SOPEEC standardization of power engineer examinations committee

Curriculum of the 2nd Class (PE Syllabus)
Part "A", First Paper

Syllabus Section #	Syllabus Statement	Objectives
Part "A1"		
1.	A.S.M.E. Code, Sections 1 & 8, Calculations:	
	Design values to be computed for the following boiler and pressure vessel parts:	
a.	Cylindrical components; dished heads; unstayed flat heads, formed heads, shells and welded covers.	*Calculate the required minimum thickness or the maximum allowable working pressure of piping, tubes, drums, and headers of ferrous tubing up to and including 12.5 mm O.D.*
		Calculate the required minimum thickness or the maximum allowable working pressure of ferrous piping, drums, and headers.
		Calculate the required thickness or maximum allowable working pressure of a seamless, unstayed dished head.
		Calculate the minimum required thickness or maximum allowable working pressure of unstayed flat heads, welded covers, and blind flanges.
b.	Openings and compensation:	
	Determine if compensation for openings in shells, headers and heads are required.	Determine if compensation for openings in shells, headers and heads are required.
c.	Stayed surfaces: dimensions and locations of staybolts, ligaments and braced surfaces.	*Calculate the required thickness and design pressure for braced and stayed surfaces in pressure vessels and the minimum required cross-sectional area of a stay.*
		Calculate the ligament efficiency method for two or more openings in the pressure boundary of a pressure vessel.
d.	Pressure relief valves: size and capacity.	*Calculate the required size and capacity of pressure relief valves.*

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	e.		Firetube Boilers:	
		i.	Combustion chambers and furnaces: corrugated furnaces; and general knowledge excluding calculation of plain circular, circular flues; and reinforced furnaces.	*Calculate required wall thicknesses of corrugated furnaces.*
				Describe plain circular furnaces, circular flues, reinforced and corrugated furnaces. (IPECC motion #2 June 2014)
		ii.	Stayed surfaces: maximum spacing of stays; areas of heads to be stayed; stresses in diagonal stays.	*Calculate the minimum required area of stays for Firetube boilers, including diagonal stays.*
2.			Industrial Administration:	
	a.		Legislation: a thorough knowledge of the jurisdictional Act and the Regulations under the Act.	*Identify the types and sources of laws and the levels and scope of the courts.*
				Define statutory delegation of powers as they apply to the Boilers and Pressure Vessels Act.
				Describe the authority that safety officers (inspectors) have within their jurisdiction.
				Determine what are the offences and penalties under the Act and the appeal process.
				Describe the typical regulations under the Boilers and Pressure Vessels Act.
				Describe the typical codes and standards referenced by the Boilers and Pressure Vessels Act.
	b.		Installations: factors and codes governing plant designs and layouts; contract specifications; working knowledge of the engineering and administration involved in plant erection; practical modifications of existing plant.	*State the codes and standards, which must be followed when designing and building a new plant.*
				Describe the steps involved in developing specifications and contracts for new installations and modifications.
				Explain the major steps involved in the design and construction of a new plant.
				Explain the roles and responsibilities in the design and construction of a new plant.

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				Explain how the design and construction of a new plant are administered and controlled.
	c.		Management:	*Management and supervision*
		i.	Functions and objectives of management.	*Define management and explain the general functions of management.*
				Explain how management goals and objectives are developed through planning.
		ii.	Personnel management: selection of staff; personnel training; motivating personnel; disciplining employees.	*Describe methods of selecting new employees.*
				Explain how employees are trained.
				Explain how to provide leadership and motivate employees.
				Explain how to manage employee performance and behaviors.
		iii.	Planning; decision making; report writing.	*Describe how business decisions are made.*
				Demonstrate proper communication skills by writing a formal report.
		iv.	Plant maintenance; inspection; budgeting.	*Describe the aspects of managing maintenance activities including management of maintenance, maintenance program development, planning, scheduling, performing maintenance, assessment and improvement.*
				Describe the different approaches to maintenance including preventive, and corrective.
				Describe how routine maintenance activities are planned, scheduled, and controlled.
				Describe the use of Gantt and PERT charts and the critical path method to schedule major maintenance activities.
				Describe the steps involved in preparing for, and conducting, a pressure vessel inspection.

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				Describe the use of computerized systems in managing maintenance, including a work order system.
				Describe various methods of monitoring equipment, including log sheets and trending.
				Describe the steps involved in developing a plant budget and controlling maintenance costs.
		v.	Safety programs.	*Describe the elements of a comprehensive safety program for a power plant.*
				Explain the purpose of and the process used for safety checklists, inspections, audits and reviews.
				Explain the purpose of and the process used for safety orientation, education, and training.
3.			Applied Mechanics:	
	a.		Velocity and acceleration: speed; linear velocity and acceleration; projectile motion angular velocity and acceleration; relative and absolute velocity.	*Calculate the displacement, velocity, and acceleration of bodies moving in a straight line.*
				Calculate the displacement, velocity and acceleration of projectiles in motion.
				Define and calculate angular displacement, angular velocity and angular acceleration.
	b.		Mass, motion and inertia: force of gravity; weight; mass inertia; accelerating force; momentum.	*Describe the relationship between mass, force, acceleration and weight.*
				Explain "inertia" and "momentum."
				Calculate the momentum and velocity of objects before and after a collision. (IPECC motion # 1 June 2014)
	c.		Work, power and energy: work, graphical representation;	*Demonstrate graphically the relationship between work, force, and distance.*
				Define and calculate the kinetic energy of moving objects

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			indicated and brake horsepower; potential and kinetic energy; conservation of energy; flywheel.	*Define and calculate indicated power.*
				Define and calculate the potential energy of stationary objects.
				Explain the Law of Conservation of Energy.
				Define work and power. Calculate brake power and mechanical efficiency of a reciprocating engine.
	d.		Torque and angular motion: moment of inertia; radius of gyration; work done by torque.	*Define and calculate moment of inertia, radius of gyration and torque.*
	e.		Motion in a circular path: centripetal acceleration; centripetal and centrifugal force; balancing of rotating masses; governors.	*Define centrifugal and centripetal force, centripetal acceleration, and perform calculations involving them.*
				Define and calculate the kinetic energy of rotating masses.
				Calculate the distance of movement of a governor due to centrifugal force.
				Calculate how to balance a rotating mass.
	f.		Friction: coefficient of friction; frictional force; motion on horizontal and inclined planes; the screw thread; transmission of power by belt drives.	*Describe the concept, types and laws of friction.*
				Define and calculate the frictional forces on a screw jack.
				Define and calculate the coefficient of friction and applied forces for objects moved on a horizontal surface by forces parallel to the SURFACE.
				Define and calculate the applied forces for objects moved on a horizontal surface by forces not parallel to the SURFACE.
				Calculate the power transmitted by a belt drive.
				Define and calculate the applied forces for objects moved on an inclined plane.
				Define and calculate maximum torque on a belt drive.

