EXAMINATION SYLLABUS FOR ENGINEER'S CERTIFICATE OF COMPETENCY (STEAM AND INTERNAL COMBUSTION ENGINES) EXAMINATION

JKKP : GP (I) 1/97
ISBN 983-99156-3-0

Published by :
The Panel of Examiners
Department of Occupational Safety and Health
Malaysia

Preface

This is the revised version of the examination syllabus for Engineer's Certificate of Competency (Steam and Internal Combustion Engines) Examinations. An update has been made to the existing syllabus including the inclusion of a new curriculum on gas turbines for those sitting for the Internal Combustion Engines examination. At the Panel of Examiners meeting on 31st. July 1996, the Panel has agreed on the revised content of the new syllabus.

This syllabus was discussed and agreed upon by members of The Panel of Examiners which consist of the following:

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December 1996

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INTRODUCTORY REMARKS

This examination syllabus for steam and internal combustion engine engineers have been revised and agreed upon by the Panel of Examiners of the Department of Occupational Safety and Health. The purpose of this syllabus is to assist candidates sitting for the examination. Section 29 of The Factories and Machinery Act 1967 requires certain machinery to be operated by certificated staff. They are steam boilers and internal combustion engines (ICE). The Act also requires certain machinery to be operated and supervised by a "Competent Person". For this purpose there are two types of certification namely Engineers and Drivers in which each certification is divided into two classes namely first and second grades. The class of driver or engineer required to operate any steam boiler is determined based on the total heating surface of the boiler whilst for the ICE, it will be based on the total horse power of the ICE. All provisions related to the grade of engineers and drivers in relation to the size of machine they take charge are clearly stipulated in The Factories and Machinery (Persons-in-Charge) Regulations 1970. However, there are exemptions given to certain types of boilers and ICE's which do not require certificated engineers or drivers. For steam boilers, they are the electrode steam boiler, the steam tube oven, the steam tube hot plate, the autoclave and any other steam boiler in which the steam generated is retained inside the boiler. For ICE's they are ICE's with a capacity of 40 horse power or less, ICE's attached to a hoisting machinery and ICE's which inspire fuel by means of a carburettor.

OBJECTIVES AND SCOPE

The objective of this syllabus is to assist and to guide candidates who will be sitting for their relevant examination. The syllabus has been developed in such a way that it covers most parts of the topics in the appropriate field. It is also intended to ensure safe operation of the machines. The examinations are divided into three categories:

(i) Part A -Practical Mathematics

(ii) Part B -Engineering Knowledge

(iii) Part C -Oral Examination

Candidates who hold a recognized degree in Mechanical Engineering are exempted from parts A and B, whereas candidates from other disciplines and with other qualifications have to sit for at least two categories. However there are special cases where exemptions may be given with the approval of the Panel of Examiners.

Part A - Practical Mathematics

This part will consist of two (2) papers namely

Paper I - 3 hours
Paper II - 2 hours

Part B - Engineering Knowledge

This part will consist of two (2) papers namely

Paper I - 3 hours
Paper II - 2 hours

Part C - Oral Examination

The candidates will be examined for their knowledge in the safe operation of the machine and its allied equipment.

The syllabus covers the following certification:

Second Grade Engineer (Steam)

- Practical Mathematics which includes Applied Mechanics, Elementary Strength of Materials, and Heat and Heat Engines.

- Engineering Knowledge which includes Principle of Operation of Steam Boilers and Their Fittings, Boiler Fuel and Theory of Combustion, Principle of Operation of Steam Turbines, Boiler House Management and Boiler Repair, and General Engineering Knowledge which includes Construction Materials, Properties of Materials, Properties of Steam, Mechanical Working of Steel, Failure of Materials, Welding, and NOT.

- Oral examination on the management and safe operation of steam plant.

Second Grade Engineer (Internal Combustion Engine)

- Practical Mathematics which includes Applied Mechanics, Elementary Strength of Materials, and Heat and Heat Engines.

- Engineering Knowledge which includes Principle of Operation of Gas Turbines and Diesel Engines, Their Fittings and Auxilliary Equipment, Fuel, Theory of Combustion, Engine Room Management, and General Engineering Knowledge which includes Construction Materials, Mechanical Working of Steel, Property of Materials, Failure of Materials, Welding, and NDT.

- Oral examination on the management and safe operation of ICE plant.

First Grade Engineer (Steam)

- Practical Mathematics which includes Applied Mechanics, Strength of Materials, Heat and heat engines, and Applied Thermodynamics.

- Engineering Knowledge which include Principle of Operation of Steam and Hot Water Boiler, and Their Fittings, Boiler Fuel and Theory of Combustion, Principle of Operation of Steam Turbines, Boiler Water Treatment and Analysis, Boiler Maintenance, Inspection and Repair, Boiler House Management and other General Engineering Knowledge which includes Construction Materials, Properties of Materials, Properties of Steam, Mechanical Working of Steel, Failure of Materials, Welding and Non-destructive testing.

- Oral examination on the management and safe maintenance and operation of steam plant, and related requirements of Acts and Regulations.

First Grade Engineer (Internal Combustion Engine)

- Practical Mathematics which includes Applied Mechanics, Strength of Materials, Heat and Heat engines, and Applied Thermodynamics.

