CHANGING THE GEOMETRIC PARAMETERS OF FIRE HOSES WHEN THEY TRANSPORT WATER

Stas S. V., Kolesnikov D. V., Bychenko A. O., Horenko L. M.

Cherkasy Institute of Fire Safety named after Chornobyl Heroes of National University of Civil Defence of Ukraine

Abstract

Main hose lines are usually laid to transport water and working solutions of foaming agents to the centre of the fire when extinguishing large fires or fires with remote water sources. Their components are separate pressure fire hoses, they come in different diameters. As a result of their operation during the transportation of fire-extinguishing substances, fire hoses can change their geometric parameters, first of all, their length. For different types of hoses and their different diameters, it was revealed that their elongation occurs under hydrodynamic pressure. In some cases, when using a plug at the end of a fire hose, the coefficient of relative elongation of fire hoses was 1.04. 3 types of hoses were used for the research: latex pressure hoses with diameters of 51 mm 77 mm type T and fire hoses with double-sided polymer coating with 51 mm type T. All hoses were previously used during the real work of fire calculations. The results presented in the paper are an average of each of the three hose types. The experiments were carried out under typical conditions in the open air using a Protek 366 fire barrel under constant fluid flow and different pressure values at its entrance. Fire hoses were placed on a horizontal surface. The amount of fire hoses elongation when transporting water depended on the physical and mechanical properties of the materials from which they are made, the pressure of the liquid at their entrance, and the flow rate. The maximum elongation (62 cm with a hose length of 1960 cm, the relative extension was 0.032) was recorded when transporting water with a fire hose with a diameter of 77 mm at a pressure at its entrance of 1.0 MPa and a flow rate of 1.9 l/s, the issue of changes in head loss along the length were not considered. There were no significant changes in the diameters of fire hoses.

Keywords: fire hose, hose line, water transportation, fire extinguishing liquid.

When using fire hoses, the same phenomena are observed that are characteristic of ordinary pipelines, such as loss of pressure along the length, water hammer, etc. In firefighting, special attention is paid to pressure losses along the length of hose lines, Actually, the size of hose lines is limited both by the capabilities of fire pumps and by pressure losses in hose lines. The study of the parameters of fire hoses when they transport fire-extinguishing liquids is complicated by the significant expansion of the nomenclature of the types of hoses used.

At the Cherkasy Institute of Fire Safety named after the Heroes of Chornobyl of the National University of Civil Defense of Ukraine, a study of the behaviour of fire hoses during the delivery of extinguishing agents was carried out [1]. Firstly, the issues of changing their geometric parameters, namely lengths and diameters, were studied. The paper [1] presents the results of measuring the main geometric parameters of several types of fire hoses during water transportation (their outer diameter and length). 3 types of hoses were used, the samples were randomly selected, and all hoses were previously used during the work of fire calculations. 6 units of each type of hose were taken. The results presented in [1] are an average for each of the three types of hoses. The most significant value of change in length using a plug at the end of a fire hose (without using a PROTEK 366 fire barrel) was recorded when generating a flow of extinguishing liquid for hoses with a diameter of 77 mm at an inlet pressure of 0.8 MPa. The change in length averaged 790 mm, and the relative elongation was 0.04 with an average initial hose length of 2011 cm [1].

The results mentioned above of the study of the fire hoses' behaviour during the delivery of fire extinguishing substances [1] were carried out without the use of a jet-forming device - a fire barrel, which to some extent distorted the value of actual changes in the geometric parameters of the hoses when they were used during firefighting.

ANALYSIS THE LATTER ACHIEVEMENTS AND PUBLICATIONS

To correct the situation, it was decided to use fire barrels, which are widely used by practical units of the operational and rescue service of the State Emergency Service of Ukraine - PROTEK 366 barrels.

According to the data of the official representative of the Protek company in Ukraine [2], the PROTEK 366 fire hydrant has 4 fixed flow values, allowing to rationally regulate the flow of liquid (water) from 1.9 to 7.9 l/s (115–230–360–475 l /min) and the shape of the jet depending on the operating conditions. At the same time, the actual avoidance of excessive water consumption is achieved by combining the parameters of type A and B barrels with barrel protection, i.e., functioning in full spray mode as a "protective screen" [2].

Although the phenomenon of "stretching" of fire hoses when transporting fire-extinguishing liquids is known, taking into account the amount of elongation can be helpful for firefighters when creating new fire extinguishing means [3, 4] in automatic water fire extinguishing systems [5, 6], and when using fire extinguishers hoses [7] or special fire barrels and nozzles [8, 9], or, for example, in cases of modelling the three-dimensional behaviour of hydraulic hoses under pressure when transporting certain liquids [10].