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	g.		Moments: moments of forces; couple; centroids and second moments of area.	*Define and evaluate forces in terms of moments and couples.*
				Define and calculate centroids and first and second moments of areas.
	h.		Stress and strain: modulus of elasticity; restricted expansion.	*Define and calculate the different types of stress.*
				Define strain, modulus of elasticity, Poisson's ratio and perform calculations.
				Describe the thermal expansion of bars, including reactions, under conditions of restricted expansion and reactions of bars composed of dissimilar metals.
	i.		Shearing forces and bending moments: sign conventions; conditions of equilibrium; simply supported beams and cantilevers; concentrated and distributed loading; mathematical and graphical solutions for shearing force and bending moment diagrams.	*Define and calculate shear forces and bending moments for simply supported beams and cantilevers.*
	j.		Torsion: fundamental torsion equation; relationship between torque, stress and horsepower; maximum and mean torque; coupling bolts.	*Perform calculations involving the fundamental torsion equation and explain the relationship between torque and stress.*
				Explain the relationship between torque and power, and calculate maximum and mean torque for solid shafts of circular cross section
				Calculate stress in coupling bolts due to torque.
	k.		Pressure of liquids: density; specific gravity; pressure at any depth; centre of pressure; Displacement.	*Describe the basics of fluid mechanics.*
				Perform calculations related to pressure in a fluid, including center of pressure of a vertical rectangular surface. *(IPECC motion # 5 June 2014)*
				Discuss submerged and floating bodies, and the uplifting forces acting upon them.

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	l.		Flow of liquids: pressure head; Bernoulli's law; Venturi meter; flow through orifices.	*Define and calculate thermal expansion of a vessel and its liquid contents.*
				Describe flow in open channels and calculate fluid flow through a weir.
				Describe liquid flow in a pipe using the continuity equation.
				Apply the law of conservation of energy to fluid flow and define Bernoulli's equation.
				Calculate fluid flow from a vessel orifice.
				Calculate flow using a venturi meter.

Part "A", Second Paper

4.			Thermodynamics:	
	a.		Heat and measurement of heat: temperature scales; absolute temperature; units of heat and their relationship; specific heat; water equivalent; sensible and latent heat; heat mixtures.	*Calculate the energy content and temperatures of substances in a mixture of solids, liquids and vapors.*
	b.		Expansion of solids and heat transfer: linear, surface and volumetric expansion; conduction, convection and radiation.	*Calculate the expansion of solids and liquids due to heat.*
				Calculate the heat transferred through composite walls and cylindrical walls, and determine the interface temperatures.
				Explain heat transfer through a liquid or gaseous film and perform calculation involving the heat transfer coefficient.
				Calculate the heat radiated from a surface using Stefan-Boltzmann Law
	c.		Work and heat: mechanical equivalent of heat; laws of thermo-dynamics; Boyle's and Charles' Laws;	*Perform calculations for a system subjected to a change in internal energy, heat, or work done.*
				Describe the behavior of a perfect gas.

			general gas law; characteristic constant of a gas; specific heats of gases; thermal efficiency.	*Define and calculate specific heats under constant volume and constant pressure conditions.*
				Explain the relationship between work and heat.
	d.		Expansion and compression of gases: Dalton's Law of partial pressures, adiabatic, isothermal and polytropic; ratios of expansion and compression; work done during expansion and compression.	*Explain Dalton's Law of Partial Pressures.*
				Calculate the work done during expansion and compression under constant pressure and isothermal conditions.
				Calculate the work done during adiabatic expansion and compression.
				Calculate the work done during polytropic expansion and compression.
	e.		Thermodynamics of steam: steam tables; saturated and superheated steam; dryness fraction; specific volume; specific heat of superheated steam; heat mixtures; throttling and separating calorimeters; internal energy of steam, enthalpy.	*Describe the basic properties of water and steam.*
				Perform calculations involving specific enthalpy, dryness fraction, specific heat and specific volume using steam tables.
				Explain the principles and use of calorimeters to measure the dryness fraction of wet steam.
				Calculate the dryness fraction of steam based on calorimeter data.
				Calculate the internal energy of steam under given conditions.
				Perform calculations involving mixtures of steam and water using steam tables and specific heats.
	f.		Entropy: entropy of water, evaporation and superheated steam; temperature-entropy diagrams and charts; computations of entropy values.	*Explain the concept of entropy and the use of the temperature-entropy diagram.*
				Calculate the change in entropy for a particular change in enthalpy at a constant temperature.
				Determine steam properties using a Mollier Chart.
	g.		Practical Cycles:	
		i.	Practical cycles: Rankine; Otto; Diesel; Brayton, thermal efficiencies; pressure-	*Explain the concept of a heat engine and describe the different types of heat engines.*

			volume and temperature-entropy diagrams.	*Describe the Carnot cycle.*
				Explain the Rankine cycle using pressure-volume and temperature-entropy diagrams.
				Explain the Otto cycle using pressure-volume and temperature-entropy diagrams.
				Explain the Diesel cycle using pressure-volume and temperature-entropy diagrams.
				Explain the Brayton cycle using pressure-volume and temperature-entropy diagrams.
		ii.	Energy flow calculations; efficiency limits of heat engines, boiler and plant efficiencies, heat balance testing.	*Determine the efficiency, equivalent evaporation, and factor of evaporation for a boiler.*
				Calculate the change in heat, work or power for a steady flow process.
				Calculate thermal efficiencies for vapor cycles and explain efficiency limits.
				Calculate thermal efficiencies for gas cycles and explain efficiency limits.
				Calculate the heat balance at different points in a Rankine cycle system using test data provided.
5.			Metallurgy:	
	a.		Non-ferrous metals: properties, composition and uses; copper; brasses; bronzes; aluminum; white metal.	*Describe the composition, physical properties, and uses of copper, lead, and tin.*
				Describe the composition, physical properties, and uses of aluminum and aluminum alloys.
	b.		The structure of metals: atoms; elements; crystalline structure of metals; grains and grain boundaries, metallographic examination.	*Explain the study of metallurgy and the atomic and crystalline structure of metals.*
	c.		Alloying elements in iron; iron-carbon equilibrium diagram; alloy steels; stainless steels and high chromium alloys; cladding steels.	*Explain the significance of the iron-carbon equilibrium diagram.*

