REPORTS OF THE COMMITTEE ON THE MODE OF DETERMINING THE HORSE-POWER OF STEAM BOILERS.

At a Meeting of the Franklin Institute, held Nov. 19, 1873, it was resolved that the accompanying statement precede the reports, viz :

At the stated meeting of the Institute, held October 15th, 1873, the accompanying reports from the "Committee on the Mode of Determining the Horse-Power of Steam Boilers," were presented.

It was thereupon resolved that, while not formally adopting the views of either report, the Institute accept the same ; and, further, that both reports be published in the Journal for the information of the members. The Chairman then gave a brief history of the work of the Committee, and concluded by urging its discharge.

It was, thereupon, on motion, resolved "that the Committee be discharged, and that the thanks of the Institute be presented to the gentlemen composing it for the faithful manner in which they had performed their laborious task."

It may be remembered that this Committee was constituted over three years ago with five members, and brought in a report on June 21st, 1871, and an additional report June 18th, 1872, both of which were published in the Journal.

At the meeting in October, 1872, the two reports were discussed, and the Institute referred the subject again to the Committee for more explicit directions, which would make the same available to practical engineers. A difference of opinion also existing as to the amount of evaporation which should be considered as horse-power, the Committee was enlarged by three additional members, representing the manufacture of modern sectional boilers, making the number of the Committee eight. The following reports, numbered 3 and 4, exhibit fully the two views taken of the question : Ed.

REPORT No. 3.

So far as the investigations of the committee have extended, they find no reason for changing the statement in relation to the practice of English boiler manufacturers of providing an evaporative capacity equal to one cubic foot of water at the boiling point turned into steam hourly under atmospheric pressure for each nominal horse power ; this practice has grown up where forty pounds per square inch is regarded as high pressure.

The practice of American engineers makes a different demand on the boiler; higher pressures are required, and the boiler manufacturer has to furnish heat absorbing surface of greater strength; in fact, the chief requirements of the boiler to be used for a manufactory are strength and surface. These cost the maker money, and they are sought by the purchasers of boilers at the lowest price they can procure them. Under these conditions the practice of engine and boiler makers has for some years been growing away from the English precedents; the economy of higher steam pressure has been already sufficiently demonstrated to here require no further discussion, and the conclusions naturally resulting from these changes in practice seem irresistible; we therefore submit the facts.

It has been frequently suggested that the designation of the size or capacity of boilers by the term horse-powers, although it has been used for about fifty years, is inapt and uncertain—the term horse-power being a dynamic expression, and the dynamic effect of a given quantity of steam varying with the engine in which it is used.

To describe the size of a boiler in its evaporative capacity per hour, under stipulated conditions, is preferable.

The conditions vary with different boilers, and should entirely be in the control of the party assuming the responsibility of the performance of the boiler. They embrace temperature of feed, pressure of steam, quantity and form of fuel, arrangement of grate proportions, forms of furnace and flue, volume and force of draft, condition of heat-absorbing surface, and, in short, every thing that affects either the combustion of fuel or the absorption of heat by the boiler.

The making of any uniform empirical standard of evaporation, equivalent to a horse-power, applicable to all boilers that can be verified by experiment is impracticable, because changes in working pressure are attended with changes in the dynamic effect or power with the same evaporative capacity, and such changes are not in direct ratio either with the increased pressure or with the degree of expansion practised in the engine.

In presenting this matter to the notice of the Institute, it would seem proper to call attention to the phenomena resulting from varying steam pressure and variations in expansion.

To do this a series of diagrams have been prepared, copied and modified* from Professor Trowbridge's book on the subject—the

* The modification consists in making the atmospheric pressure the zero initial point in starting pressure, so as to correspond with the steam gauges now generally used, instead of an absolute vacuum 14·7 lbs. below the atmosphere.

result of extended experiments, made in the Novelty Iron Works, N. Y., and checked by careful comparison with other published experiments.

(No. 1.) The first diagram shows the number of pounds of water required to produce one indicated horse-power, in a non-condensing engine, at different pressures and different points of cut-off.

(No. 2.) The second shows the theoretical quantity and the actual quantity of water required per horse-power per hour, with steam at 80 pounds per square inch pressure, cut-off at various points in the stroke. These experiments were made on engines of the slide-valve type, the valves at each end of the cylinder and clearances equal to five per cent. of the piston displacement.

The upper curve is obtained from an engine of more than ten cubic feet cylinder capacity, and the next lower curve from one of less than one cubic foot cylinder capacity.

The lowest line is from a computation of specific volume, according to Mariotte's Law," without clearances, and the line above it, from a similar calculation, embracing clearances equal to one-twentieth of the piston displacement.