- Engineering Knowledge which include Gas Turbine Power Plant Fundamentals Operational Systems, Fuel and Combustion, Materials, Mechanical Working of Steel Theory of Lubrication, Welding and Non-Destructive Testing.

- Oral examination on the knowledge of managing the plant in terms of safe operation and maintenance, and related requirements of Acts and Regulations.

Definition:

Under the Factories and Machinery Act, 1967 a "steam boiler" is defined as any closed vessel in which for any purpose steam is generated under pressure greater than atmospheric pressure, and includes any economiser used to heat water being fed to such vessel, and any superheater used for heating steam and any pipes and fitting connected thereto.

Internal Combustion Engine

Under the Factories and Machinery Act, 1971. All "internal combustion engines" (ICE) have to be under the charge of persons holding a Certificate of Competency except for an ICE installed in a hoisting machine, an ICE with a capacity of not more than forty horse-power and an ICE which inspires fuel by means of a carburrettor. As agreed by the Panel of Examiners, ICE's also include gas turbines.

1.0 SECOND GRADE ENGINEER (STEAM) EXAMINATION SYLLABUS

1.1 PART A -PRACTICAL MA THEMA TICS

This part will consist of two (2) papers namely -

Paper I - 3 hours
Paper II - 2 hours

and candidates will be examined for their knowledge in Applied Mechanics, Elementary Strength of Materials, and Thermodynamics. Detail of these are as follows -

(a) Applied Mechanics

(i) Forces, Mass, Impulse, Momentum, Work and Energy Power

Forces acting on rigid body; Moments of forces; Compositions and resolutions of forces; Laws of solid and liquid friction (Friction angle and inclined plane); Mechanical advantage and efficiency of simple machines; Condition of equilibrium of solids and simple frame structures and beams; Moment of momentum, moment of inertia, their relation and measurement; Conservation of energy and momentum; Rectilinear motion of body under constant or variable forces; Equation of motion of a particle; and Motion of a body in a circular path with uniform speed.

(ii) Pressure and velocity change along a stream line

Bernoulli's theorem; and Flow through orifice

(b) Elementary Strength of Materials

Hooke's Law; Young's Modulus; Poisson's Ratio; Modulus of Rigidity; Thermal stress; Theory of simple bending; Bending moment and shearing forces diagrams; Theory of torsion of solid and hollow round shafts; Analysis of stress; and Theory of thin shell and strength of rivetted and welded joints.

(c) Thermodynamics

(i) Heat Units

B. Th.U.; C.H.U; gm-cal; and Joules

(ii) The Law of Perfect Gas

Absolute temperature; Isothermal, adiabatic and polytropic expansion and compression; Specific heat Cp and Cv and their relationship; and internal energy, enthalpy and entropy.

(iii) Heat Transfer

Heat transfer by conduction, convection and radiation -simple application; Properties of steam (change of state, latent heat, wet, dry saturated and superheated steam, dryness fraction); Use of steam table; Throttling; Separating and throttling calorimeter; and Boiler efficiency.

(iv) Reciprocating Steam Engine

Indicator diagrams (hypothetical and actual); Diagram factor; M.e.p, h.p, and b.h.p; and Compounded engines (thermal, mechanical and overall efficiency).

(v) Steam Turbine

Elementary principles; Simple velocity diagrams; Steam turbine efficiency; and Principles of energy boundary.

(vi) Combustion of Fuel (solid, liquid and gases)

Higher and lower calorific values; Chemical equations (stoichiometry); Excess air; and, Incomplete combustion of fuel.

(vii) Refrigeration -Vapour Compression Cycle

Coefficient of performance; and capacity.

1.2 PART B - ENGINEERING KNOWLEDGE

This part consist of two (2) papers namely -

(i) Paper I - 3 hours
(ii) Paper II - 2 hours

and candidates will be examined for their knowledge on the following subjects

(a) Steam and Hot Water Boilers

Different types of boilers (e.g. fire and water tubes boilers, vertical shell type, multitubular underfired, economic package and waste heat); Constructional details; Mountings and fittings (e.g. water level gauges, steam pressure gauge, feed water regulator, safety valves, main stop valve, globe valve, gate valve, check valve, non-return valve); flue gas path pattern (singular or multiple, and function of baffle plates); and, Starting cold boilers, operating under emergency situations, idling procedure and maintenance (tubes, shell, drums, headers, superheater, economiser, furnace, air heater, pumps, fans and stacks).

(b) Combustion of Fuels

Theory of combustion (condition, constant temperature, constant volume and constant pressure); Combustion process (supply air, air-fuel mixture, combustion temperature, combustion time, combustion gases, and temperature of combustion gases); Gas analysing technique; and, Draft (natural, forced, draft differential, and factors affecting draft).

(c) Measuring Gauges and Instruments

The purpose, basic working principles, constructional details and functions of the main parts of commonly used gauges and instrument (e.g. pressure gauge, thermometer, pyrometer, barometer, salinometer, and hydrometer).

(d) Boiler Repair, Inspection and Maintenence

Repairs of tubes, shell, furnace, fittings and ancillary machinery including the statutory and technical (standards and codes) requirements; Internal and external inspection (procedure and implementation); and, Maintenance (daily, routine and planned).