	d.		Heat treatment of metals: normalizing; annealing; spheroidizing; hardening; tempering; quenching.	*Explain the purposes of, and processes used, in the heat treatment of steels.*
	e.		Welding symbols	*Identify and describe common types of welds and associated welding symbols. (IPECC motion #3 June 2014)*
	f.		Metallurgical applications/specifications to power plant piping and tubing	*Explain how to interpret metal specifications.*
				Explain typical selection of metals for process plant applications (what is selected and why).
	g.		Electrochemistry principles applied to corrosion,	*Define corrosion and explain the electrochemical principles involved.*
				Explain how the environment can affect corrosion.
			corrosion forms,	*Explain the most common corrosion mechanisms.*
				Describe the predominant corrosion mechanisms that potentially affect various power plant systems and equipment.
			control method,	*Explain the methods used to control and prevent corrosion at the design stages and during operation.*
			testing, monitoring,	*Explain the methods used to monitor and test for corrosion during plant operation.*
			prevention and failure analysis.	*Explain the main components of corrosion failure analysis and a typical corrosion failure report.*
6.			Testing of Materials:	
	a.		Procedures and interpretations affecting tensile, hardness and impact tests; forms of specimens tested.	*Explain the procedures and interpretation of tensile, hardness, and impact tests.*
	b.		Mechanical, physical and thermal properties of ferrous metals: creep resistance, corrosion resistance and fatigue tests.	*Explain how to monitor and test metals for creep, fatigue and corrosion.*
	c.		Weldment defects: dimensional defects; structural discontinuities; defective properties.	*Explain the causes and significance of welding discontinuities.*

	d.		Nondestructive testing: visual inspection; magnetic particle inspection; liquid penetrant testing; proof tests; leak tests, ultrasonic, radiography, acoustic emission.	*Explain visual inspection, and the procedures used.*
				Explain magnetic particle inspection and the procedures used.
				Explain liquid penetrant testing and the procedures used.
				Explain ultrasonic testing and the procedures used.
				Explain radiography, the procedures used and how to interpret the results.
				Explain acoustic emission testing and the procedures used.
				Explain the methods of leak testing.
				Explain the procedure for a proof test.

Part "A", Third Paper

7.			Boilers:	
	a.		Steam generator design considerations.	*Explain how the ratings of boilers and steam generators are calculated.*
				Explain the factors to be considered in designing a steam generator.
				Contrast the influence of solid fuel, liquid fuel, and gas fuel on steam generator design.
				Describe furnace casing design considerations.
	b.		Methods of heat transfer; circulation; steam generator ratings.	*Explain the principles of natural water circulation in a steam generator.*
				Explain why forced circulation is used in a steam generator and how it is attained.
				Explain the design, placement, and installation considerations for water walls, superheaters, desuperheaters, reheaters, economizers, and air heaters.

	c.		Specialized boiler designs and applications	*Describe the purpose and use of specialized steam generator duct arrangements, including air heater bypasses, economizer bypasses, and air heater recirculation.*
				Describe typical designs, components, and operating strategies for once-through steam-flood boilers.
				Describe typical designs, components, and operating strategies for fluidized bed boilers (bubbling bed and circulating bed types).
				Describe typical designs, components, and operating strategies for heat recovery steam generators.
				Compare different designs of heat recovery steam generators (HRSG): natural circulation, controlled circulation and once-through (OTSG).
				Describe typical designs, components, and operating strategies for supercritical steam generators.
				Describe typical designs, components, and operating strategies for black liquor recovery boilers.
				Describe typical designs, components, and operating strategies for refuse boilers used in waste disposal.
				Describe typical designs, components, and operating strategies for bio-mass boilers.
	d.		Types and applications of firetube and watertube boilers/steam generators.	*Describe typical designs, components, and operating strategies for waste-heat boilers (firetube and watertube types).*
	e.		Boiler fittings, including safety devices, drum internals, soot blowers.	
	f.		Boiler details: waterwalls; superheaters; desuperheaters; attemperators; economizers; air heaters; blow-down systems; flash tanks;	*Explain the purpose and placement of screen tubes, divisional walls, water cooled stringer tubes in superheaters, and wall-mounted radiant superheaters.*

			steam separators.	
	g.		Methods of installation and support: foundations; settings; methods of tubing; top drum erection; shop and field assembly.	*List the steps to construct a steam generator.*
				Describe top and bottom support systems for a steam generator.
	h.		Insulation: duct and baffle arrangements; boiler casings.	*Describe the methods used to insulate different parts of a steam generator.*
	i.		Operation: start up and shut down; boiling out; drying out refractory; lay-up procedure; safety precautions.	*Describe the detailed hot and cold startup procedures for a steam generator including safety precautions.*
				Describe the detailed shutdown procedure for a steam generator including safety precautions.
				Describe the detailed lay-up procedures for a steam generator including safety precautions.
				Describe the detailed refractory dry out procedure for a new steam generator including safety precautions.
				Describe the detailed boil out procedure for a new steam generator including safety precautions.
				Describe standard shutdown activities and preventive maintenance procedures required for a boiler.
	j.		Maintenance; mechanical and chemical cleaning; inspection; upkeep and repairs; hydrostatic test; safety precautions.	*Describe the mechanical cleaning procedures for a boiler including safety precautions.*
				Describe the detailed chemical cleaning procedures for a watertube boiler including safety precautions.
				Describe the detailed hydrostatic testing procedure for a boiler including safety precautions.
	k.		Boiler Inspections: detailed procedure for complete inspection of a large boiler	*Describe the detailed procedure for complete inspection of a boiler including water side, fireside, and auxiliary equipment.*

