SCHULTE & ASSOCIATES
Building Code Consultants
3500 Creighton Road, K5
Pensacola, FL 32504
fpeschulte@aol.com
847.312.7617

FIRE PROTECTION HISTORY-PART 135: 1906 (COAL-FIRED STEAM FIRE ENGINES)

By Richard Schulte

Among the technical committees reporting at the tenth Annual Meeting of the National Fire Protection Association was the Committee on Fire Engines. The following is the transcript of this Report. Aside from the Report, photographs of coal-fired steam fire engines utilized in the early part of the century and equipment used in testing the fire engines were printed in the Proceedings.

"REPORT OF COMMITTEE ON FIRE ENGINES.

The Committee on Fire Engines has considered the following topics, among others, and reached the conclusions specified below.

In reaching those conclusions, it is largely indebted to the work of the National Board of Fire Underwriters, which, through its Committee of Twenty, has been the pioneer in establishing a uniform system of testing fire engines and in applying such system on an extensive scale. Acknowledgement is further made to the same organization for many of the specific instructions for engine testing embodied in this report and for the sample test blank appended.

Credit is also due to the Boston Fire Department for the original development and adoption of many of the testing methods recommended herein. The appliances illustrated in the report were largely designed by the engineers of the Boston Fire Department and of the Committee of Twenty.

1. TYPES OF ENGINES.–We believe it would be unwise at this time to prescribe for approval exclusive types of fire engines. The reasons for this conclusion are:

a. By prescribing exclusive types of boilers or pumps, the healthy development and manufacture of fire engines would be unwisely restricted.

b. Commercial competition is continually improving the efficiency of fire engines with consequent abandonment of the less efficient types. Therefore, the proscription of the latter is daily becoming less necessary.

c. High efficiency and capacity can be better secured by establishing standard rating requirements which shall specify the amount of water which must be discharged by an engine under specified conditions in order to secure standard rating.

d. The purchase of fire engines by a city does not call for the close supervision which is necessary when private interests install fire pumps and other devices at the request of the underwriters. Because:– cities are limited in choice to a few well developed types of engines practically all of which are efficient; the engines being purchased more for the city's own protection than for the benefit of insurance interests, there is less temptation to install inferior apparatus; the influence of civic pride is a real factor in the purchase of engines of high grade. All of which tend to make it unnecessary for this association to prescribe exclusively one or more types of engines.

2. RATING FIRE ENGINES.– Uniform standard ratings should be established both for future engines and for those already in service.

a. Desirability of Standard Rating. The need for a standard rating has been felt by city authorities, by Underwriters and by fire engine manufacturers. The present system by which any manufacturer rates his engines as first, second or third size, or extra first and double extra first size without much regard to the action of his fellow manufacturers leads to constant confusion.

Two instances will illustrate. The engines in a certain city were tested under like conditions by the chairman of this committee. In the list were one first size engine, stationed in the valuable business district, and one fourth size engine of different make stationed in the suburbs. When tested for capacity, the little fourth size engine exceeded the discharge of the first size engine by more than 200 gallons per minute, and even then the smaller engine was handicapped by being run by the crew of another engine. Again, the engineers of the Committee of Twenty have tested some 400 engines throughout the country, including a fair proportion of extra first and double extra first sizes. And yet the highest capacity which has been recorded to date was found in an engine of the first size with a rated capacity of some 350 gallons less than that of the double extra first size.

A few manufacturers have a habit of rating their engine at capacities which cannot be attained in actual practice, and as prices have hitherto been based largely on rated instead of actual capacity, injustice has been done both to the purchasing city and to competing manufacturers of full capacity engines. For these reasons, and others, the committee recommends that the Association establish standard ratings for fire engines.

b. Enforcement of Ratings. The Committee believes that the N. F. P. A. is hardly in a position to demand that municipalities test and rate their engines according to any set method. Neither can the N. F. P. A. require cities to purchase engines exclusively of the sizes proposed. But doubtless many city departments, knowing that a standard of excellence has been set by us, will gladly see to it that all engines purchased by them in the future shall conform to that standard.

Under such circumstances, builders would unquestionably design their engines to meet the new requirements and these newly designed engines would promptly establish the future standard.