(e) Boiler Fuel

Solid fuel (e.g. coal, lignite, wood and wood waste); Liquid fuel (petroleum oil, black liquor and other chemical derivatives); gaseous fuel (LPG, natural gas and waste heat); composition and properties of different types of fuel; and, advantage and disadvantage of different type of fuels.

(f) Boiler Water Treatment

Pure water; Impurities; Contaminated feedwater; external and internal treatment; Hard scale; Soft scale; Carry over; Priming; Foaming; and, Water treatment programme.

(g) Steam Properties

Steam (wet, saturated, superheated, degree of superheat and fraction); Temperature-entropy and temperature-enthalpy diagrams; and, application of wet and superheated steam.

(h) Pump and Compressor

Basic working principles, selection criteria, advantages and disadvantages of different types of compressors and pumps.

(i) Steam Turbines

Types and working principles (impulse, reaction, combination of impulse and reaction); and, Safe operation (start-up and shut-down).

(j) Condensers

Types and working principles, construction and construction materials, and maintenance.

(k) Governors

Types and working principles, function in turbine, and relay mechanism

(l) Materials

Chemical (e.g. carbon, phosphorus, silicon, manganese, chromium, nickel, molybdenum, cadmium) and physical properties of construction materials; Mechanical testing (tensile, bend, hardness, nick break and charpy test); Stress-strain relationship (proportional limit, yield point, ultimate stress, permanent set, breaking stress point and elastic limit); Heat treatment (e.g. annealing, normalising, stress releiving, spheroidising, hardening and tempering) and effect on microstructure; and, Solution treatment.

(m) Mechanical Working of Steel

Hot work (forging and rolling) and cold work (cold roll and cold working)

(n) Creep and Fatigue

Creep and fatigue behaviour, factors affecting and testing method.

(o) Corrosion and Control

Causes (chemical attack, electro-chemical attack and stress influenced); Prevention and control (surface protection, metal cladding, electroplating); surface modification (e.g. cladding and chroming), metal spraying, painting, and cathodic protection.

(p) Welding

Basic principles and different types (e.g. shielded-arc, gas shielded metal arc, gas shielded tungsten-arc, plasma-arc, electroslag, stud and gas welding); Weld joint and preparation (butt, lap, fillet and nozzle); Welding defects (e.g. cracks, cavities, inclusions, lack of penetration, and fusion, imperfect shape), methods of detection and repairs; and, Destructive testing (e.g. tensile test, bend test, hardness test, proof test, fatigue test).

(q) Non-Destructive Testing

Non-destructive testing (radiography, ultrasonic, magnetic particle test, dye penetrant test and eddy-current); NDT operator qualification programme (national and international); Welding Procedure Qualification and Welder Performance Qualification Test.

1.3 Part C -Oral Examination

The candidates will be examined for their knowledge in the safe operation of a Steam Boiler and other auxilliaries. Detail of these are as follows –

(i) Working principles of various type of steam and hot water boilers, steam turbines and steam engines, and their fittings and functions.
Note: The candidate is expected to know the operation of all types of boilers, steam engines and steam turbines.

(iii) Boiler operation (e.g Start-up procedure, shut-down, emergency situation, conditional monitoring (e.g. water hammer, priming, foaming, familiarisation with all safety features etc). Installation of new boiler, various type of testing (water gaguge test, steam test etc.); and Basic boiler water treatment.

(iv) Boiler House management (e.g. Managing Log Book, Safety and Health aspects in boiler room)

(iv) Plant safety management (Policy statement, arrangement, implementation, accident prevention); Contingency Plan / Emergency Response Plan.

(v) The candidate is expected to know how to sketch the steam boiler, piping system, fittings etc.

(vi) Related provisions under The Factories and Machinery Act 1967 and regulations made thereunder.

(vii) Identification of parts (e.g. defected samples, failure tubes etc) and common boiler deposits.

(viii) Boiler inspections (defects identification, proposal for repair, codes and procedures).

2.0 SECOND GRADE ENGINEER (INTERNAL COMBUSTION ENGINE) EXAMINATION SYLLABUS

2.1 PART A - PRACTICAL MATHEMATICS

This part will consist of two (2) papers namely –

Paper I - 3 hours
Paper 11 - 2 hours

and candidates will be examined for their knowledge in Applied Mechanics, Elementary Strength of Materials, and Thermodynamics. Detail of these are as follows -

(a) Applied Mechanics

(i) Forces, Mass, Impulse, Momentum, Work and Energy, Power

Forces acting on rigid body; Moments of forces; Compositions and resolutions of forces; Laws of solid and liquid friction (Friction angle and inclined plane); Mechanical advantage and efficiency of simple machines; Condition of equilibrium of solids and simple frame structures and beams; Moment of momentum, moment of inertia, their relation and measurement; Conservation of energy and momentum; Rectilinear motion of body under constant or variable forces; Equation of motion of a particle; and, Motion of a body in a circular path with uniform speed.

(ii) Pressure and velocity change along a stream line

Bernoulli's theorem; and Flow through orifice

(b) Elementary Strength of Materials

Hooke's Law; Young's Modulus; Poisson's Ratio; Modulus of Rigidity; Thermal stress; Theory of simple bending; Bending moment and shearing forces diagrams; Theory of torsion of solid and hollow round shafts; Analysis of stress; and, Theory of thin shell and strength of rivetted and welded joints.