			including water side, fire side, and auxiliary equipment; thermal radiation techniques; inspection records and reporting procedures; liaison procedure with boiler inspector; involvement of other personnel inspection (engineering staff, operators); inspection equipment; inspection safety.	*Describe boiler inspection techniques and equipment.* *Describe the required inspection records and reporting procedures.* *Describe the roles and responsibilities for an inspection including engineering staff, operators, and boiler inspector.* *Describe the safety requirements during a boiler inspection.*
8.			Pumps:	
	a.		Practical Applications of pumping theory for power plants;	*Explain selection criteria for pump applications.* *Interpret pump operating characteristics and performance curves.*
	b.		Installation; maintenance; operation/control.	*Describe the procedure for the installation of a large, multi-stage centrifugal pump.* *Describe the typical repairs and preventive maintenance procedures required for a multi-stage centrifugal pump.*
	c.		Constructional details including: impeller types; seal selection; shaft alignment; thrust balancers; tachometers.	*Describe the selection criteria for seal types and materials in a centrifugal pump.* *Describe the methods of counteracting thrust in a centrifugal pump.*
	d.		Boiler feed pump re-circulation control.	*Describe the methods of control for a multi-stage centrifugal pump including recirculation control.*
9.			Water Treatment:	
	a.		Water and its impurities.	*Describe the sources of the impurities found in raw water* *Describe the effect of the listed water impurities on power plant equipment and processes.*
	b.		Methods of feedwater treatment: subsidence; coagulation; filtration; oil removal; lime-soda softening; hot process phosphate softening; sodium and hydrogen Zeolite softening; silica	*Explain the purpose, equipment, operation, and limitations of sedimentation.* *Explain the purpose, equipment, operation, and limitations of coagulation and flocculation.*

			removal; demineralization; deaeration; evaporation; electro-dialysis and electro-deionization (ED /EDI); reverse osmosis (RO); microfiltration	*Explain the purpose, equipment, operation, and limitations of filtration.*
				Explain the purpose, principles, equipment, operation, and limitations of microfiltration.
				Describe how oil is removed from water.
				Explain the purpose, equipment, operation, and limitations of mechanical deaeration.
				Explain the purpose, equipment, operation, and limitations of evaporation.
				Explain the purpose, equipment and operation of lime-soda softening.
				Explain the purpose, equipment, operation and limitations of hot process phosphate softening.
				Explain the purpose, equipment, operation, and limitations of sodium Zeolite softening.
				Explain the purpose, equipment and operation, of hydrogen zeolite softening.
				Describe how silica is removed from water.
				Explain the purpose, equipment, and operation of demineralization, including condensate polishing.
				Explain the purpose, equipment, and operation of electrodialysis (ED) and electrodeionization (EDI.)
				Explain the purpose, equipment, and operation of reverse osmosis (RO.)
	c.		Internal treatment of boiler water: control of scale, foam, embrittlement, return line corrosion; chelating agents; sludge conditioning; pH control; deaeration; carryover; blowdown; chemical feed systems; silica turbine blade deposits.	*Explain the causes, effects, and control of scale.*
				Explain the causes, effects, and control of foam in boiler water.
				Explain the causes, effects, and control of caustic embrittlement.
				Explain the causes, effects, and control of return line corrosion.
				Explain the use of chelating agents in boiler water.

				Explain the use of sludge conditioning in boiler water.
				Explain the use of pH control in boiler water.
				Explain the use of chemical deaeration in boiler water.
				Explain the causes, effects, and control of carryover of boiler water.
				Explain the use of blowdown from boiler water.
				Explain the use and control of chemical feed systems for boiler water.
				Explain the control of silica to avoid turbine blade deposits.
	d.		Analytical methods and equipment:	
		i.	Instruments: embrittlement detectors; steam purity; total solid meters; methods of steam sampling; measurement of pH.	*Explain the purposes and principles of testing instruments, including embrittlement detector, total solids meter, and pH meter.*
		ii.	Water analysis and interpretation of analytical results.	*Explain the significance and importance of standard methods of water analysis.*
				Describe which analyses are appropriate at given sampling points including the significance of the sampling point locations.
				Interpret the results of a comprehensive standardized water analysis including the relationship of the various parameters.
				Explain the purpose of steam purity measurement and process of steam sampling.
	e.		Cooling water treatment; slime and algae control, corrosion control.	*List the water impurities of concern in a cooling water system and the effects caused by each one.*
				Describe control methods for a cooling water system for control of corrosion, fouling, and microbiological attack including chloride corrosion, and delignification.

	f.		Industrial waste treatment: effects caused by waste discharge; mechanical, chemical and biological methods of waste treatment.	*Describe the potential effects of wastewater discharge.*
				Compare and contrast mechanical, chemical, and biological methods of wastewater treatment including the advantages and disadvantages of each.
				Specify an appropriate method of wastewater treatment for a particular case study.
	g.		Potable Water treatment and testing	*Describe the methods used for potable water treatment and analysis.*

Part "B", First Paper

10.			Heat Engines and Prime Movers:	
	a.		Steam Turbines:	
		i.	Applications of operating principles: impulse and reaction turbines, classifications	*Explain selection criteria for a turbine application.*
		ii.	Construction: casings; rotors; dummy pistons; blading; diaphragms; glands; seals; flexible couplings; bearings; thrusts.	*Describe the design and components of steam turbine casings and casing drains.*
				Describe the design and components of steam turbine rotors, blading, and diaphragms.
				Describe shaft seal designs, including stuffing boxes, carbon rings, labyrinth and water seals.
				Describe the design and components of steam turbine bearings.
		iii.	Details: turning gears; drains; rotor adjustment; dynamic and static balancing; critical speed; lubricating oil systems; jacking oil pump; piping; reducing gears; expansion and anchoring.	*Describe the purpose, design and components of a turning gear.*
				Describe the purpose, design and components of an adjusting gear.
				Explain critical speed.
				Describe the design and components of lubricating oil and jacking oil systems.

				Describe the design of speed reducing gears.
				Describe the design and components of flexible couplings.
				Describe the ways in which steam turbines are designed to counteract thrust.
				Describe the purpose and design of expansion and anchoring components.
		iv.	Control: governors; governor systems; control valves; grid type extraction valves; casing relief valves; overspeed trips; turbine supervisory equipment.	*Describe the purpose and design of steam turbine governors and governor systems.*
				Describe the purpose and design of steam turbine stop valves and control valves.
				Describe the purpose and design of steam turbine grid type extraction valves.
				Describe the purpose and design of steam turbine casing pressure relief systems including rupture diaphragms.
				Describe the purpose and design of steam turbine overspeed trips.
				Describe the purpose and design of steam turbine supervisory equipment.
		v.	Operation: starting up and shutting down; normal operation; flow diagrams; efficiencies.	*Describe the detailed hot and cold start-up procedures for a large steam turbine, including safety precautions.*
				Describe the detailed shutdown procedure for a large steam turbine including safety precautions.
				Explain what checks are performed on a large steam turbine during normal operation.
				Sketch the flow of steam and condensate through a condensing steam turbine and a non-condensing steam turbine.
		vi.	Maintenance: repairs; shaft alignment; bearing; thrust, blade and packing clearances; blade fouling and erosion; cleaning after erection.	*Explain the preventive maintenance requirements for a large steam turbine. Include shaft alignment, bearings, clearances for thrust, blades, shaft seals, correction of blade fouling, erosion and cleaning.*