(No. 3.) The third diagram shows the increase of horse-power due to increased pressure with the same rate of evaporation.

(No. 4.) The fourth diagram shows the quantity of water required to be evaporated in a boiler to produce one horse-power with different steam pressures in a theoretically perfect non-condensing steam engine.

An examination of these diagrams will serve to show the impracticability of establishing any uniform system of rating steam boilers in horse-powers by any easy mode of computation.

It is the experience of all engineers that moderate excess of steam boiler capacity, beyond the actual requirements of the engine, is attended with economy in fuel, and a stint of boiler with waste of fuel.

In view of variations of capacity of the same boiler under varied conditions, the discontinuance of the term horse-power, as descriptive of the size and capacity of the boiler, would appear to be proper; and it is suggested as preferable that purchasers and makers should, instead, describe fully and in accurate terms the evaporative capacity of boilers proposed, and the conditions under which they are to be worked and tested, or to specify the indicated horse-power to be developed in an engine under fully and exactly stipulated conditions of speed, pressure, economy and grade of expansion.

In conclusion, the following mode of making tests of the evaporative capacity of steam boilers is suggested as being easily managed by persons practically familiar with steam machinery, and only involving apparatus which can be readily procured in most manufacturing establishments.

That the water be weighed in, and pumped from, a tank placed on a platform scale, the temperature at which it enters the boiler measured by a thermometer inserted in the feed pipe, the pressure at which the steam is delivered is determined by a steam gauge, and its temperature by a thermometer inserted in the steam pipe near the boiler.

In case of boilers exceeding 100 cubic feet hourly evaporative capacity, measuring of the water in a tank is preferable as being more convenient.

A convenient means of applying thermometers in water and steam pipes is to screw a hollow plug of iron, open at the top and closed at the bottom, vertically into the upper side of the pipe, so that the lower portion of the plug is in the current flowing through the pipe. Into the cavity of the plug a little quicksilver is dropped, and the bulb of the thermometer is inserted in it. The function of the quicksilver is to secure prompt conduction of heat from the tube to the thermometer bulb.

The preferable form of thermometer for this use is that known in the trade as chemical thermometers; the whole instrument, including its porcelain scale, being enclosed in a glass tube.

The advantage of this mode of applying thermometers is that the thermometer is not exposed to pressure, as it is when directly inserted in the pipe, and, in the event of breaking, no leak from the pipe ensues, and the plugs, which are inexpensive, remaining in the pipe, the thermometer can be readily applied or removed without interruption to the working of the boiler.

The weight of a cubic foot of water at 212° is almost exactly 60 pounds avoirdupois.

When the water is measured at temperatures say between 45° and 70° Fahrenheit, $4\frac{1}{2}$ per centum should be added for the increase in volume, from expansion in heating to 212° .

The temperature of steam when not superheated is most easily deduced from the pressure, as shown in a table, marked No. 5, from Rankine; if superheated, a thermometer inserted in the pipe is a convenient mode of ascertaining it; for converting feed water of

other temperatures than 212° to an equivalent quantity of that temperature, and for converting steam of other pressures than that of the atmosphere to an equivalent quantity at atmospheric pressure, the annexed table, also from Rankine, marked No. 6, serves to conveniently make the conversion.

As the committee do not recommend the testing of all boilers at one uniform pressure, conversions such as are accomplished by these tables are useful in making comparisons of results from boilers tested under different conditions of feed temperature and steam pressure.

The committee are of the opinion that it is not properly within the province of a scientific association to attempt to adjust commercial standards, nor to engage in the interpretation of contracts between buyer and seller, and have endeavored to show what has been the practice of different parties in making boilers and engines, and what are the requirements in evaporative capacity for producing one horse-power under different conditions, and, in conclusion, respectfully suggest that controversies in such questions are most easily avoided by employing competent engineering skill in selecting and purchasing boilers.

The number of elements that necessarily enter into the successful operation of boilers is so great, that it is unreasonable to look for adequate skill among those not specially educated and practically familiar with the subject.

The computations required to convert different temperatures of feed to an equivalent in a fixed standard temperature, and to convert varying temperatures and pressures of steam into an equivalent in a fixed standard, are not such as persons engaged in mercantile and manufacturing pursuits are conversant with; and whilst there is no mystery surrounding these operations, there are wide differences of opinion between engineers as to the proper basis of calculations for converting thermal units into foot pounds or other dynamic expressions.

This wide difference of view between careful and intelligent experimenters is sufficient to place others on their guard in making calculations of such conversions, and forms a strong argument in favor of stipulating fully and exactly the conditions under which steam boilers are to be operated, and then testing them under such conditions.

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