(c) Thermodynamics

(i) Heat Units

B.Th.U.; C.H.U; gm-cal; and Joules.

(ii) The Law of Perfect Gas

Absolute temperature; Isothermal, adiabatic and polytropic expansion and compresston; Specific heat and specific volume and their relatioship; and internal energy, enthalpy and entropy.

(iii) Rotary expander and compressor

Indicator diagrams (hypothetical and actual); Diagram factor; M.e.p, h.p, and b.h.p.; and Compounded engines (thermal, mechanical and overall efficiency).

(iv) Heat Balance for Engine

Elementary principles and cycles of operations of internal combustion engines and air compressors; Constant volume; the diesel and dual cycles; Calculation of work done; and Cam (cam diagrams for internal combustion engines, and angles of cam peak centre lines relative to crank).

(v) Gas Turbine and Compressor

Elementary principles (axial flow and radial flow); Simple velocity diagrams; Performance characteristics and efficiencies; and Principles of energy boundry.

(vii) Combustion of Fuel

Higher and lower calorific values; Chemical equations (stoichiometry); Excess air; and Incomplete combustion of fuel.

2.2 PART B - ENGINEERING KNOWLEDGE

This part consist of two (2) papers namely –

(i) Paper I - 3 hours
(ii) Paper II - 2 hours

and candidates will be examined for their knowledge on the following subjects:

(a) Typical Gas Turbine Plant

Basic theory of gas turbine systems (e.g. open, closed and combined cycle; TS diagram, Carnot cycle, Bray ton Cycle); Major Components and Functional Description of gas turbine systems (Compressor, Burner, Turbine, Generator); Constructional details; Mountings and fittings; Operation (Pre- start check, Checks during normal operation, and during emergency); Troubleshooting; Idling procedure.

(b) Gas Turbine Safety System

Electrohydraulic safety system (Power oil system, Fuel gas system, Compressor blow-off system), Governor, their functions and principle of operation; and Tripping systems.

(c) Measuring gauges and Instruments

The purpose, basic working principles, constructional details and functions of the main parts of commonly used gauges and instrument (e.g. pressure gauge, thermometer, pyrometer, barometer, salinometer, and hydrometer).

(d) Maintenance

Basic maintenance of gas turbine and compressor, and other ancilliary machinery (weekly, routine, the use of logsheets).

(e) Gas Turbine Fuel

Liquid fuel (petroleum oil, and other chemical derivatives); gaseous fuel (LPG, natural gas and waste heat); composition and properties of different types of fuel; and advantage and disadvantage of the different type of fuels.

(f) Combustion of Fuels

Theory of combustion (condition, constant temperature, constant volume and constant pressure); Combustion process (supply air, air-fuel mixture, combustion temperature, combustion time, combustion gases, and temperature of combustion gases);

(g) Theory of Lubrication / Friction (Tribology)

The importance of lubrication in turbo generating systems and how they are being applied (Engine oil system, Jacking oil system, Hydraulic rotor bearing and Power oil system); Other type of gas turbine cooling system and, type of bearings and seals used.

(h) Materials

Chemical (carbon, phosphorus, silicon, manganese, chromium, nickel, molybdenum, cadmium) and physical properties of construction materials; Mechani- cal testing (tensile, bend, hardness, nick break and charpy test); Stress-strain relationship (proportional limit, yield point, ultimate stress, permanent set, breaking stress point and elastic limit); Heat treatment (annealing, normalising, spheroidising, hardening and tempering) and effect on microstructure.

(i) Mechanical Working of Steel

Hot work (forging and rolling) and cold work (cold roll and cold working). a) Creep and Fatigue Creep and fatigue behaviour, factors affecting and testing method.

(k) Corrosion and Control

Causes (chemical attack, electro-chemical attack and stress influenced); Prevention and control (surface protection, metal clading, electroplating), surface modification (e.g. cladding and chroming), metal spraying, painting, cathodic protection and water treatment.

(l) Welding

Basic principles and different types (shielded-arc, gas shielded metal arc, gas shielded tungsten-arc, plasma-arc, electroslag, stud and gas welding); Weld joint and preparation (butt, lap, fillet and nozzle); Welding faults (cracks, cavities, inclusions, lack of penetration, and fusion, imperfect shape), methods of detection and repairs; Destructive testing (tensile test, bend test, hardness test, proof test, fatigue test), Welding Procedure Qualification and Welder Performance Qualification Test.

(m) Non-Destructive Testing

Non-destructive testing (radiography, ultrasonic, magnetic particle test, dye penetrant test and eddy-current); NDT operator qualification programme (national and international);

(n) Internal Combustion Engine (Petrol, Diesel and Gas Engine)

The principles underlaying the working of Internal Combustion Engines (Petrol, Gas and Oil Engines); Constructional details of ICE in general use; Use of Indicator diagram; Supercharging; Governor and governor gears; Starting gears; Construction of engine foundations; Vibration and noise; The testing of ICE.