The widespread adoption of the proposed ratings can also be hastened through the influence of the local and national organizations forming the active membership of this association, should such assistance be considered necessary.

c. Limits of Classification. After a study of the engine sizes in use throughout the country and after conferences with manufacturers, it seems advisable to limit the Standard Ratings for the present at least to three sizes, viz.: 600 gallon, 800 gallon and 1,000 gallon per minute engines. No smaller capacity than 600 gallons per minute is given consideration for the reason that smaller engines after a few years' service, could not be relied upon with ordinary handling to furnish two efficient streams. The upper limit is set at 1,000 gallons per minute, as experience shows that but few engines now in service could meet the proposed requirements for this rating.

d. Number of Classes. The objectionable multiplicity of existing sizes is cut down to three. It is believed that city and town requirements can be as well filled by these three sizes as by the eight or ten hitherto in vogue.

The smallest size would serve for suburban districts and localities not closely built up. The second size is intended for ordinary city use. Such engines would be easily able to play two effective 1¼-inch streams or a single powerful stream up to 1-3/4 inches in diameter.

The largest size is desirable for the protection of congested value districts and specially hazardous locations. Engines of this size should be able single handed to supply water tower or other extra powerful streams, such as are needed to reach and penetrate very hot and extensive fires.

e. Method of Rating. The rating of each individual engine should depend upon its actual pumping capacity as determined by a standard test. Several other methods have been considered, such as a rating based on the pump dimensions combined with an assumed piston speed; or a rating based exclusively on one or more of the boiler dimensions. Neither of these methods, however, makes proper allowance for wide variations in type and efficiency of different engines.

The method of rating by actual tested capacity provides a fair and just system of classification, applicable alike to all makes and types of fire engines. To ensure fairness to all the essential conditions under which different engines are tested must be uniform, and to secure the fullest practical value from the tests, the conditions should be similar to those under which the engines would actually operate at fires. The three principal features which indicate the efficiency of an engine are:

> *1. Pumping capacity, measured in gallons per minute.*
>
> *2. Ability to discharge the water pumped under a pressure materially higher than that at which it is received. This increase in pressure is termed the net water pressure, and is measured by the difference, in pounds per square inch, between the suction and discharge pressures.*
>
> *3. The ability to furnish an adequate discharge against suitable net water pressure continuously and without slowing down during an extended period of time.*

These three factors, of which the last two should be constant in all tests, form the basis for each engine's rating. That means, for example, that an engine to obtain a rating of 600 gallons must run continuously during a one hour test, maintaining all the time water pressure at the engine 100 pounds in excess of the pressure on the suction, and during that time it must pump at an average rate of at least 600 gallons per minute.

This is a brief summarization of the standard test by means of which it is proposed to establish the rating of individual engines.

3. STANDARD ENGINE TESTS.

a. Method. A standard method of testing steam fire engines should be established with tests suitable to furnish reliable answers to the following questions:

> *1. How many gallons of water per minute can the engine pump continuously during an hour's run against a net water pressure of 100 pounds?*

2. Does the engine show sufficient excess capacity when handled by an expert to guarantee full capacity under ordinary handling?

3. Does the boiler when properly fired, furnish steam enough to do the work required?

4. Does the engine utilize the steam efficiently?

5. Are the pump valves, plungers and water connections in good working condition and devoid of excessive slip?

6. Can the engine go through an hour's hard work without heating any bearings or starting any bolts or joints?

7. Does the engine work efficiently against a high net water pressure?

8. Do the pumps fill properly when drafting?

Each test should include three runs. The first, lasting one hour with the engine supplied by a hydrant, is to determine the capacity of the engine under standard conditions, and to ascertain the working condition of boiler and machinery. The second, lasting fifteen minutes, also at a hydrant, is to show the engine's efficiency when working against a high water pressure. The third, lasting fifteen minutes, is to demonstrate its operation when drafting its water.

In each run, both the amount of water actually discharged and the quantity displaced by the plungers are to be measured, the pressures on both the discharge and suction sides of the pump, and the boiler pressure to be recorded, and the number of revolutions to be set down for each minute of the test.

In addition to the foregoing, note should be made of all defects and other points which may have a bearing on the efficiency of the engine.

b. Apparatus for testing.

