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FIRE PROTECTION HISTORY-PART 129: 1905
(HIGH PRESSURE MUNICIPAL WATER DISTRIBUTION SYSTEMS)

By Richard Schulte

The ninth Annual Meeting of the National Fire Protection Association was held in New York City in late May 1905. With the recent conflagrations which destroyed large swaths of Baltimore (February 7 and 8, 1904) and Jacksonville (May 3, 1901) fresh in their memories, naturally the means to prevent such large fires was the topic of discussion. One of the means devised to assist in preventing the widespread devastation of fires sweeping through cities was improvements in the municipal water supply systems.

Among the technical committees reporting at this meeting was the Committee on High Pressure Systems for Fire Service. The following is a transcript of the Committee's Report:

"***HIGH PRESSURE SYSTEMS FOR FIRE SERVICE.***

Everett U. Crosby, Chairman.

Albert Blauvelt, J. R. Freeman, W. C. Robinson,
B. I. Cook, E.G. Hopson, Ralph Sweetland.

Mr. Crosby. I wish to assure you, Mr. President and Gentlemen, that what has been said before to-day in nowise [no way] *influences me in the statement which I am about to make. The Committee on High Pressure Systems for Fire Service has not been able to meet frequently during the past year. The subject was taken up in correspondence last November and December, and the work thereafter dragged for a considerable period. A short time since the Chairman had in hand a draft of the report which was submitted to the membership, and at the time this went to the printer we had received replies from all but two of the Committee members, Messrs. Blauvelt and Freeman–Mr. Blauvelt wiring to go ahead, and then Mr. Freeman writing to go ahead on the report. Since then Mr. Blauvelt has received a copy of the report, and he coincides with it except that–not using his language, he wrote at some length–he is not in favor particularly of urging an extension of the standpipe and outside hose stream service, wishing to put the chief reliance on the sprinkler system. I am not sure that Mr. Freeman is here, but I hope he is and will take part in the discussion.*

The subject given us under the above title came up for our consideration due to the investigation by a Committee of this Association of a system of street fire mains established in Philadelphia, Pa., and fed from a high pressure gas engine driven pumping station. Furthermore, our attention was called to a proposed system of fire mains in Chicago, Ill., fed by high pressure pumps. As a result, it has been suggested that such systems might become more generally used due to the fact that in a great many places throughout the country the domestic water supply has been found inadequate for fire service, and in other places is under suspicion.

Again, the inefficiency of existing portable steam fire engine service is becoming more and more apparent.

The following is a summary of recent tests of steam fire engines picked at random from service equipment of many of the best city departments in the country:

Number of engines tested	*102*
Nominal capacity.	*69,800 gallons*
Actual capacity	*55,900 "*
Percentage of efficiency	*80%*

In many cases the efficiency of individual "steamers" is less than 50%.

These tests were made under conditions favorable to the engines: time, location and conditions were selected by the Departments and every endeavor made to secure best results at tests. The duration of the tests was very limited, but even under these conditions the percentage of efficiency is low and it is evident that under stress of conditions obtaining during serious and prolonged fires or conflagrations, with frequent changes of location, less careful handling and continued stress of work, the efficiency would be much less than in the tests. The low efficiency of fire engine pumping may be due to mechanical defects, fouling, improper handling, poor stoking, unsatisfactory fuel, or other causes. To obtain best results for these apparatus, a combination of favorable conditions, seldom or ever met with in practice, is necessary. Stationary pumping plants in large units under ample power and with well trained operating force are not subject to the many adverse influences that affect the individual fire engine and can deliver supply both in quantity and force unattainable by any other practicable means.

Quantity and force of delivery are essential to cope with extreme conditions. Whether the numerous powerful streams that can be derived from high pressure systems such as have been recently designed will be sufficient to check a conflagration when once well under way is not claimed, but it is indisputable that the force at the disposal of a fire department will be largely augmented and may be concentrated to better purposes.

All this has prompted a desire for a review of our subject, that the functions of a high pressure service may be outlined and understood, and the most feasible methods pointed out for attaining the desired results.

The term "high pressure" here applied is in contradistinction to a low pressure service, such as is inadequate for efficient hose steamer purposes. This "high pressure" might be spoken of as "adequate pressure," or "adequate direct pressure," meaning a sufficient pressure for fire streams when directly connected to hydrants without the intervention of steam fire engines.

