environmental monitoring and management programs for operating facilities.*	*3B2.15.6*