EXPOSITION

Calculation mechanisms of pump-hose systems based on hydraulic calculation methods must consider such features of pressure hoses as changes in their diameters and lengths during the transportation of fire-extinguishing substances to the device for forming a jet, for example, a fire barrel or attachments [1]. It is essential that in work [1], there was some, albeit insignificant, thickening of the sleeves, but in practice, both their diameter increase and a narrowing were recorded. At the same time, the values of diameter changes remained within the margin of error of the chosen measurement method.

To calculate pressure losses in fire hoses, the value of the specific hydraulic resistance of one meter of a fire hose of a particular diameter and the weight of the hydraulic resistance of a standard fire hose with a length of 20 meters of a specific diameter is used. For practical calculations, the value of the hydraulic resistance of one fire hose is most often used [1].

Fire hoses were randomly selected for the experiments: pressure fire latex hoses with a diameter of 51 mm; compression latex fire hoses with a diameter of 77 mm, type T; pressure fire hoses with double-sided polymer coating 51 mm type T. 6 units of each of the three selected types of hoses were taken. Next, the results of the experiments for the averaged values of the geometric parameters of each hose type are presented. The research were conducted under normal conditions at a temperature of about 20 ºC on a horizontal surface.

As in previous studies [1], we do not indicate the manufacturers of fire hoses but only their type. The main difference in the conduct of these experiments concerning [1] was the use of the PROTEK 366 fire barrel in different modes of its application in the formation of a continuous water jet. According to the four fixed values of the liquid flow rate for the PROTEK 366 fire barrel, 1.9 – 3.8 – 6.0 – 7.9 l/s (at a nominal pressure of 0.7 MPa) were selected. The studied hoses were located on a horizontal surface after a 20 m long hose was connected to a fire truck.

During experiments using the PROTEK 366 fire barrel, the constancy of the liquid flow was ensured, and the modes of "protective screen" and washing were not used. The barrel "worked" in forming a continuous jet of constant flow within each experiment.

The thicknesses and lengths of pressure fire hoses were measured identically according to previous studies (Fig. 2) [1].

Fig. 1. *Study changes in the geometric parameters of fire hoses when using the PROTEK 366 fire barrel.*

As a result of the conducted research, it was established that the thickening of the hose was insignificant. Moreover, in some cases narrowing of the hose was recorded. However, according to the methods of carrying out the measurements and the tools used, it can be assumed that the established values of changes in diameters did not exceed the measurement errors.

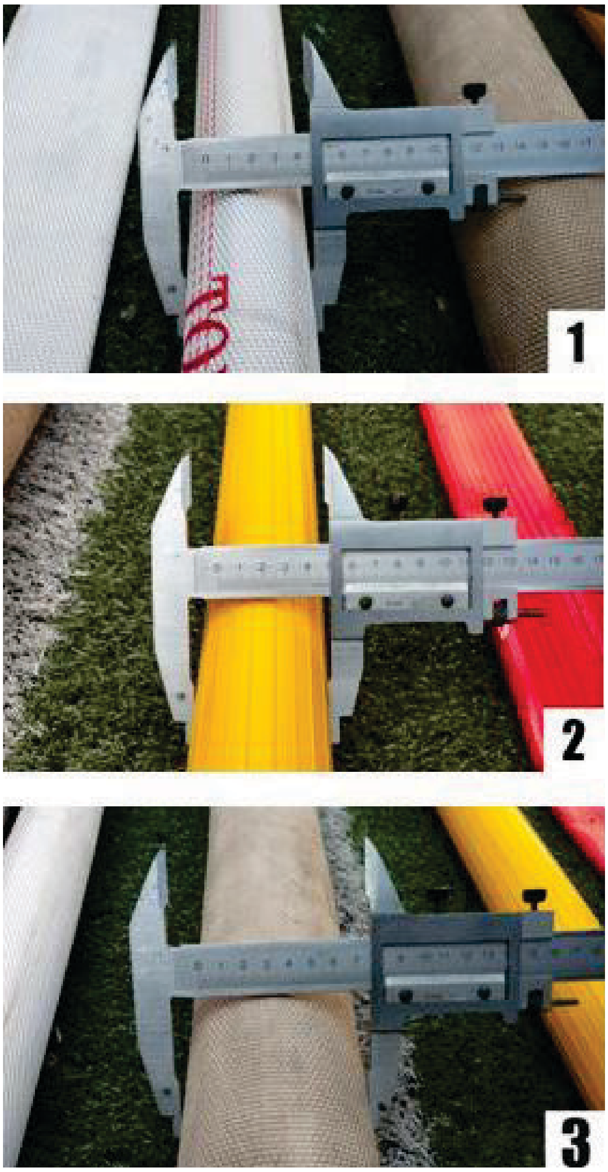

Fig. 2. *Determination of the geometric parameters of the investigated fire hoses (change in diameter),*
1 – pressure fire latex hose with a diameter of 51 mm, type T;
2 – pressure fire hose with double-sided polymer coating 51 mm, type T;
3 – pressure latex fire hose with a diameter of 77 mm, type T [1].