A high pressure fire system must at all times be capable of furnishing a supply of water adequate, both in volume and pressure, for the local needs and uses.

Where such a system is to be specified, its proper uses (outlets) will be found to be much the same for all cities, and the pressure necessary will not vary greatly, but the quantity of water advisable and the water supplies available will be found to differ materially.

WATER OUTLETS AND PRESSURES REQUIRED THEREFOR.

In the consideration of this subject, we will start in at the point where the water is discharged, in order that we may determine the pressure and volume required and thereby suggest the hydrants, piping and water supplies necessary.

A water system for fire extinguishment to be comprehensive should be capable of feeding all of the following services:

(1) INSIDE HOSE STREAMS, as connected with standpipes, or brought into building by a Fire Department, for which 25 lbs. minimum noz[z]*le pressure is desired. It is to be noted these streams are subject to intermittent use, as by the operation of a shut-off nozzle.*

If it is desirable, as hereafter pointed out, to maintain a high pressure system in constant automatic service at a minimum pressure of 100 lbs. in the pipe line, and to take the "first stream" brought into a building by the Department from a high pressure hydrant, such a stream can be easily handled under a pressure of 100 lbs. at the hydrant, and, if desired, could be used at reduced noz[z]*le pressure by throttling at the hydrant valve.*

The inside metal standpipes when used for a fire inside the building which they are located, could be put in service by opening a gate valve in a metal pipe connection from the high pressure street main to the standpipe, said gate valves being normally closed and under sole control of the Fire Department or, by connecting flexible hose from the nearest high pressure hydrant to the siamese inlet of the standpipe.

For this and similar purposes, hose of diameter not less than 3-inch should be employed.

For the 25-Ib. minimum noz[z]le pressure inside standpipe stream, I00 Ibs. at the high pressure street main would provide for the stories of buildings up to 100 ft. in height. An ability to increase this street pressure to 200 Ibs. would take care of the interior standpipe service for a fire in the building in which the standpipe was located in all structures likely to be erected.

For use by the occupants of the building before the arrival of the Public Department, domestic city water supply, gravity or pressure tanks can be kept connected with the standpipes.

(2) AUTOMATIC SPRINKLER SYSTEMS, as used in the interior of numerous buildings, and destined to be much more generally employed in the future, are the most efficient known means of fire extinguishment. These systems require for fully satisfactory service not less than 25 lbs. pressure at highest sprinkler level, and the approved makes, together with the piping and valves of the system, are safe under 300 lbs. pressure. It will, therefore, be seen that pressures which properly serve the above noted inside hose stream service will be adequate for automatic sprinkler systems. These systems require an automatic supply of good pressure at all time, which is now and can continue to be provided by pressure of gravity tanks, or domestic water supplies where the latter are of value for this purpose.

We recognize as debatable the practice of connecting the high pressure system to the automatic sprinkler system through metal piping and keep this supply in automatic service at all times. Against this procedure it is stated that, should a fire get beyond control in such a sprinkled risk and break the large piping, the high pressure service would thereby be bled through a large vent, either 4 or 6-inch in size, the latter under considerable pressure readily discharging as much as 7,500 gallons per minute. The breaking of one such connection might perceptibly affect the pressure in the high pressure mains, and the breaking and discharge through two or more might seriously impair or destroy the efficiency of a high pressure service.

Ordinarily, a fire would not get beyond control in a sprinklered risk because the sprinklers would prevent, but there are a few conditions which might bring this to pass, such as a sprinklered risk being burned by a severe exposure fire, a sprinklered risk burning due to a portion or all of the sprinkler equipment being out of service due to oversight or repairs, or to the system being overcome by unusual internal conditions, such as an explosion. Should such a disaster occur, recourse would next be had to the gate valve in the connection from the high pressure main to the sprinkler system, which would be located outside the building. Importance attaches to its precise location, as it should be well away from the wall and not directly in front of the building being supplied, but, say, 20 ft. to one side, so that access to it would be less likely to be prevented by heat, smoke or falling walls. Such gate valves would be located in pits near center of street accessible by man-holes, or of gate posts type, located at sidewalk margins.