				Describe the purpose of and procedure for static and dynamic balancing.
		vii.	Theory: nozzles; velocity diagrams; angle of entry and velocity calculations; work done on blades and blade characteristics.	*Explain the principles of steam turbine nozzle design.*
				Explain a steam turbine steam velocity diagram.
				Calculate the steam velocity and angle of entry for impulse and reaction turbine blading.
				Calculate the work done on steam turbine blades and the resulting power developed.
				Calculate steam turbine Rankine cycle thermal efficiency.
		viii.	Condensing equipment	
		viii. a.	Condensers: types and constructional details; backwashing and cleaning; leak testing.	*Describe the principles and design of jet, air cooled, and surface condensers.*
				Describe the purpose, principle and design of surface condenser support and expansion systems.
				Explain the significant parameters in condenser performance.
				Calculate condenser thermal efficiency from the test data.
				Explain the procedures used to troubleshoot condenser performance.
				Explain the procedures used to backwash and clean a condenser.
		viii. b.	Condenser ancillary equipment: air ejectors; cooling water systems; intakes and intake screens; cooling towers and ponds; atmospheric exhaust valves; circulating pumps; condensate pumps.	*Describe the purpose, principle and design of air ejectors and vacuum pumps.*
				Describe the purpose and flow of cooling water systems.
				Describe the purpose, principle and design of cooling water intake screens, circulating pumps, cooling towers, and cooling ponds.
				Describe the purpose, principle and design of condenser atmospheric exhaust (relief) valves.

				Describe the purpose, principle and design of condensate pumps.
	b.		Internal Combustion Engines:	
		i.	Applications: two and four stroke, oil burning, gas and dual-fuel.	*Explain design, applications, and selection criteria for the different types of reciprocating internal combustion engines.*
		ii.	Fuels: classification; properties; impurities; methods of purifying and clarifying; injection systems; ignition systems; scavenging and supercharging arrangements.	*Explain fuels and combustion processes and fuels used by internal combustion engines.*
				Describe the design of internal combustion engine scavenging and supercharging arrangements.
				Describe the design and components of internal combustion engine fuel conditioning systems, injection systems, and ignition systems.
				State the purpose and describe the control of a typical internal combustion engine including the operation of safety devices.
		iii.	Operation and maintenance: causes and prevention of incomplete combustion; starting up and shutting down: prevention of crankcase explosions; crankcase safety fittings; piston and cylinder troubles; repair and replacement of worn or broken parts.	*Describe the detailed startup procedures for an internal combustion engine.*
				Describe the detailed shutdown procedures for an internal combustion engine.
				Explain the routine maintenance and monitoring requirements for an internal combustion engine.
				Explain the major maintenance and overhaul requirements for an internal combustion engine.
				Explain the troubleshooting of combustion and engine problems.
		iv.	Cooling: piston and jacket cooling water systems; cooling water treatment and removal of deposits; lubricating oil systems.	*Describe the design and components of internal combustion engine cooling systems and cooling water conditioning systems.*
				Describe the purpose, design and components of internal combustion engine lubricating oil systems.

	c.		Gas Turbines:	
		i.	Applications of operating principles; types of gas turbines	*Explain applications and selection criteria for the different types of gas turbine engines.*
		ii.	Open and closed cycle systems; regeneration; intercooling and reheating.	*Describe the principles and design of open and closed cycle gas turbine systems.*
				Describe the principles and design of combined cycle and cogeneration systems using gas turbines.
				Describe the principles and design of gas turbine regeneration, intercooling, and reheating.
		iii.	Gas turbine applications: dual shaft machines; free-piston gas generators, combined cycle.	*Describe the principles and design of gas turbine shaft arrangements.*
				Describe the design and components of gas turbine compressors, combustors (combustion chambers) and turbines.
				Describe the design and operation of gas turbine air intake and exhaust systems.
				Describe the design and operation of a gas turbine lubricating oil system.
		iv.	Construction: rotors; blading; compressors; combustors: combustion chambers.	*Describe the design and operation of a gas turbine fuel system.*
				Describe the design and operation of a gas turbine steam or water injection system and a dry low NOx system.
		v.	Operation and control: starting up and shutting down; normal running procedures; control systems; safety devices.	*Describe the components and operation of gas turbine supervisory and control systems.*
				Describe the principles and design of gas turbine protection devices.
				Describe the detailed hot and cold startup procedures for a gas turbine, including safety precautions.
				Describe the detailed shutdown procedure for a gas turbine, including safety precautions.
				Explain the routine maintenance and monitoring requirements for a gas turbine.

				Describe the major maintenance and overhaul requirements for a gas turbine.
				Explain the troubleshooting of gas turbine problems.
11.			Lubrication:	
	a.		Plant lubrication program: lubrication survey; types of lubricating systems, air compressor, gas turbine, internal combustion engine, steam turbine; lubricating oil / governing/seal oil systems;	*Describe a typical power plant lubrication program, including a lubrication survey.*
				Describe the methods of manufacture and the different classifications of lubricants.
				Describe the significance and measurement of lubricating oil characteristics, including viscosity, relative density, API gravity, pour point, and dielectric strength.
				Explain the different types of lubricating/governing/seal oil systems.
	b.		Engine Lubricating oil maintenance: causes of deterioration; additives; oil purification equipment.	*Explain the typical causes of lubricating oil deterioration.*
				Describe the types of lubrication additives.
				Describe the components and operation of a typical lubricating oil purification system.
	c.		Applications of ball and roller bearings and their lubrication; bearing seals.	*Describe the various applications of ball-and-roller bearings and their lubrication, including bearing seals.*
12.			Piping:	
	a.		Piping material identification and selection, appropriate Code procedures, inspection, leak tests.	*Explain selection criteria for piping materials.*
				Calculate the required thickness and maximum allowable working pressure of piping.
				Describe typical inspection procedures for piping installations and repairs.
				Describe a typical routine inspection procedure and schedule for high-energy piping.
	b.		Strength of piping; high temperature effects.	*Explain the effects of high temperature on piping strength.*
	c.		Support; expansion allowances; cold springing; drainage; insulation.	*Describe the design and installation criteria for a piping system layout.*