1. Nozzles. Provide a smooth-bore nozzle of suitable size to pass all the water pumped at a moderate nozzle pressure. (Nozzles from 1[-]5/8 inches to 2 inches in diameter are needed for capacities in excess of 600 gallons per minute). In some instances, two smaller nozzles (1¼- inch to 1½-inch) may be preferable to a single large nozzle.

2. Piezometer Couplings or Pitot-tube Connections. The most convenient method for reading the nozzle pressure is by means of a piezometer coupling inserted directly between the hose and the nozzle with no play-pipe intervening. Two forms of piezometer couplings are shown in Figure 1. No. 1, which combines in the same appliance, a full set of testing nozzles, can be attached to 2½-inch hose. No. 2 is applicable to 3½-inch hose, such as is used in deluge sets. Where a single inspector takes all readings, it will be found convenient to connect the piezometer to a gage near the engine by means of rubber tubing, as shown in Figure 2.

In the absence of piezometer couplings, a Pitot tube connection, two forms of which are shown in Figure 1 (Nos. 3 and 4) may be used. Such connections are also of value in checking the results obtained with piezometer couplings.

3. Revolution Counter. A continuous acting revolution counter of reliable type is necessary to afford proper record of the revolutions made by the engine. Two forms are shown in Figure 1, No. 5 is mechanical and No. 6 is electrical. The mechanical type is to be preferred. The electrical counter appears in Figure 3, while the contact on the engine by which it is operated is shown in Figure 4.

4. Gages. Accurate gages, two or three in number, should be provided to register both the discharge and suction water pressures at the engine, and the nozzle pressure. Portable inspectors' test gages are preferable to the regular gages on the engine, though it is sometimes more convenient to make use of the latter after suitable calibration. A desirable arrangement is shown in Figure 3, where the discharge and suction pressures are read alternately on one gage while the nozzle pressure appears on the others. Air chambers serve to reduce the vibration of the gage pointers without undue throttling.

5. Hose. A short length of 3[-]1/2-inch hose attached by a 2½-inch by 3½-inch enlarger to a screw gate valve on one of the engine's discharge outlets serves as an easy channel for leading the water from the engine to the nozzle. The gate is inserted next to the engine in order to maintain constant discharge pressure even when the speed of the engine changes. This arrangement is shown in Figures 5 and 6.

Note.–A competent inspector can obtain reliable results with no other special apparatus than a stop watch and a gage with Pitot connection. The more elaborate equipment is however, highly desirable as the results are then less likely to suffer from accidental errors, the inspector can give more attention to the general operation of the engine, and the work is much more conveniently handled.

d. Directions for Testing.

*1. Preliminary. See that ample waterway is provided for carrying off the full capacity of the engine without requiring a water pressure at the engine more than 80 pounds above the static hydrant pressure.**

** (In estimating the capacity of the waterways, it is convenient to remember that a flow of 1,000 gallons per minute would cause losses of about 120 pounds in 50 feet of ordinary 2½-inch hose; of about 60 pounds in the same length of 3-inch hose, and of about 30 pounds in two parallel 50 foot lines of 2½-inch hose, or a single 50 foot length of 3½- inch hose. A deluge set would cause a further loss of about 12 pounds. The pressures necessary to drive the same 1,000 gallons per minute through nozzles of different sizes are shown below:*

Diameter of nozzle, inches	**1-1/4**	**1-3/8**	**1-1/2**	**1-5/8**	**1-3/4**	**1-7/8**	**2**
Total pressure at nozzle necessary to discharge 1,000 gallons per minute, pounds	470	319	225	163	121	91.7	70.8

By the use of the foregoing factors of resistance and discharge, a single setting of an ordinary slide rule will enable the inspector to select at once the combination of hose and nozzles adapted to his requirements).

Have all gages carefully calibrated and their connections inspected in order to avoid leaks. Usually special tapped caps are necessary to allow the inspector's gages to connect with the suction and discharge chambers of the engine.

Attach the revolution counter and see that it is properly adjusted.

Make provision for ample supply of fuel. Cannel or similar coal should be used, of a quality which burns freely under the boiler without forming clinkers or melting together on the grate bars.

Prepare suitable forms for recording all observations. (A sample form of log adapted from that used by the Committee of Twenty, is shown herewith).

Note.–No directions are given for putting the engine in proper working condition, as it is assumed that it will be handled by a competent crew. Care should be taken in selecting a hydrant with ample water supply.