The nature and properties of the fuel and lubricating oils generally used in Internal Combustion Engines; The supply of air and fuel to cylinders of engine of different types; The constructional details of apparatus for carburetting and atomising fuel; The means of cooling the cylinders and pistons; Constructional details and working of pumps and compressor.

Supervision required during operation; maintenance of various parts of machinery; The use and management of valves, pipes, connections and safety devices employed.

Troubleshootings; Enumeration and description of defects arising from the operation of ICE and the remedy for such defects.

2.3 PART C - ORAL EXAMINATION

The candidates will be examined for their knowledge in the safe operation of Internal Combustion Engine. Details of these are as follows –

(i) Basic Working Principles of various type of Gas Turbine system and their cycles (include compressor, turbine, their fittings/control equipments etc).

(ii) Operation of Gas Turbine (e.g start-up, synchronising, supervision and protection, load shedding, shut-down, emergency situation, troubleshooting, familiarisation with all safety features); Control Room management; and, Safety and health aspects of personnel during operation.

(iii) Description on routine, daily, preventive and major maintenance (e.g. Hot-section maintenance, Compressor maintenance, Bearing maintenance etc.); Procedures, and safety and health precaution.

(iv) Plant Safety Management (Policy statement, arrangement, implementation, accident prevention); Contigency Plan / Emergency Response Plan.

(v) Related provisions under the Factories and Machinery Act 1967, and regulations made thereunder .

(vi) The candidate is expected to know how to sketch the system and their essential fittings, including explaination on the function of every main parts.

(vii) Basic working principles of various type of Internal Combustion Engines (Petrol, diesel and gas engines), their cycle, process of combustion, major components and their functional operations.

(viii) Supervision and protection during operation (e.g Exhaust temperature, Lub. oil pressure, water temperature etc.)

(ix) Operating procedures (pre start-up, start-up, emergency shut down, synchronising engine to generating set etc.)

3.0 FIRST GRADE ENGINEER (STEAM) EXAMINATION SYLLABUS

3.1 PART A -PRACTICAL MA THEMA TICS

This part will consist of two (2) papers namely -

Paper I - 3 hours
Paper II - 2 hours

and candidates will be examined for their knowledge in Applied Mechanics, Strength of Materials, and Applied Thermodynamics. Detail of these are as follows -

(a) Applied Mechanics

(i) Forces, Mass, Impulse, Momentum, Work and Energy, Power

Forces acting on rigid body; Moment of forces; Moments and couples; Composition and resolution of forces; Polygon of forces; Laws of solid and liquid friction (friction angle and inclined plane); Friction between unlubricated surfaces (friction angle, friction clutches, friction on inclined plane); Inertia forces on elements of plane mechanism; Mechanical advantage and efficiency of simple machines; Belt and rope drives; Engine turning moment diagrams, flywheels, governors; Condition of equilibrium of solids and simple frame structures and beams; Moment of momentum, moment of inertia, their relation and measurement; Conservation of energy and momentum; and, Rectilinear motion of body in a cicular path with uniform speed.

(ii) Vibration

Body with single degree of freedom; Transverse vibration of beam; and, Torsional oscillations.

(iii) Pressure and velocity change along a stream line

Bernoulli's theorem; Flow through orifice

(b) Strength of Materials

(i) Hooke's Law; Young's Modulus; Poisson's Ratio; Modulus of Rigidity; Thermal Stress; Theory of Simple Bending; Bending Moment and Shearing Force Diagram; Theory of Torsion of Solid and Hollow Round Shafts; and, Analysis of Stress.

(ii) Stress and Strain

In tension, compression and shear; Relation between elastic constants; Co-planar principal plane and stresses; Maximum shear stress; Stresses in thick walled cylinders under internal and external pressure; and, Theory of thin shells and strength of rivet ted and welded joints.

(iii) Beams

Direct and shear stresses in beam; Relationship between slope, curvature and deflection; Determination of shear force (SF), bending moment, slope and deflection of cantilevers, and freely supported and built-in beams for simple types of loading.

(iv) Torsion

Transmission of power; Closed coil helical springs; Combined bending, torsion and thrust; Principal stresses in shafts; Strain energy in tension, bending and torsional and combined loading.

(c) Applied Thermodynamics

(i) First and Second Law of Thermodynamics

(ii) Heat units

B.Th.U., C.H.U., gm-cal and Joules; Specific heat, and mechanical equivalent of heat.

(iii) The Law of Perfect Gas

Absolute temperature; Isothermal, adiabatic and polytropic expansion and compression; Specific heat Cp and Cv and relationship between them; Internal energy, enthalpy and entropy.

(iv) Heat transfer

Heat transfer by conduct(on, convection and radiation (simple application); Properties of steam (change of state, latent heat, wet, dry saturated and supersaturated steam, dryness fraction); Use of steam table; Thtrottling; Separating and thtrottling calorimeter; and, Boiler efficiency.

(v) Reciprocating Steam Engine

Indicator diagrams (hypothetical, actual); Diagram factor; M.e.p., h.p., b.h.p.; and Compounded engines (thermal, mechanical and overall efficiency)

(vi) Steam Turbine

Elementary principles; Simple velocity diagrams; Steam turbine efficiency; and Principle of energy boundry.

(vii) Combustion of Fuels

Higher and lower calorific values; Chemical equations (stoichiometry); Excess air; and Incomplete combustion of carbon.