	d.		Theory and effects of water hammer.	*Explain the theory and effects of water hammer.*
	e.		Layouts of piping in Power and Pressure Plants.	
13.			Mechanical Drawing:	
	a.		Pictorial drawing;	*Interpret the information provided in pictorial drawings* (IPECC MOTION 12-SC-2-06) January 2014
	b.		Orthographic, auxiliary, isometric and oblique drawings.	*Interpret the information provided in orthographic, isometric, and oblique drawings.*
	c.		Sectioning and dimensioning.	*Interpret the information provided in construction drawings with sectioning and dimensioning.*
	d.		Flow diagrams; piping drawings; (IPECC MOTION 12-SC-2-08) January 2014	*Interpret the information provided in process flow drawings.*
				Explain the use of isometric piping system and spool drawings in piping systems.
	e.		Industrial Drawings, types and interpretation	*Interpret the information provided in process and instrumentation drawings (P&IDs.)*

Part "B", Second Paper

14.			Power Plant Systems	
	a.		Feed water systems; layout and operation. regenerative feed heating cycle; closed feed systems; feed heaters; deaerators;	*Describe, using a sketch, the design and operation of feedwater systems.*
	b.		Steam Piping systems	*Describe, using a sketch, the design and operation of steam distribution systems.*
	c.		Fuel systems; layout and operation.	*Describe, using a sketch, the design and operation of fuel oil supply systems.*
				Describe, using a sketch, the design and operation of fuel gas supply systems.
				Describe, using a sketch, the design and operation of solid fuel supply systems.
	d.		Steam Condensate system; layout and operation.	*Describe, using a sketch, the design and operation of condensate systems.*

	e.		Cooling water systems; layout and operation.	*Describe, using a sketch, the design and operation of cooling water systems.*
	f.		Waste handling systems; layout and operation.	*Describe, using a sketch, the design and operation of waste handling systems.*
	g.		Integration of power plant water systems	*Explain how different power plant water systems interconnect and what parameters are significant to each.*
15.			Control Instrumentation:	
	a.		Electrical and Electronic Pressure measuring devices and component placement/installation.	*Describe the design, use, and placement of electrical and electronic pressure measuring devices.*
	b.		Electrical and Electronic Temperature measuring instruments and component-placement /installation.	*Describe the design, use, and placement of electrical and electronic temperature measuring devices.*
	c.		Flow measurements with differential pressure flow meters:	
		i.	Primary elements: orifice plate; flow nozzle; venturi tube; pitot tube; flow-nozzle pipes.	*Describe the design, use, and placement of venturi tubes, orifice plates, flow nozzles, and pitot tubes.*
		ii.	Indicating mechanisms: manometer; ring balance; force balance; electric.	*Describe the design and use of: manometers, ring balance, force balance, and electric flow indicating mechanisms.*
		iii.	Component placement/installation.	
	d.		Liquid level measurement and control and component installation: ball-float; displacement-type; hydrostatic head; electric and pneumatic level transmission; electric and magnetic type level-limit devices; remote water-level indicators.	*Describe the design, use, and placement of the following liquid level measurement devices: ball-float, displacement-type, hydrostatic head, electric and pneumatic level transmission, electric and magnetic type level-limit devices, and remote water-level indicators.*
	e.		Final control elements: types and flow characteristics of control valves; construction details of control valves; power operators ---solenoid, pneumatic-diaphragm, power cylinder, electric motor.	*Describe the types, construction, and flow characteristics of control valves.* *Describe the design, operation, and application of the following valve operators: solenoid, pneumatic-diaphragm, power cylinder and electric motor.*
	f.		One, two and three element boiler feedwater control systems.	*Describe the principle, design, application, and limitations of single, two, and three-element boiler feedwater control systems.*

	g.		Superheated/reheated steam temperature control; steam pressure reducing and desuperheating control systems.	*Describe the principle, design, application, and limitations of superheated and reheated steam temperature control systems.*
	h.		Modes of automatic control; two position (; proportional; proportional-plus-reset and proportionalplus-reset-plus-rate.	*Describe the principle, design, application, and limitations of the following automatic control methods: proportional, proportional-plus-reset, and proportional-plus-reset-plus-rate.*
		i.	Control Systems: Distributed Control Systems, Programmable Logic Controller,	*Describe the principle, design, components, application, and limitations of Distributed Control Systems (DCS).*
				Describe the principle, design, application, and limitations of Programmable Logic Controllers (PLC).
6.			Fuels and Combustion:	
	a.		Combustion chemistry; chemical analysis of fuels.	*Describe the nature of combustion and the different types of fuels.*
	b.		Fuels: classification; heat values; properties; fuel handling;	*Describe the proximate and ultimate analysis and calculate the heating value of fuel.*
	c.		Combustion: bomb calorimeter; analysis of flue gases; quantity of air required for combustion; draft calculations.	*Given the results of a bomb calorimeter test, calculate the heating value of a fuel.*
				Calculate the amount of air and excess air required for combustion of fuel.
				Explain flue gas analysis parameters and their significance.
				Calculate theoretical draft, flue gas velocity, and stack diameter.
				Calculate draft fan power and efficiency.
	d.		Furnace types and designs; refractories; arches; separately fired reheat furnace.	*Describe steam generator furnace designs including cyclone furnaces and divided furnaces. Explain the purpose and placement of furnace arches.*
				Explain the purpose and design of separately fired superheat and reheat furnaces.
				Explain the purpose, types, characteristics, and placement of refractory in a furnace.