Finally, in event of a sprinklered building burning due to one of the causes above cited, and the outside control gate valve being inaccessible due to adverse circumstances, the waste of water through the connection should be stopped by closing the gate valves in the high pressure main next nearest in both directions. This, however, might involve the shutting of other connections to other sprinkler systems, to standpipes, and to street hydrants located on both sides of the street in the same block. It is of course true that siamese hose inlets could be provided for sprinkler systems to which connection could be safely made from the high pressure hydrant upon arrival of the Department. This would mean a delay of several minutes, fatal to automatic sprinkler protection. Hence, it is necessary to have the sprinkler systems fed at all times by a high pressure connection, or by independent satisfactory water supplies at each building.

It is therefore seen that an important usefulness of high pressure connections to sprinkler systems would be in rendering unnecessary a great deal of expenditure now necessitated in furnishing private water supplies. While but few property owners take advantage of the benefits of sprinkler protection, such a course might be considered unnecessary, but with the general introduction of sprinklers into city properties which is bound to come about and which will be stimulated by the use of a high pressure service connection for water supply, the community will doubtless be benefited by the making of such connections, which should, however, be most carefully safeguarded.

We, therefore, have to recommend that automatic sprinkler systems be regarded as among the proper outlets for a high pressure fire system; that a permanent metal pipe connection for automatic constant service should be allowed from the street main to well installed and maintained sprinkler equipments; that pipe 4-inch in size is adequate for giving the initial pressure and service, pending the arrival of the Fire Department; and that siamesed hose inlets to sprinkler systems be provided in addition for the connection of high pressure hose lines to give increased volume should it be desired after the arrival of the Department; that care should be exercised in the location of the control gate valve in the 4-inch pipe connection and that laws or ordinances prescribe a penalty for the use of water from the high pressure main through the sprinkler connection for any purpose whatsoever other than fire extinguishment.

(3) OUTSIDE HOSE STREAMS, namely, those directed on a fire from without the building in which it is burning.

The loss of pressure due to friction in fire hose is, as a rule, not properly appreciated, and frequently the complaints as to lack of water supply should be more properly lodged against the necessity of using long hose lines. For all such high pressure services, effort should be made to diminish this trouble by very frequently locating hydrants and by hose of larger diameter than the 2-1/2 inch now most commonly used for fire streams. The three-inch diameter hose should be the minimum and may be regarded as reasonably satisfactory for this service. It In now used in a number of our large cities and proves satisfactory under heavy pressure, rough usage and long periods of service. Even larger diameter hose, namely, 3-1/2 inch, is in use on the high pressure service system In Philadelphia.

We find no objection raised to 1-1/4 inch diameter smooth bore noz[z]*les as especially well adapted for ordinary inside and outside Department streams, but it is generally admitted that, with fires of any consequence, a considerable number of larger diameter streams should be promptly employed, for which purpose 2-inch diameter noz*[z]*les are here recommended. The latter under 75 Ibs. noz*[z]*le pressure will discharge approximately 1,000 gallons per minute.*

The following table gives the pressure required at hydrant to overcome friction loss in hose streams of various lengths and maintain 75 Ibs. noz[z]*le pressure, the noz*[z]*le being located at the same level. For the 2-inch noz*[z]*le it is assumed that two hose lines, each of the length stated, will he siamesed together.*

[TABLE OMITTED]

The loss of pressure in the 3-inch and 3-1/2 inch hose probably represents unusually good conditions, and in practice may somewhat exceed the above figures. Not included in the above are losses not exceeding 5 Ibs. incurred in a siamese connection.

In actual practice, an average of about one-third more hose is laid out in a stream than required to reach from the hydrant to the noz[z]*le location if measured in a direct line. With hydrants located with reasonable proximity, this will mean that hose lines varying in length from 100 to 400 ft. will need to be employed, and we must provide pressures sufficient to overcome the friction loss under the most severe conditions, namely, in 400 ft. of hose.*

Outside hose stream service is divided into the following four classes:

(a) HAND HELD PORTABLE STREAMS OPERATED FROM THE GROUND. Seventy-five lbs. pressure at the noz[z]*le is about as high as is feasible and allow the control, direction and moving about of such streams while in service, even if in the hands of a well trained squad of firemen.*

It is seen from the foregoing table that 173 lbs. hydrant pressure is required to feed a 2-inch smooth bore noz[z]*le, discharging, approximately, 1,000 gallons of water per minute, viz.: at 75 lbs. noz*[z]*le pressure, if two lines of 3-inch good quality hose, each 400 ft. long are used. Therefore, to provide for this class we must be able to maintain pressures at the hydrants varying, let us say, from 100 to 175 lbs.*