(viii) Refrigeration -Vapour Compression Cycle

Coefficient of performance; Capacity.

3.2 Part B - Engineering Knowledge

This part consist of two (2) papers namely –

(i) Paper I - 3 hours
(ii) Paper II - 2 hours

and candidates will be examined for their knowledge on the following subjects

(a) Steam and Hot Water Boilers

Different types of boilers (e.g. fire and water tubes boilers, vertical shell type, multitubular underfired, economic package and waste heat); Constructional details; Mountings and fittings (water level gauges, steam pressure gauge, feed water regulator, safety valves, main stop valve, globe valve, gate valve, check valve, non-return valve); flue gas path pattern (singular or multiple and function of baffle plates).

(b) Boiler Operation

Starting cold boilers (precaution -furnace explosion, dust explosion); connecting of more than one boiler; Operating under emergency situations, idling procedure and maintenance (tubes, shell, drums, headers, superheater, economiser, furnace, air heater, pumps, fans and stacks); Uses of low-pressure steam and hot water boiler for process heating; Special type of boiler for high pressure and temperature steam.

(b) Boiler Water Treatment

Pure water; Impurities; Type of water source; Recomended feedwater quality; Contaminated feedwater; External and internal treatment; Hard scale; Soft scale; Carry over; Priming; Foaming; Water treatment programme; and Water analysis.

(c) Boiler Maintenance, Inspection and Repair

External and internal inspection; Boiler failure, causes and methods of repair (Window patch, tube plugging); Testing of safety features (e.g. Gauge glass, low water fuel cut-out, high/low water alarm); Maintenance (daily, routine and planned).

(d) Boiler Fuel

Solid fuel (e.g coal, lignite, wood and wood waste); Liquid fuel (petroleum oil, black liquor and other chemical derivatives); gaseous fuel (LPG, natural gas and waste heat); composition and properties of different types of fuel; and, advantage and disadvantage of different type of fuels.

(e) Combustion of Fuels

Theory of combustion (condition, constant temperature, constant volume and constant pressure); Combustion process (supply air, air-fuel mixture, combustion temperature, combustion time, combustion gases, and temperature of combustion gases); Gas analysing technique; and Draft (natural, forced, draft differential, and factors affecting draft).

(f) Steam Properties

Steam (wet, saturated, superheated, degree of superheat and dryness fraction); Temperature-entropy and temperature-enthalpy diagrams; and application of wet and superheated steam.

(g) Materials

Chemical (carbon, phosphorus, silicon, manganese, chromium, nickel, molybdenum, cadmium) and physical properties of construction materials; Mechanical testing (tensile, bend, hardness, nick break and charpy test); Stress-strain relationship (proportional limit, yield point, ultimate stress, permanent set, breaking stress point and elastic limit); Heat treatment (annealing, normalising, spheroidising, hardening and tempering) and effect on microstructure. Iron-Carbon equilibrium diagram (austenite, martensite, pearlite, binite)

(h) Mechanical Working of Steel

Hot work (forging and rolling) and cold work (cold roll and cold working).

(i) Creep and Fatigue

Creep and fatigue behaviour, factors affecting and testing method.

(j) Corrosion and Control

Causes (chemical attack, electro-chemical attack and stress influenced); Prevention and control (surface protection, metal cladding, electroplating), surface modification (e.g. cladding and chroming), metal spraying, painting, cathodic protection and water treatment.

(k) Welding

Basic principles and different types (shielded-arc, gas shielded metal arc, gas shielded tungsten-arc, plasma-arc, electroslag, stud and gas welding); Weld joint and preparation (butt, lap, fillet and nozzle); Welding defects (e.g cracks, cavities, inclusions, lack of penetration, and fusion, imperfect shape), methods of detection and repairs; Destructive testing (tensile test, bend test, hardness test, proof test, fatigue test). Welding Procedure Qualification and Welder Performance Qualification Test.

(l) Non-Destructive Testing

Non-destructive testing (radiography, ultrasonic, magnetic particle test, dye penetrant test and eddy-current); NDT operator qualification programme (national and international).

3.2 PART C -ORAL EXAMINA TION

The candidates will be examined for their knowledge on the safe operation of steam boiler and other auxiliary , understanding of related statutory requirements, and proper management of a steam plant.

(i) Working principles of various types of steam boilers, steam engines and steam turbines, their fittings and functions.

(ii) Boiler operation (e.g Start-up procedure, shut-down, emergency situation, .conditional monitoring, familiarisation with all safety features etc). Installation of new boiler, various type of testing. Identification of essential fittings.

(iii) Boiler House management (e.g Managing Log Book, Safety and Health aspects in boiler room)

(iv) Plant safety management (Policy statement, arrangement, implementation, accident prevention); Contingency Plan / Emergency Response Plan.

(v) The candidate is expected to know how to sketch the steam boiler, piping system, fittings etc.

(vi) Related provisions under The Factories and Machinery Act 1967 and regulations made thereunder, and The Occupational Safety and Health Act 1994 (e.g. Requirements for importation, manufacturing, installation and operation of steam boilers in this country; Duty of designer, manufacturer and supplier).

(vii) External and internal inspection of boiler, fault finding, identification of defects or failures, administrative procedure for repairs.