Therefore, it can be assumed that the diameters of the fire hoses selected for research remain unchanged in the entire range of applied pressures and consumption of the fire extinguishing agent - water.

According to the technical characteristics of the PROTEK 366 fire hydrant, the water flow rate was chosen discretely as 1.9 – 3.8 – 6.0 – 7.9 l/s (115 – 230 – 360 – 475 l/min), and the pressure in front of the hydrant was 0.2 – 0.4 – 0.6 – 0.8 – 1.0 MPa.

The results of experiments for three types of fire hoses are presented in Fig. 3.

The maximum elongation was recorded when generating a flow of a fire-extinguishing liquid using a hose with a diameter of 77 mm at a pressure at its inlet of 1.0 MPa and a flow rate of about 1.9 l/s. The change in length was 620 mm (Fig. 4). Thus, for this hose, the relative elongation was 0.032 (the length of the studied hose is 1960 cm). Note that according to the current DSTU 9069:2021 "Fire-fighting equipment. Fireman's hoses are flat-folded for fire-rescue vehicles. General requirements and test methods" even the most among the relative elongation values determined in the study (0.032) corresponds to the current requirements for the use of fire hoses.

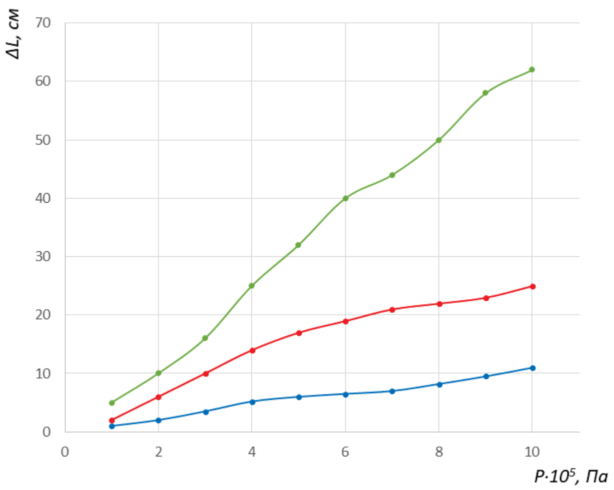

Fig. 3. *The pattern of changes in the lengths of the investigated fire hoses when using the PROTEK 366 fire barrel,*
1 – pressure fire latex hose with a diameter of 51 mm, type T;
2 – pressure latex fire hose with a diameter of 77 mm, type T;
3 – pressure fire hose with double-sided polymer coating 51 mm, type T.

In the future, it is planned to test the investigated types of hoses for maximum tension without transporting water, possibly using a burst testing machine with electrohydraulic or electromechanical load devices.

Such studies are intended to contribute to the determination of some optimal modes of operation of fire hoses, since their longitudinal stretching and thickness stretching/contraction during the transportation of liquids, together with mechanical damage during service, eventually lead to their failure.

The picture of the change in the length of the pressure latex fireman's hose with a diameter of 77 mm, type T, when using the PROTEK 366 fire barrel is presented in Fig. 5.