(b) MACHINE HELD SEMI-PORTABLE STREAMS DISCHARGED FROM THE GROUND.– There are now various devices for relieving the recoil at the free end of the hose stream and making it easy and comparatively safe for one or more men to care for the nozel [nozzle]*. Small platforms with metal universal joint play pipes and connections attached are used for this purpose, similar fittings mounted on apparatus wagons, and also legs which rest upon the ground and are at the other end strapped or attached to the play pipe.*

Such devices are of material importance in facilitating the use of high pressure streams, and the better types should be ascertained and recommended. With some of them, a moderate increase of service pressure over that obtained with ordinary hand held stream is feasible, and with others, there is no practical limit to the increased pressure which can be safely handled.

We believe, however, that a 2-inch noz[z]*le discharge under 75 lbs. noz*[z]*le pressure possesses the qualities necessary for effective service from the ground, and that no higher pressures are advisable for this type of service, even if buildings are unusually high, as increased pressure would not materially better the penetration of such a stream within stories at a high level. The angle of discharge from ground renders them of comparatively little service above the 4th or 5th stories of average buildings.*

© SEMI-PORTABLE STREAMS FROM DEPARTMENT WATER TOWERS.– These excellent devices which raise the noz[z]*le from the ground the equivalent of three or four stories bring said stories into the realm of effective service of an outside stream, and for this purpose the pressures required must be increased some 25 to 40 Ibs. to overcome the head from this high elevation at which the tower noz*[z]*le is discharged and the friction in the apparatus.*

(d) STREAMS FROM METAL STANDPIPES AND ROOF HYDRANTS ON NEARBY BUILDINGS. We regard this class of service as offering excellent opportunities, and would advise that street fronts of buildings in congested city districts at intervals not exceeding I00 ft. be fitted with 6-inch standpipes with metal ladders attached; a siamese to be provided at the bottom near sidewalk level with two 3-inch hose inlets and a check valve in each; with a 3-inch hose outlet and independent control gate at each 20 ft. in the height of standpipe and with two hose outlets each with independent gate at top of hydrant near roof level. All of these standpipes to be tested at 300 Ibs. pressure at street level by the Fire Department, at least once a year, and a law enacted making it a misdemeanor for anyone without permit from the Fire Department to alter or impair this standpipe service.

Upon response of the Fire Department, connection should always be made by hose from the nearest high pressure hydrant to the base of standpipe, ready to be put in operation if needed. Metal universal joint noz[z]*les for direct connection with the standpipe outlets should be carried by the Department and one or two attached at the outlets at proper level on the standpipe most advantageously situated. Such a standpipe, thus fitted, upon arrival of the department, would rival a water tower in efficiency and constitute a vantage point from which streams could be discharged without the immediate presence of firemen who might find the position untenable due to heat or smoke, and yet the pipe and its outlets could be under the control of the hydrant man at the high pressure hydrant several hundred feet distant.*

With exposure fires threatening buildings from the rear, streams could be connected up to the roof hydrant outlets, carried over the roof, and used to excellent advantage from such a location.

This class of service requires high pressure due to height of buildings as at present erected. There is, however, some reasonable limit in height of buildings beyond which it should not be required to extend the public fire service, thereby taxing all for the excessive wants of a few. These latter should provide their own fire protection, build and occupy so as to be non-combustible, or, where the building laws are lax enough to permit such conditions, go without protection and perhaps without insurance. Such buildings are at present infrequently located, and the burning out of the tops of such pinnacles should not seriously menace lower surrounding buildings.

We could, therefore, consider 100 ft. above grade as a fair limit of height for full service of a high pressure system. This limit would require, using round figures, a maximum of 225 lbs. pressure at hydrant--viz., 75 lbs. for noz[z]le pressure, 100 lbs. for friction loss in hose and pipes and 44 lbs. equivalent to the standpipe head.

(e) EXPOSURE SPRINKLERS, COMMONLY KNOWN AS OUTSIDE SPRINKLERS. Systems fitted with these sprinklers are now being developed to an efficient state where ample water supply and pressure can be found with which to supply them. Our proposed high pressure fire service system would constitute an ideal water supply for them and would be connected up to a siamese inlet as above described for the standpipes.