	e.		Firing equipment: pulverizers; oil and gas burners; storage and heating of oil; ash and slag disposal; ash fusion temperature, fuel burning systems.	*Describe the principle, design, and application of oil, gas, and coal burners.*
				Describe the principle, design, and application of pulverizers.
				Describe the principle, design, and application of ash and slag disposal systems.
				Explain the significance, monitoring, and control of ash fusion temperature.
	f.		Draft: systems and equipment.	*Describe the designs and applications of forced and induced draft fans.*
				Explain the methods which control furnace draft.
	g.		Combustion Control:	
		i.	Classification of systems; methods of operation; pneumatic, electric and hydraulic mediums; control systems and installations for gas, oil and coal firing.	*Describe, using a sketch, the combustion control arrangements in a steam generator.*
				Explain series, parallel, and series/parallel combustion control.
				Explain turbine-following, boiler-following, and integrated combustion control systems.
		ii.	Flue-gas analysis; CO_2, O_2 and combustibles recorders.	*Calculate the mass and volumetric analysis of a fuel.*
		iii.	Combustion safeguards: purge and fan-failure interlock systems; flame-failure control systems; photo electric tubes; rectifier rods.	*Describe the operation of purge, fan failure, and flame failure interlock systems.*
				Describe the operation of flame detectors.
		iv.	Packaged boiler-control systems: programming sequence; limiting devices and alarms.	*Describe, using a sketch, a typical programming sequence for a packaged boiler control system.*
				Describe the typical limiting devices and alarms for a packaged boiler combustion system.
17.			Environmental Protection	
	a.		Monitoring equipment and troubleshooting procedures: continuous	*Explain the basic principles of operation for Continuous Emissions Monitoring Systems (CEMS) measurement instruments.*

			emissions monitoring systems; wastewater monitoring; data interpretation; troubleshooting	*Explain the general requirements for Continuous Emissions Monitoring Systems (CEMS.)*
				Explain the general requirements for wastewater monitoring.
				Explain how data that is received from environmental monitoring equipment is interpreted.
				Explain the significance of environmental monitoring equipment failure.
				Describe the procedure used for troubleshooting environmental monitoring equipment.
	b.		Specific environmental controls and equipment: integrated environmental controls; technical knowledge and efficient operating practices and monitoring for the following:	
		i.	Flue gas desulphurization	*Describe the purpose, design, operation, and application of Flue Gas Desulphurization (FGD) systems.*
				Explain the significance, procedures, and equipment for reduction of CO2 emission from a boiler.
				Describe the purpose, design, operation, and application of an electrostatic precipitator.
		ii.	Selective catalytic reduction	*Describe the purpose, design, operation, and application of Selective Catalytic Reduction (SCR) systems.*
		iii.	NO_x reduction	*Explain the significance of NOx reduction in a power plant, and the procedures and equipment used to reduce NOx emission from a boiler and from a gas turbine.*
		iv.	Flue gas chemical conditioning	*Explain the purpose, effects, and application of flue gas chemical conditioning in a power plant.*
		v.	Baghouses and precipitators	*Describe the purpose, design, operation, and application of a baghouse.*
	c.		Significance of measured parameters:	

		i.	Air quality particulates, stack opacity, SO_2 and NO_x concentration and mass flow, mercury, O_2, CO_2, hydrocarbons	*Explain the significance of the following air quality parameters: particulates, stack opacity, SO2 concentration, SO2 mass flow, NOx concentration, NOx mass flow, mercury, O2, CO2, and hydrocarbons.*
		ii.	Wastewater - iron, phosphorous, biological oxygen demand, chemical oxygen demand, hydrocarbons, temperature, flow, pH, nitrogen.	*Explain the significance of the following water quality parameters: iron, phosphorous, biological oxygen demand (BOD), chemical oxygen demand (COD), hydrocarbons, temperature, flow, pH, and nitrogen.*

Part "B", Third Paper

18.			Electrotechnology:	
	a.		A.C. Theory:	
		i.	The sine wave: generation of an alternating electromotive force; root mean square values; vector representation of sinusoidal quantities, peak, peak to peak.	*Explain the vector relationships between AC voltage and current.*
				Explain the significance of root mean square values for AC sine waves.
				Calculate root mean square and peak-to-peak values for AC sine waves.
		ii.	Resistance, inductance and capacitance in single-phase A.C. circuits; inductive reactance; capacitive reactance, impedance, resonance.	*Explain voltage/current relationships and calculate power in purely resistive circuits.*
				Explain voltage/current relationships and calculate power in purely inductive circuits.
				Explain voltage/current relationships and calculate power in purely capacitive circuits.
				Explain voltage/current relationships in circuits containing resistance/inductance and resistance/capacitance.
		iii.	Power in A.C. circuits; true and apparent power; practical importance of power factor; power factor correction.	*Calculate impedance, reactance, true and apparent power, and power factor in AC circuits.*
				Explain the significance of power factor and how it can be improved in AC circuits.
		iv.	Three-phase circuits: delta and star connected alternators and loads,	*Explain the principle and significance of three-phase AC circuits, star, and delta connections in alternators, transformers, and*

			current and voltage relationships; three-phase power.	*AC motors.*
				Calculate phase voltage, phase current and apparent and true power in a three-phase AC circuit.
	b.		D.C. Machines:	
		i.	Generators: principle of operation; construction; commutation; armature reaction; interpoles; compensating windings; lap and wave wound armatures; generator types and characteristics; parallel operation; voltage regulation; theory of self-excitation; efficiency and power losses; selection of generators and applications; parallel operation; ratings.	*Describe the construction and operating principles of a DC generator.*
				Explain the principle and application of compensating windings, interpoles and lap and wave armature windings.
				Explain the principles, applications, and load/voltage characteristics of generators.
				Describe the parallel operation and voltage regulation of DC generators.
		ii.	Motors: principle of motor action; torque development; Fleming s left-hand rule; back electromotive force: voltage, current and speed computation; motor types and characteristics; starting arrangements; dynamic and regenerative braking; speed control; efficiency and power losses.	*Review the principle of DC motor operation, including torque development and back emf.*
				Calculate torque, speed and current of a DC motor.
				Explain the principle and application of shunt, series, and compound-wound DC motors including speed control.
				Explain the principle and application of counter-E, current limit, and time limit DC motor automatic starters.
				Explain the principle and application of dynamic and regenerative braking.
				Calculate efficiency and discuss the reasons for power losses in a DC motor and generator.
	c.		A. C. Machines:	
		i.	Alternators: types; construction of stators, rotors and exciters; stator windings;	*Explain the operating principles, design and construction of alternators with salient-pole and cylindrical rotors.*
				Explain the relationship between alternator speed, frequency, and number of pole pairs.