2. Capacity or Rating Test. The engineer should have an opportunity to get his engine well "tuned up" before starting on the one hour run, and should be fully informed as to what is desired of him. Churn (or hand relief), automatic relief and sprinkler valves should be kept tightly closed throughout the test. During the "tuning up " the inspector gradually opens the discharge gate valve, at the same time directing the engineer to bring the water pressure up to a point 100 pounds in excess of the suction pressure. The test should start when the speed is as high as the steam supply will allow in view of the net water pressure of 100 pounds.

During the run, the inspector should see that the net water pressure is maintained as constant as possible at 100 pounds, variations being corrected by slight changes in the throttle or in the discharge gate valve. The throttle valve should be kept nearly, if not fully, wide open. Readings of the revolution counter and of the steam, discharge and suction pressure should be taken every minute while the nozzle pressure is read at least twice and preferably four times each minute.

Note should be made of blowing off steam, of heated bearings, leaks in steam and water connections, and of all defects, delays or accidents. Before concluding the run, the steam pressure should be brought to about the point recorded at the beginning of the run.

The figures obtained from this test should be worked up to show the average number of gallons per minute discharged during the hour; the average number of gallons displaced by the pump plungers, the slip expressed in per cent of the water displaced; the average net water pressure; the average steam pressure, and the useful horsepower exerted by the pumps.

Alternate Method. Should the hydrant supply prove insufficient or no practical means be available for measuring the total discharge of the engine, the capacity test may consist of two runs. The first, a displacement test, to obtain the net displacement of the pumps, and the second like the capacity test described above, except that a portion of the water pumped is allowed to circulate between the pump chambers through the relief valve (churn valve). In this case the capacity of the engine is figured from the average revolutions per minute multiplied by the net displacement of the pumps per revolution as previously determined by the displacement test. The net displacement is figured by dividing the quantity of water measured at the nozzle by the number of revolutions.

3. High Pressure Test. This test, lasting fifteen minutes, is carried out in the same manner as the capacity test, except that the discharge pressure should be 200 pounds in excess of the suction pressure. Special attention should be paid to the operation of the pumps, and to their tightness and rigidity under high pressure. A small nozzle for measuring the water discharged is advisable.

4. Test at Draft. In this fifteen minute test, the engine draws its water from some reservoir or stream, preferably between four and twelve feet below the level of the pump chamber. The discharge pressure is kept at 100 pounds, minus the head represented by the difference in water level between pump and reservoir. In other respects the test is similar to the capacity test.

e. Results.

To obtain a rating of 600, 800 or 1,000 gallons, an engine must, with ordinary handling, maintain an average discharge during its capacity test at least equal to the rating. At a city acceptance test, where the engine is run by the manufacturer's expert, the discharge should exceed the rating by at least 10 per cent to allow for less skillful handling when in regular service. When rating engines which have already seen service, a reduction in the requirement of one per cent for each year in service is a fair offset for the usual deterioration in the boiler, no reduction to exceed 10 per cent.

Slip in excess of 7 per cent should be cause for rejection, and, if found in engines already in service, should receive prompt attention from the repair bureau.

In concluding, the Committee believes that many other topics relating to fire engines, such as: the use of uniform wheel boxes and axles, uniform suction inlets, standard equipment, etc., are of sufficient importance to warrant the continuance of its service.

The President. You have heard the report of the Committee. What is your pleasure?

Mr. Howarth. I would like to ask the Committee if having the parts accessible has been considered. In examining a steamer recently it looked well and presented a fine appearance, but at any time some of the parts might require adjustment, and whether the parts were accessible or not is an important feature; also the question of motive power, as to whether using steam or gasoline motor.

Mr. Curtis. That the Committee has not taken up this year. They have been used in some cities, and they have given satisfaction, but their use is still very limited.