We are inclined to recommend this procedure, rather than permanent metal piping, fearing the valves in the latter might be operated by property owners in event of a widespreading fire, and promiscuous and extended use of such systems would not only mean the application of water where it was not needed, but bleed even the best of high pressure services, possibly to the point of exhaustion.

So far as pressure is concerned, that which would be adequate for the standpipe service would properly serve the exposure sprinklers.

To properly supply the several services, pressures must be maintained at the hydrants as follows (using round figures):

[TABLE OMITTED]

QUANTITY OF WATER.

We have above indicated the water pressures necessary for efficient fire fighting, and will now refer to the amount of water which should be provided, capable of all being discharged at not less than the pressures above specified.

We would first call attention to a feature we note in water works or other reports as to the amount of water consumed for fire purposes. It is customary in water works phraseology to speak of the discharge per 24 hours. Few fires last so long a time. It is necessary that sufficient water be supplied to feed all the outlets put in service at one time, and we will here speak of the quantity desired per minute, the unit employed by the fire protection engineer.

In fighting city fires there are two situations to be taken into consideration–the local fire and the conflagration. The former is represented by a fire in one building or a few contiguous properties either in one block or on opposite sides of alleys or streets. It is reasonable to direct efforts and provide apparatus and water supply with the intention of extinguishing such a fire. The amount of water to be provided for local fires will depend upon the area of the buildings, the occupancy, height, depth and construction, and also upon the barriers existing in the way of fire walls, wire, glass [wired glass]*, shutters, and exposure sprinkler protection at window o-penings, and on open areas; in other words, upon the amount and location of the combustibles.*

In providing quantity of water for a high pressure service under the least exacting conditions, we would recommend as a minimum for local fires some 18, 1-1/4" streams, or 7, 2" streams, which are equal to 7,500 gallons per minute discharge at the required pressures. For the most exacting local fire requirements, we should judge as adequate discharge under the conditions named of 20,000 gallons per minute, which is the equivalent of 50, 1-1/4" streams, or 20, 2" streams.

The second condition for which we have to provide is the fire which has spread beyond control and developed into what is termed a "conflagration." It must be understood that buildings as they now exist in our cities, crowded with vast quantities of combustibles, without adequate separation by fire walls, and without suitable window protection, present conditions which allow fires therein to extend absolutely beyond human control. Nevertheless, there is at such times a great work to be done by the fire department in following up and limiting the spread of such a fire, in fighting it on its side boundaries and at the rear and in the prevention of back fires and extinguishment of distant fires originating from flying fire brands. For this purpose, we advise a reserve increasing the quantities above specified from 50 to 100 per cent, conditioned upon the extent and nature of such conflagration district.

DURATION OF SERVICE.

For how long a period shall water be furnished to these outlets? Baltimore burned for the greater part of two days. Other historic conflagrations have been of longer duration. Where provision is to be made for a conflagration service, it would seem reasonable to indicate as a minimum available quantity of water an amount which would supply the service in its full efficiency for a period not less than 36 hours.

SOURCE OF WATER SUPPLY.

It is needless to report a gravity service, which fulfills the requirements here set forth, as most desirable. It will mean a service constantly maintaining a high pressure but normally throttled by gate valves for the use of the first few hose streams which will control and extinguish the large majority of fires. Pumping plants with power from steam, electricity or gas, are also practical for this purpose, the customary reasonable precautions being taken as to fireproofing of buildings, freedom from interruption of service either in respect to power, pumps or water supply; and the use of multiple units so that a single break or state of repairs will have but little effect upon the whole. Where available, the providing of connections for use of sea water as a reserve supply is to be recommended and will doubtless frequently be availed of as providing complete assurance of a water supply without limit in event of adverse contingencies.

DISTRIBUTION PIPE SCHEME.

No unusual conditions are to be met under this heading, simply the use of the proper specifications for heavy pressure pipes, hydrants, hose, noz[z]*les and holders, which are all now commercial realities. Special care must be exercised in the planning of the gridiron system, the use of properly laid pipe of suitable size so as not to cause a drop in pressure of any importance, due to friction loss*[,] *while delivering at any point in the system the full amount of water there required under the pressure conditions specified. The well established practice is to be noted of placing gate valves where the gridiron crosses at all street intersections, that short lengths of piping not exceeding one block could be at any time cut out, leaving the rest of the system in complete service.*

In view of the usefulness of these systems for "first streams" and the desire to keep them in operation for fire purposes at all times, it is advisable that they be not used for any other purposes, such as street flushing.