(viii) Boiler water treatment (internal and external), and the detailed programme.

(ix) Special type of boiler (e.g. Waste heat, high pressure and temperature boiler).

(x) The conduct of steam test, its purpose and frequency.

Note : The first grade candidates is expected to answer in depth of every questions posed.

4.0 FIRST GRADE ENGINEER (INTERNAL COMBUSTION ENGINE) EXAMINATION SYLLABUS)

4.1 PART A - PRACTICAL MATHEMATICS

This part will consist of two (2) papers namely –

Paper I - 3 hours
Paper II - 2 hours

and candidates will be examined for their knowledge in Applied Mechanics, Strength of Materials, Heat and Heat Engines and Applied Thermodynamics Detail of these are as follows –

(a) Applied Mechanics

(i) Forces, Mass, Impulse, Momentum, Work and Energy, Power.

Forces acting on rigid body; Moment of forces; Moments and couples; Composition and resolution of forces; Polygon of forces; Laws of solid and liquid friction (friction angle and inclined plane); Friction between unlubricated surfaces (friction angle, friction clutches, friction on inclined plane); Inertia forces on elements of plane mechanism; Mechanical advantage and efficiency of simple machines; Belt and rope drives; Engine turning moment diagrams, flywheels, governors; Condition of equilibrium of solids and simple frame structures and beams; Moment of momentum, moment of inertia, their relation and measurement; Conservation of energy and momentum; Rectilinear motion of body in a cicular path with uniform speed.

(ii) Vibration

Body with single degree of freedom; Transverse vibration of beam; and Torsional oscillations.

(ii) Pressure and velocity change along a stream line

Bernoulli's theorem; Flow through orifice.

(b) Strength of Materials

(i) Hooke's Law; Young's Modulus; Poisson's Ratio; Modulus of Rigidity; Thermal Stress; Theory of Simple Bending; Bending Moment and Shearing Force Diagram; Theory of Torsion of Solid and Hollow Round Shafts; Analysis of Stress;

(ii) Stress and Strain

In tension, compression and shear; Relation between elastic constants; Co-planar principal plane and stresses; Maximum shear stress; and Theory of thin shells and strength of rivetted and welded joints.

(iii) Beams

Direct and shear stresses in beams; Relationship between slope, curvature and deflection; Determination of shear force (SF), bending moment, slope and deflection of cantilevers, and freely supported and built-in beams for simple types of loading.

(iv) Torsion

Transmission of power; Closed coil helical springs; Combined bending, torsion and thrust; Principal stresses in shafts; Strain energy in tension, bending and torsional and combined loading.

c) Applied Thermodynamics

(i) First and Second Law of Thermodynamics

(ii) Heat units

B.Th.U., C.H.U., gm-cal and Joules; Specific heat, mec equivqlent of heat.

(iii) The Law of Perfect Gas

Absolute temperature; Isothermal, adiabatic and pol expansion and compression; Specific heat c and c and rela' between them; Internal energy, enthalpy and entropy.

(iv) Heat transfer

Heat transfer by conduction, convection and radiation application);

(v) Reciprocating Steam Engine

Indicator diagrams (hypothetical, actual); Diagram factor; M.e.p,h.p, b.h.p.; Compounded engines (thermal, mechanical and efficiency)

(vi) Heat Balance for Engine

Elementary principles and cycles of operations of internal combustion engine and air compressors; Constant volume, diesel and dual cycles; Calculation of work done; Cam (cam diagram for ICE, angles of cam peak centre lines relative to crank).

(vii) Combustion of Solid and Liquid Fuel

Higher and lower calorific values; Chemical equations (stoichiometry); Excess air; Incomplete combustion of carbon.

(viii) Refrigeration -Vapour Compression Cycle

Coefficient of performance; Capacity.

3.2 PART B - ENGINEERING KNOWLEDGE

This part consist of two (2) papers namely –

(i) Paper I - 3 hours
(ii) Paper II - 2 hours

and candidates will be examined for their knowledge on the following subjects

(a) Gas Turbine Power Plant Fundamentals

Basic theory of gas turbine systems (e.g. open, close and combine cycle; TS diagram, Carnot cycle; Bray ton cycle); Gas turbine process; Major components and Functional description of typical gas turbine power plant (Compressor, Type of combustor/burner, Turbine, Generator); Constructional details; Mounting and fittings; Operational procedures (Pre-start check, Start-up; Check during normal operation and emergency); Troubleshooting; and Idling procedure.

(b) Operational Systems

Various operational systems in a gas turbine plant (Lubrication and Emergency oil system, Jacking oil system, Ignition fuel system, Fuel gas system, Exhaust gas system, Power oil system, Gas turbine drain system, Hydraulic rotor barring system, Air intake and compressor systems, Fuel oil and water injection systems).

(c) Combustion and Fuels

Types of fuel (Liquid -petroleum oil, and other chemical derivatives; Gaseous fuel -LPG, natural gas and waste heat); Composition and properties of different types of fuel; Advantage and disadvantage; Theory of combustion (Condition, constant temperature, constant volume and constant pressure); Combustion process (supply air, air-fuel mixture, combustion temperature, combustion time, combustion gases and temperature of combustion gases).