			relationship between speed, frequency and number of pole pairs; cooling systems; shaft sealing systems; voltage regulators; synchronizing; parallel operation; power factor control, voltage drops in armatures; rating, efficiency and power losses.	*Describe the purpose and construction of an exciter.*
				Describe the purpose and design of voltage regulators used for an alternator.
				Describe the cooling systems used for an alternator including circulating air cooling, hydrogen cooling, and stator winding cooling water systems.
				Describe and explain the procedure for purging and charging a hydrogen system. (IPECC motion #8 June 2014)
				Describe shaft sealing arrangements for an alternator.
				Explain the theory and significance of alternator synchronization and parallel operation including the impact on power factor.
				Explain efficiency and power losses in an AC generator.
		ii.	Single-phase motors: universal, shaded pole and split-phase types; repulsion-start and reluctance-start types; capacitance starting method.	*Describe the principles, applications, and operation of single-phase AC motors. Include universal, shaded-pole, split-phase, capacitance-start, repulsion-start, and reluctance-start.*
				Describe the principle of a pulsating magnetic field for single-phase AC motors and rotating magnetic field for three-phase AC motors.
				Describe the principles, applications, and operation of wound rotor motors.
				Define full-load amps, locked rotor amps, service factor amps.
		iii.	Polyphase induction motors; principle of operation; rotating magnetic field; slip and rotor speed; stator and rotor construction; starting methods.	*Describe the torque/speed characteristics of induction motors and the relationship between torque, slip and rotor speed.*

		iv.	Synchronous motors: general facts concerning synchronous motors; stator and rotor construction, starting methods.	*Describe the principles, applications, starting methods and operation of a synchronous motor.*
		v.	Transformers: principle of transformer action; ratings; efficiency and losses; short and open circuit tests; types of construction; methods of cooling; connections; paralleling; instrument transformers.	*Describe the construction of core type and shell type transformers.*
				Explain the factors that affect transformer rating.
				Calculate load, power, iron and copper losses, and efficiency in a transformer.
				Explain the purpose and procedures for transformer short and open circuit tests.
				Describe the methods of cooling a transformer.
				Describe the methods of connecting a transformer, including delta-delta, star-star, delta-star, and star-delta.
				Explain the theory and significance of transformer paralleling.
				Describe the applications of instrument transformers.
				Explain transformer protection and the switch gear operation. *(IPECC 2013,Motion# 12-2-C-13-2B3-18-c-v)*
		vi.	Protection of electrical systems: alternator stator and rotor protection devices; motor protection devices; transformer safety fittings.	*Explain the purpose, interpretation, and significance of protection relaying as it applies to the protection of a large alternator.*
				Explain the purpose, interpretation, and significance of the protection devices for a large motor.
				Describe the safety controls used on a transformer including fast and slow gas detection, oil temperature alarms, low oil level protection, winding temperature alarms, overcurrent and undervoltage protection, synchronization checks, overexcitation, ground fault protection, phase sequence relays, dissolved gas monitoring, and

				differential protection.
		vii.	Circuit-protective equipment; interrupting capacity; fuses; switches; circuit-breakers; relays.	*Describe the significance fuses and circuit breakers provide as protective devices including continuous rating, interrupting capacity, and inverse time principle.*
				Describe the purpose and designs of different types of fuses.
				Describe the operation of circuit breakers used for different voltages, including moulded-case, oil-immersed, airblast, air-break, vacuum, and SF6 switchgear.
				Describe the operation of switches and contactors used for different voltages.
19.			Principles of Air and Gas Compression:	
	a.		Applications of air and gas compression: effects of altitude, temperature, humidity.	*Describe the design and application of compressors including a selection of prime movers.*
				Explain the effects of altitude, air temperature, and humidity on air compressor performance.
	b.		Reciprocating, axial, centrifugal and rotary compressors: operation, applications; construction; regulation and control; drive selection criteria and preventive maintenance.	*Describe the design of reciprocating compressors.*
				Describe the design of rotary compressors.
				Describe the design of centrifugal and axial compressors.
				Describe the types and operation of coolers and air driers including types of desiccants.
				Describe the regulation and control of compressors.
				Describe the monitoring and protection devices for a compressed air system.
				Describe the monitoring, troubleshooting, and typical preventive maintenance for a compressed air system.

	c.		Ancillary equipment: valves; coolers; receivers; oil and water separators; filters; unloaders; safety/relief valves; instruments; piping layouts, dryers.	*Describe the installation of a compressed air system showing all ancillary equipment including typical instrumentation.*
20.			Industrial/Commercial Refrigeration:	
	a.		Applications of refrigeration: compression and absorption systems; thermoelectric refrigeration; hermetic cycles; cascade systems; heat pump systems.	*Describe the types of refrigerants.*
				Describe the principles and operation of vapor compression refrigeration systems.
				Describe the principles and operation of absorption refrigeration systems.
				Describe the principles and operation of multi-stage and cascade refrigeration systems.
				Describe the principles, applications, and operation of heat pump and thermoelectric systems.
				Describe the design of hermetic refrigeration systems.
	b.		Refrigerating plants; types; layouts; installation details.	*Describe the codes and standards which apply to the design, installation, and operation of a refrigeration plant.*
	c.		Plant equipment: compressors; condensers; evaporators; liquid receivers; oil separators; absorbers; generators; heat exchangers; rectifiers; driers; scale traps; piping and fittings; cold room construction.	*Describe the design and operation of refrigeration compressors.*
				Describe the design and operation of evaporators, condensers, receivers, scale traps and dehydrators.
				Describe the design and operation of absorbers.
				Describe the design and operation of valves and fittings.

	d.		Operation of refrigerating plants: starting up and shutting down; charging; hand and automatic purging; automatic expansion valves; compressor lubrication; brine solutions; leak testing; trouble shooting.	*Describe the detailed startup and shutdown procedures for a refrigeration system.*
				Explain absorption system startup and shutdown.
				Explain leak testing, charging, purging, and compressor lubrication.
				Describe the common operating problems and troubleshooting procedures for a refrigeration system.
	e.		Safety and control: Code requirements; safety fittings; compressor and system instrumentation and controls; cooling water system controls.	*Describe the purpose and operation of the various operating, actuating, limiting and safety controls used in refrigeration systems.*
				Explain refrigeration metering devices.
				Explain evaporator and compressor capacity controls.
	f.		Computations of capacities and performances of refrigerating plants; ideal and practical refrigerant cycles; theoretical piston displacement; heat pump effect; Theoretical power; pressure-enthalpy charts.	*Describe the general refrigeration cycle and the application of the Carnot cycle.*
				Describe the relationship between enthalpy and pressure for a refrigeration cycle.
				Define and calculate the refrigerating effect and the mass of refrigerant circulated.
				Calculate the coefficient of performance for a refrigeration system.
				Calculate the capacity of a refrigeration machine.
				Calculate the theoretical power of a refrigeration compressor.
				Calculate the theoretical bore and stroke of a refrigeration compressor.