

ENGINEERING and MECHANICS

EXAMINATION OF ENGINEERS.

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The examination of steam engineers for licenses on land or sea, or for admission into the various societies that are supported for the purpose of benefitting the craft, is always an interesting subject, and to prospective candidates for these honors it is peculiarly fascinating. As a rule an examining board does not adopt a list of questions for those to answer who apply for examination, although it may have such a list from which to make selections for use at various times. This makes it practically impossible to inform the candidate in advance of what he will be required to answer. He must therefore gain a general knowledge of the business, and having become well grounded in its fundamental principles, apply them to the solution of problems presented, use good judgment in formulating replies and never get nervous or excited.

All men are not qualified to pass these examinations, neither is every man who finds himself a member of an examining board qualified to discharge the duties of that important position.

Sometime ago it was the writer's privilege to attend an important meeting of engineers, a feature of which was an ideal examination of a candidate for admission to their ranks, and as much interest in the questions asked has been manifested, an article in which these questions are fully answered will prove beneficial to many others interested.

There were twenty-five questions propounded, and while the replies given here are more elaborate than can be allowed for an ordinary examination, they are none too explicit to convey a full and correct knowledge of the subjects treated. The questions, answers, and explanations follow:

1. How would you proceed to inspect a boiler?

A. Every part of the shell, tubes and heads that can be reached should be examined and a thorough search made for places affected by internal or external corrosion, pitting, cracks, blisters, and bagging caused by lack of water.

Internal corrosion may be caused by steam and water leaking into a not in use, or by certain impurities in the feed water while it is under pressure every day. External corrosion is caused by water dripping on the outside of it from leaky steam pipe, valve stem, or on account of holes in the boiler house roof.

Pitting is caused by impure feed water, and sometimes by allowing a boiler to stand many days with warm water in it, although said water may be pure. In some cases small blisters are raised on the metal, and when these are broken, pits, or hollow places, are found under them.

Cracks are caused by unequal contraction and expansion, by injudicious use of the drift pin, and by expanding tubes into the heads. Very close examination will disclose their presence, and sheets and heads that are imperfect in this respect may be detected by means of a light steel hammer in the hands of an experienced engineer, as when they are struck the sound differs from that given out by sound iron or steel.

Blisters are caused by imperfections in iron plates, for where several pieces are rolled together to make a boiler plate the weld may not be perfect throughout the whole piece, and when put into hard service the different layers become separated and a blister is formed. If the defect does not extend deep into the plate it may be trimmed, its extent carefully noted, and if the remaining portion is as strong as the riveted joint, no further precautions are necessary, except to make sure that it does not spread. If the blister is large and deep it will be necessary to cut it out and put on a patch.

The bagging of a sheet is caused by lack of water in direct contact with it. This does not necessarily mean that the water line has been allowed to fall so low that the part has been uncovered, for grease may have collected upon the sheet and thus effectually prevented the water from retreating it, the result of which is that it has been overheated and the pressure has bulged it out, or caused a "bag" to appear.

All of the rivets should be tested in order to detect loose ones, and every brace examined, for if one is loose or broken it will cause unnecessary stress to come upon others, which may strain or break them. While the engineer or inspector is inside the boiler, he should see that all the pipes connecting try cocks, water and steam gauges are free from rust and sediment, and if an excessive

amount of scale is on the tubes and shell it should be removed. The safety valve should be examined and tested in order that it may be known to be in good working order, and all superfluous weights removed from its lever.

2. A boiler is sixty-six inches in diameter, the plates are three-eighths-inch thick, and have a tensile strength of 60,000 pounds per square inch of sectional area. The strength of the seams is 75 per cent. of the solid plate and the factor of safety is 5. What is the safe working pressure?

A. One hundred and two pounds. It is calculated as follows (for every applicant for a license should be able to explain the examples given him): The plates possess a tensile strength of 60,000 pounds per square inch of sectional area, but they are only three-eighths inch thick, therefore the ultimate strength of a strip one inch wide is $60,000 \times .375 = 22,500$ pounds. ($\frac{3}{8} = .375$).

A boiler plate cannot be considered stronger than its weakest part, and in this case the seam has 75 per cent. of the strength of solid plate, therefore $22,500 \times .75 = 16,875$ pounds, which is the actual strength of the plate put into this boiler, calculated from the weakest part, which is the seam. This is to be divided by one-half of the diameter, and $16,875 \div (66 \div 2) = 511$ pounds, which is the bursting pressure of this boiler. The factor of safety is 5, which means the bursting pressure is to be divided by 5 to obtain the safe working pressure. $511 \div 5 = 102$ pounds.

3. The area of a safety valve is ten square inches the steam pressure ninety pounds, and the distance from valve to fulcrum is three inches, and the ball weighs one hundred pounds. What should be length of the lever in order that the weight shall balance the steam pressure, neglecting the weight of valve and lever?

A. Twenty-seven inches. As the area of valve is ten square inches, the pressure ninety pounds, and the distance from valve to fulcrum three inches, these factors must be multiplied together and the product divided by weight of ball. $10 \times 90 \times 3 \div 100 = 27$.

4. Give the principal cause or causes for boiler explosions?

A. There is nothing mysterious about boiler explosions, as they are all caused by putting more pressure on than the boilers are able to carry, hence the failures. There is, however, a variety of reasons for this, as a boiler may have become weakened by abuse and unavoidable wear, until it is no longer strong enough to carry the ordinary working pressure. In many cases where boilers are not insured, the pressure to be carried is determined by what is needed to drive the engine, without regard to the strength of boiler. Some of the defects which weaken a boiler are so covered that it is impossible to detect them, and several explosions have occurred from this cause. Incorrect steam gauges and safety valves that require the use of a sledge hammer to lift them from their seats have caused explosions from over-pressure.

5. The crank of an engine is fifteen inches long and makes ninety revolutions per minute. How many feet does the piston travel in a minute?

A. Four hundred and fifty feet. As the crank is fifteen inches long, the stroke is 30 inches, so that the piston travels sixty inches per revolution, and $60 \times 90 \div 12 = 450$ feet. Some confusion seems to exist among men in charge of steam plants who are not well informed, concerning the proper way to measure the stroke of an engine, and some amusing results have been secured in efforts to calculate the piston speed under these conditions, but the above way is correct for making the calculation, and the way to determine the length of the crank is to measure from the centre of crank shaft to the centre of crank pin.

6. The initial pressure on a piston is seventy pounds, and the compression is thirty-five pounds, both gauge pressures. Is the clearance half filled?

A. This is one of the questions intended to "catch" the candidate, or, in other words, to offer a test for quick action in arriving at conclusions, as the reply involves the consideration of several things. When the writer first heard that question it appeared as if the intention was to ask if the compression pressure equalled one-half of the initial pressure, when both are measured from a perfect vacuum, as this is the true basis from which to start. If we take the atmospheric pressure at fifteen pounds the total initial pressure is eighty-five pounds, and the compression fifty pounds, so that the latter is more than one-half the former. Such a reply might be understood as an attempt to put an incorrect construction upon sentences that are very plainly worded, and a candidate