(d) Materials

Chemical (carbon, phosphorus, silicon, manganese, chromium, nickel, molybdenum, cadmium) and physical properties of construction materials; Mechanical testing (tensile, bend, hardness, nick break and charpy test); Stress-straln relationship (proportional limit, yield point, ultimate stress, permanent set, breaking stress point and elastic limit); Heat treatment (annealing, normalising, spheroidising, hardening and tempering) and effect on microstructure; Iron-carbon equilibrium diagram.

(e) Mechanical Working of Steel

Hot work (forging and rolling) and cold work (cold roll and cold working).

(f) Creep and Fatigue

Creep and fatigue behaviour, factors affecting and testing method.

(g) Corrosion and Control

Causes (chemical attack, electro-chemical attack and stress influenced); Prevention and control (surface protection, metal clading, electroplating, surface modification (e.g. cladding and chroming), metal spraying, painting, cathodic protection and water treatment.

(h) Theory of Lubrication / Friction (Tribology)

The importance of lubrication in turbo generating systems and hoe they are being applied (Engine oil system, Jacking oil system, Hydraulic rotor bearing and Power oil system); Type of seals; Other type of cooling systems.

(i) Welding

Basic principles and different types (shielded-arc, gas shielded metal arc, gas shielded tungsten-arc, plasma-arc, electroslag, stud and gas welding); Weld joint and preparation (butt, lap, fillet ann nozzle); Welding defects (cracks, cavities, inclusions, lack of penetration, and fusion, imperfect shape), methods of detection and repairs; Destructive testing (tensile test, bend test, hardness test, proof test, fatigue test), Welding procedure qualification and welder performance qualification test.

(j) Non-Destructive Testing

Non-destructive testing (radiography, ultrasonic, magnetic particle test, dye penetrant test and eddy-current); NDT operator qualification programme (national and international);

(k) Internal Combustion Engine (Petrol, Diesel and Gas Engine)

Ideal and actual cycles for Internal Combustion Engines and their representation by pressure-volume and temperature-entropy diagrams; The process of combustion in spark ignition and compression ignition engines (Flame propagation and detonation in spark ignition engines, Effect of dissociation and changes in specific heats, Ignition delay and utilisation of the air in compression ignition engines. Air-fuel ratio, The composition of exhaust gases and the control of power output from ICE)

The principles underlaying the working of Internal Combustion Engines (Petrol, Gas and Oil Engines; Two stroke and Four stroke); Constructional details of ICE in general use; Use of Indicator diagram; Supercharging; Governor and governor gears; Starting gears; Construction of engine foundations; Vibration and noise; The testing and performance of ICE (Apparatus and procedures, indicator diagram, fuel consumption and heat distribution; dynamometer and useful power output, engine losses, accuracy of measurement); Utilisation of waste heat; Energy balance of installation in service.

The nature and properties of the fuel (Liquid and gases, chemical composition, calorific value and its determination, properties of importance in relation to combustion in engines, methods of determining octane and cetane values); Purification, filtration, handling and storage of fuels; Lubricating oils generally used in Internal Combustion Engines; The supply of air and fuel to cylinders of engine of different types; The constructional details of apparatus for carburetting and atomising fuel; The means of cooling the cylinders and pistons; Constructional details and working of pumps and compressor.

Air compressors (reciprocating and rotary blower and supercharger); Adiabatic and isothermal efficiency; Heat transferin intercoolers; Charging and exhausting the cylinders of two-stroke and four-stroke reciprocating engines; volumetric and scavanging efficiency; Silencing.

Supervision required during operation; maintenance of various parts of machinery; The use and management of valves, pipes, connections and safety devices employed.

Troubleshootings; Enumeration and description of defects arising from the operation of ICE and the remedy for such defects.

3.3 PART C - ORAL EXAMINA TION

The candidates will be examined for their knowledge in the safe operation of Internal Combustion Engine (Gas Turbine), the related requirements of Acts and Regulations, and the ability of managing the work place in a safe and healthy environment. Detail of these are as follows –

(i) Basic Working Principles of various type of Gas Turbine system and their cycles (e.g. compressor, turbine, combustor, their fittings/control equipments etc.).

(ii) Operation of Gas Turbine (e.g start-up, synchronising, supervision and protection, load shedding, shut-down, emergency situation, troubleshooting, familiarisation with all safety features); Control Room management; and Safety and health aspects of personals during operation.

(iii) Type of maintenance (e.g description on routine, daily, preventive and major); Procedures, and safety and health precaution.

(iv) Plant Safety Management (Policy statement, arrangement, implementation, accident prevention); Contigency Plan / Emergency Response Plan.

(v) Related provisions under the Factories and Machinery Act 19671 and regulations made thereunder; The Occupational Safety and Health Act 1994.

(vi) Safety and health hazards; Identification and rectification

(vii) The candidate is expected to know how to sketch the system and their essential fittings, including explaination on the function of every main part.

(viii) Basic working principles of various type of I.C.E (Petrol, diesel and gas engines); Major components and their functional operations; Process of combustion; Supervision and protection of I.C.E. during operation; Troubleshooting and corrective actions.

(ix) Engine room management (the use of log book, managing the shift, maintenance management etc.).

Note : First grade candidates is expected to answer in depth of all second grade questions.

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