

EXTRA FIRST-CLASS ENGINEER.

55. A candidate for an extra first-class engineer's certificate must possess a first-class ordinary certificate, a motor certificate endorsed for first-class service in steamships, or a first-class engineer's certificate of service.

In addition to compliance with the requirements specified for first- and second-class engineers, the candidate is required—

- (a) To be able to express himself suitably in reports and business letters relating to his work, and in essays on technical subjects with which he ought to be familiar :
- (b) To have sufficient knowledge of mathematics (including the elements of the calculus, trigonometry, &c.) to enable him to work problems in theoretical and applied mechanics, thermodynamics, electricity, hydraulics, hydrostatics, and naval architecture, and in other subjects related thereto :
- (c) To be able to produce a good dimensioned working-drawing of any part of the machinery of a vessel.

He is also required to display a satisfactory knowledge of the following subjects :—

- (d) The construction and working of the various designs of marine boilers, including those of the water-tube type ; the theoretical principles governing their construction ; the methods and processes employed in their manufacture ; and the determination, by calculation, of the strength of the various parts, with special reference to the riveting, stays, shell, flat plates, and furnaces :
- (e) The construction and working of the different forms of marine engines and propellers in all their details, including turbines, and the various types of internal-combustion engines ; the methods and processes employed in their manufacture ; the fundamental principles on which they act ; and the determination, by calculation, of the strength of the various parts :
- (f) The composition and properties of the materials commonly used in the construction of marine engines and boilers ; the processes employed in their manufacture ; and the methods of testing them :
- (g) The principles of theoretical and applied mechanics ; the theory of strain and stress ; the nature of the strains and stresses produced by the pressure and temperature of the working-fluid in the various parts of the engines and boilers ; and the formulation of rules for the bending of beams and for the twisting and bending of shafts :
- (h) The modern theory of heat ; the thermodynamics of gases ; and the solution of problems relating to the power and performance of marine engines and boilers :
- (i) The theory and practice of combustion ; the chemical composition of the fuels used in steam and motor ships ; the determination of the thermal value of fuels of given composition ; the production of draught ; and the proportioning in regard to safety and economy of the area of the boiler-heating surface, grate-surface, sectional area of air-passages, area of water-surface, and volume of steam-space and of water-space :
- (j) The principles involved in the design and construction of safety-valves, with special reference to spring-loaded valves ; and the determination of the size of a valve for a given duty :
- (k) The causes, effects, and precautions to be taken against water-hammer action in steam pipes and valves ; the conditions which promote the formation of explosive gases in air-compressors, and in air-pipe systems of motor-ships, and the precautionary measures and safeguards adopted in respect thereto :
- (l) The deterioration and preservation of boilers and other pressure vessels usually found on board ship, with special reference to galvanic action, pitting, and corrosion, and to the use of zinc, lime, and soda ; the general results obtained from past experience in relation thereto, and the various chemical reactions involved :