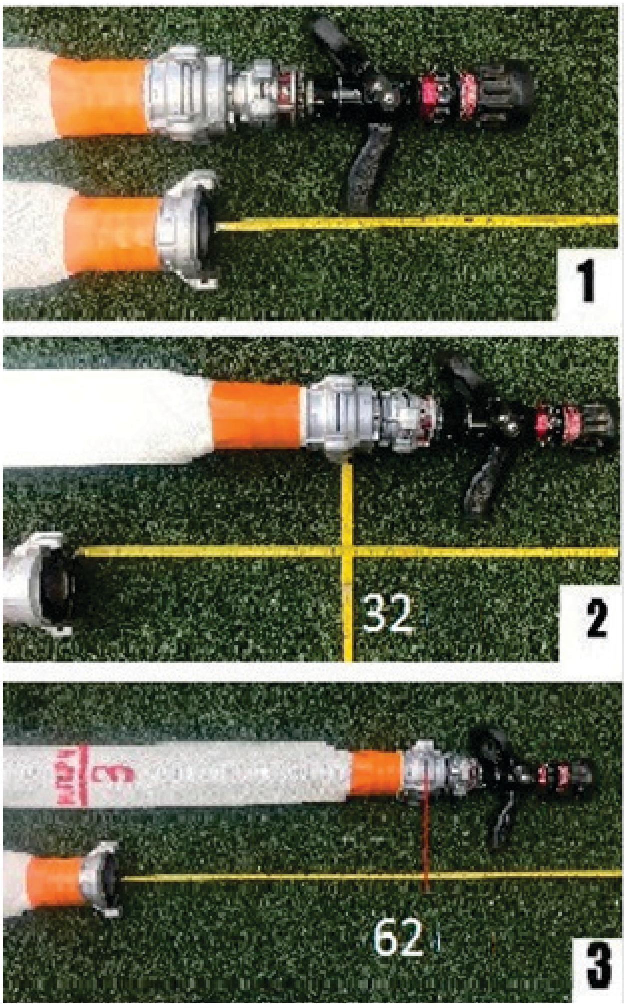

Fig. 4. *Measurement of the geometric parameters of pressure latex fire hoses with a diameter of 77 mm, type T (changes in length) when using the PROTEK 366 fire barrel,*
1 – fixation of the initial state;
2 – a comparative increase in the size of the hose at a flow rate of 475 l/min and a pressure of 1.0 MPa;
3 – a relative increase in the length of the hose at a flow rate of 115 l/min and a pressure of 0.4 MPa.

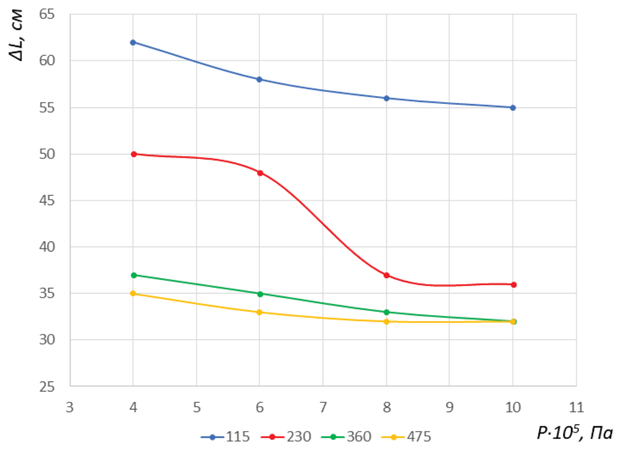

Fig. 5. *Picture of the change in the length of the pressure latex fireman's hose with a diameter of 77 mm, type T, when using the PROTEK 366 fire barrel.*

Under the recommendations for the use of the investigated types of hoses, the value of the maximum pressure at the entrance of the PROTEK 366 fire barrel did not exceed 1.0 MPa. A further increase in the pressure value does not affect the growth in the range of the water jet generation. Therefore it does not make practical sense for this type of fire barrel and will most likely lead to a further lengthening of the hoses.

CONCLUSION

1. The conducted experiments made it possible to state minor changes in the diameters of the investigated fire hoses, which do not significantly impact the process of transporting fire extinguishing liquids to fire barrels or nozzles. In addition, the established values of diameter changes did not exceed the measurement error values.
2. The facts of the lengthening of the investigated fire hoses have been established. The maximum change in length was observed when using a plug at the end of the hose line and gradually decreased with the increasing flow rate of the fire barrel under the condition of a constant pressure value. Thus, it can be stated that in connection with the change in consumption, there is a longitudinal deformation of the fire hose, which is related to the physical and mechanical properties of the material from which it is made, primarily its elasticity. Another reason for the lengthening of the fire hose is the manifestation of hydrodynamic pressure, as a quantity characterized by the arithmetic mean value of the sum of normal stresses in the liquid.
3. The maximum elongation was recorded when generating a flow of a fire-extinguishing liquid using a hose with a diameter of 77 mm and a length of 1960 cm at a pressure at its inlet of 1.0 MPa and a flow 1.9 l/s, which meets the requirements of current regulations on the operation of fire hoses (the relative elongation was 0.032).
4. The amount of extension of fire hoses when transporting fire-extinguishing liquids (water in the conducted research) depends on the physical and mechanical properties of the materials from which they are made, the fluid pressure at their entrance and consumption. The temperature dependence of the change in the geometric parameters of fire hoses when using the PROTEK 366 fire barrel was not investigated.

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