Mr. French. I think the suggestions that Captain Curtis makes are of a good deal of interest to all of us. One thing I would like to ask is this: It certainly is desirable to keep to our standard whenever we can do so without sacrificing too much. There has been a long experience in rating fire pumps of various sizes in accordance with the 500, 750 and 1,000 gallon classes, and it almost seems to me there would be no difficulty in making the same classification apply to steamers. It is evident from what Mr. Curtis says that the 600 and 800 sizes might very well apply to steamers if those steamers were rated 500 and 750 respectively. It would mean that they would ordinarily have a little margin, just as the ordinary Underwriters' steam pump has a little margin under ordinary conditions. Then it would put those two things on one plane. With the 1,000 gallon pump it is quite evident that most steamers are not quite able to come up to that requirement, and it seems to me there is a place to encourage manufacturers to bring that up. So when we say we have got a 500 gallon steamer or 750 gallon steamer, we would mean that under ordinary conditions we could get 600 gallons, 800 gallons, or perhaps even 1,100 gallons, just as we now mean when we refer to steam pumps; but under conditions of a fire on a cold night and all the conditions you know of so well, we would probably be able to get 500, 750 or 1,000. That would seem to work right in with the fairly well established hose stream for ordinary work, although of course I appreciate in fire department work an inch and a quarter stream and more than 250 gallons per minute is quite common, still 250 gallons is a pretty good starting point. Now the boiler I suppose is ordinarily the chief reason for the inability to pump water, and I have wondered why the steam fire engine builders have not gone to higher steam pressures the same as the locomotive and automobile builders have, so that with the same weight of boiler, using steam at higher pressure, you would be able to use a smaller pump and get your power better. That of course is not quite pertinent just now, but is offered as a suggestion.

Now in the matter of testing, of course all of these methods which you outline are excellent and can be applied by the Committee of Twenty and other similar well organized engineering bodies, but I wonder whether it would not be feasible–possibly you have contemplated it, because I have not had a chance to read the report –putting in just a simple form of ordinary test the same as we are using in hundreds and hundreds of pumps every year, where we put on three or four lines of hose which you gage at the hydrant or at the connection of the hose with the steamer; then from your fire stream tables–which are not absolutely correct, but which are sufficient for a great deal of good, practical work– measure your steamer's capacity, and in that way with the simple test outlined any body of people in any small community could simply start in–that is, the city or town people could go right on with that simple test, make the test in a few hours, and find out pretty closely what the steamer was doing, at least close enough for all practical purposes. The acceptance test for our large cities could be done and should be done better, but it seems to me we want to make this thing just as practical, just as serviceable and available over just as large a territory as possible. You may have covered that, and I only make the suggestion because I do not know all that the report contemplates.

Mr. Curtis. That point is not specifically covered in the report but very easily can be included. The only objection is in actual practice it is very difficult to get your run of hose and nozzles such that you maintain even approximately your 100 pounds net pressure, or any other specific net pressure, and if you don't get that you have no basis on which to draw any conclusions. If you take one engine at a test on high pressure hydrant, and only get a discharge pressure of about 20 or 30 pounds above the engine, you get a wonderful discharge out of that engine, and it may be only fit for the scrap heap.

Mr. French. I think that could be covered by doing as the report suggests– making the pressure on the steamer say 100 pounds above hydrant pressure. And then you get whatever pressure you want from the steamer by using the right size nozzle, and if the pressure doesn't come out right, perhaps by using the standard hose, and putting in another length of hose or taking one out you will bring the pressure up or down and still have it where you want it. You have got something that the ordinary man who is not highly scientific can operate, and he can give the steamer good measure, and he can find out when these fellows are trying to sell him something that is more of a windmill than a pump.

Mr. Curtis. I think it would be well to incorporate such a simplified test.

The President. The Committee will give that consideration.

Mr. Curtis. Of course that would not cover the points of slipping in the pumps at all. To get any approximate of your slipping, you must have a pretty accurate measurement of the water pressure.

Mr. French. You can find out whether it is pretty bad or fair.

The President. The report is before you. What is your pleasure?

Mr. Merrill. I know we all regret that we did not have an opportunity to read this report in print, so we could have a fuller opportunity to analyze it; but we realize how busy Captain Curtis has been, and I am sure we all feel indebted to him for getting this report, even at this late moment. I move you the acceptance of the most excellent paper, and the authorization to print it in the proceedings.

The motion was seconded by Mr. Phillips and unanimously adopted.

Although the Report and discussion which follows are lengthy, what is of particular interest to note is that the fire engines which are being discussed are horse-drawn coal-fired steam-powered pumping apparatus. Also of interest is the size of the pumps being discussed, 600, 800 and 1,000 gpm. Note that the discussion indicates the difficulty in manufacturing pumping equipment capable of achieving a flow of 1,000 gpm.

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