Once such a system is properly installed, its efficiency will largely depend upon its careful maintenance, checked up by organized tests and examinations, all of which should he gone into most carefully and reported upon frequently, using detailed report blanks for such purpose.

Such a high pressure system is a tool of the public fire department, who are responsible for fire fighting and the results attained; hence the control of such a system should be in the hands of the fire department, thus centralizing authority and responsibility. This will naturally require the employment of engineers of high intelligence and ability.

Attention is called to the urgent need of bettering the fire fighting facilities in many cities, due to the present deficiency of water supply, both in pressure and quantity, and the shortcomings of the present steam fire engines and other equipment service.

A high pressure system must of itself, without the intervention of steam fire engines, at all times be capable of furnishing a supply of water adequate both in volume and pressure for the local needs and uses.

Such a service shall be comprehensive enough to supply hose streams used within a building, either those brought in by the fire department, or attached to standpipes; also automatic sprinkler systems; hose streams directed from the ground without the building which is on fire, whether held by hand or by mechanical attachments and whether stationary or portable; it shall also properly serve outside streams directed from metal standpipes, roof hydrants, water towers, and exposure sprinklers.

Aside from such exceptionally large discharge orifices which might be employed on water towers, we suggest for general hose stream use, smooth bore noz[z]*les of 1-1/4" to 2" diameter[,] hose of not less than 3" diameter for street use; hydrants frequently enough located so that all of the water required at any one building can be there discharged without the use of hose lines longer than 400 feet. The hydrants to be used for this purpose should all be located within 250 to 300 feet of the building to be protected.*

We suggest 100 feet above grade be considered the maximum height for which full public fire service need be provided; that buildings exceeding this height be required to have non-inflammable construction or occupancy, or equipped with automatic sprinklers and other fire appliances, provided with proper independent water supplies.

Maximum pressures in the street hydrant necessary for such services vary from 100 lbs. to 225 lbs., and must be provided for.

Devices for holding the noz[z]*les of semi-portable hose streams are advised.*

The development of outside standpipe service along the lines indicated is strongly urged.

The required capacity of the water supplies at the pressures indicated should range according to conditions in individual cities from 7,500 gallons to 20,000 gallons per minute for local fires, and 50 to 100 per cent additional for conflagration fires; these quantities to be provided for not less than 36 hours' constant service.

We deem such systems practicable, of decided advantage for certain places, and recommend their introduction.

Respectfully submitted,

Committee on High Pressure Systems for Fire Service.

(It was voted that the report be accepted and printed in the proceedings.)"

As noted in the Committee's Report, the City of Philadelphia had already installed a high pressure municipal distribution system exclusively for fire department use and the City of Chicago was contemplating providing such a system to prevent a repeat of the Great Chicago Fire.

There are several points of particular interest in this report. First, the fact that it was estimated that the quantity of water necessary to properly handle fires in buildings not protected by a sprinkler system was estimated to be in the range of anywhere from 7,500 gpm to 20,000 gpm. Second, the fact that it was estimated that an additional 50 to 100 percent of the water supply required would be necessary to prevent a major conflagration. Third, the high pressure water supply system proposed by the Committee was limited to handling fires in buildings 100 feet or less in height and the recommendation that the height of buildings be limited to 100 feet.

The rationale for proposing that cities consider the installation of a high pressure water supply system was, of course, based both upon the number of recent conflagrations that had occurred in the United States and Canada (Chicago, 1871; Boston, 1972; St. John, 1877; Seattle, 1889; Jacksonville, 1901; Baltimore, 1904; Toronto, 1904) and also the fact that fire apparatus used by fire departments at the turn of the century was simply unreliable.

While the concept of a dedicated high pressure water supply system was workable on paper, the installation of such a system with the piping technology of the first decades of the 20th century eventually proved to be unworkable in practice. With the replacement of horse-drawn steam-powered fire apparatus with motorized apparatus, the reliability of the pumping equipment improved and made the high pressure water supply systems obsolete. The high cost to maintain these systems caused cities that installed such systems to eventually abandon them.

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Source: "*Proceedings of the Ninth Annual* [NFPA] *Meeting*", New York, New York, 1905.