Warehouse premises and tank farms fire safety problem

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ABSTRACT

Introduction. Presented the approach to studying impact of foaming agent process solution shelf life on the surface activity and fire-extinguishing efficiency of foams. One of the most important problems in construction is to ensure fire safety of construction objects. Fires arising at industrial facilities and construction sites are always catastrophic, both for the economy and for the environment. Storage facilities and tanks in which various types of materials and substances, often toxic and fire-hazardous, can be stored are of particular danger. Addresses the problem of oil product warehouse premises and tank farms fire safety using foam extinguishing system. The problem consists in reduction of foaming agent concentration in the process solution during long-term storage. Concentration reduction is expressed in a surface activity decrease and in violation of spreading coefficient structure, namely, by an increase in surface and interfacial tension. Consequently, the use of foaming agent process solution for extinguishing fire at oil product warehouse premises and tank farms that is not capable of providing required foam expansion ratio and spreading coefficient for successful subsurface suppression of oil products flame.

Materials and methods. Four brands of fluorinated foaming agents are tested according to the methods described in GOST R 50588-2012 "Foaming agents for fire extinguishing. General technical requirements and testing methods" and GOST R 53280.2-2010 "Automatic fire extinguishing units. Fire extinguishing agents. Part 2. Foaming agents for subsurface suppression of oil and oil products fires in tanks. General technical requirements and testing methods".

Results. The studies have shown that foam quality determining fire extinguishing capacity of foam extinguishing system changes over foaming agent process solution shelf life and depends on spreading coefficient structure, which is characterized by surface and interfacial tension values for foaming agent process solution.

Conclusions. The process solutions made from modern (biologically soft) fluorinated foaming agents decrease in their surface activity over time and become unsuitable for oil products subsurface suppression. To maintain efficiency of the foam extinguishing system used to ensure fire safety of oil product warehouse premises and tank farms, age of the process solution in the circulating pipeline system should not exceed one day.

KEYWORDS: fire safety, warehouse premises, oil products extinguishing, spreading coefficient, fire extinguishing efficiency, subsurface suppression, surface tension, interfacial tension

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Проблема обеспечения пожарной безопасности складских помещений и резервуарных парков

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АННОТАЦИЯ

Введение. Представлены результаты исследований влияния срока хранения рабочего раствора пенообразователя на поверхностную активность и огнетушащую эффективность пен. Одной из наиболее важных проблем в строительстве является обеспечение пожарной безопасности строительных объектов. Пожары, возникающие на промышленных объектах и на строительных площадках, всегда катастрофичны как для экономики, так и для окружающей среды. Особую опасность несут складские помещения и резервуары, в которых могут храниться различные материалы и вещества, часто токсичные и пожароопасные, представляют особую опасность. Рассматривается проблема обеспечения пожарной безопасности складских помещений и резервуарных парков с использованием системы пенного пожаротушения. Проблема заключается в уменьшении концентрации пенообразователя в рабочем растворе при длительном хранении. Снижение концентрации выражается в снижении поверхностной активности и нарушении структуры коэффициента растекания, а именно в увеличении поверхностного и межфазного натяжения. Следовательно, при тушении складских помещений и резервуарных парков используется рабочий раствора пенообразователя, который не способен обеспечить требуемую кратность пены и коэффициент растекания для успешного тушения нефтепродуктов.

Материалы и методы. проведены испытания четырех марок фторированных пенообразователей, согласно методикам, описанным в ГОСТ Р 50588-2012 «Пенообразователи для тушения пожаров. Общие технические требования и методы испытаний» и ГОСТ Р 53280.2-2010 «Установки пожаротушения автоматические. Огнетушащие вещества. Часть 2. Пенообразователи для подслоного тушения пожаров нефти и нефтепродуктов в резервуарах. Общие технические требования и методы испытаний».

Результаты. Исследования показали, что качество пены, определяющее огнетушащую способность системы пенного пожаротушения, меняется со сроком хранения рабочего раствора пенообразователя и зависит от структуры коэффициента растекания, которая характеризуется значениями поверхностного и межфазного натяжений рабочего раствора пенообразователя.

Выводы. Рабочие растворы, полученные из современных (биологически мягких) фторированных пенообразователей с течением времени снижают поверхностную активность и становятся непригодны для тушения нефтепродуктов подслоным способом. Для сохранения эффективности системы пенного пожаротушения, используемой для обеспечения пожарной безопасности складских помещений и резервуарных парков с нефтепродуктами, рабочий раствор в циркулирующей системе трубопроводов должен быть не старше одних суток.

КЛЮЧЕВЫЕ СЛОВА: пожарная безопасность, складские помещения, тушение нефтепродуктов, коэффициент растекания, огнетушащая эффективность, подслоное тушение, поверхностное натяжение, межфазное натяжение

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INTRODUCTION

Construction is one of the fastest growing industries, which keeps up with scientific and technological progress. One of the key roles of construction is the creation and renewal of the social and industrial infrastructure of the country. In the market of industrial construction and civil real estate there is always a great demand, growing every day.

One of the most important problems in construction is to ensure fire safety of construction objects. Fire from ancient times is both friend and enemy for man. In most cases, fires occur due to the non-observance of elementary fire safety rules and the lack of extinguishing agents, whether it is a residential house or an industrial facility.

Fires arising at industrial facilities and construction sites are always catastrophic, both for the economy and for the environment. Storage facilities and tanks in which various types of materials and substances, often toxic and fire-hazardous, can be stored are of particular danger.

Temporary facilities and warehouses are located on the construction site so that a fire that has arisen on one of these objects cannot spread to neighboring objects. Therefore, the rules provide for a minimum distance between these objects, called fire breaks. The smallest size of breaks, stipulated by the norms, depends on the fire resistance of buildings and structures. The minimum gap between buildings with low fire resistance is 20 m, and with a large one 10 m. At the construction site, you cannot store more than 5 m³ of flammable liquids and 25 m³ of flammable liquids. These fluids should be placed in underground or semi-basement rooms.

Timber warehouses pose a significant fire hazard. Therefore, they are placed no closer than 15 m from buildings. Dry grass, chips, bark and other combustible wastes are systematically removed from the warehouses. This waste is stored on a designated site, located no closer than 50 m from the warehouse. As waste accumulates, they are either disposed of or taken to a landfill.

Warehouse premises and tank farms fire safety remains a very urgent task. Recent accidents at oil products storage facilities evidence low efficiency of the means used to prevent and extinguish fires resulting in devastating impacts and losses [1, 2].

The most effective mean to extinguish fire at oil product warehouse premises and tanks is foam [3]. Examining the entire process flow of foam extinguishing revealed that one of the key factors reducing fire extinguishing efficiency of the system is a decrease in foaming agent concentration during process solution storage [4–7].

This paper is aimed at studying impact of foaming agent process solution shelf life on the surface activity and fire-extinguishing efficiency of foams.

The following authors have had the greatest contribution to research and development of foam extinguishing systems: A.F. Sharovarnikov, I.I. Petrov, V.Ch. Reutt, S.S. Voevoda, D.L. Bastrikov, V.P. Molchanov, etc. These authors mainly carried out research aimed at developing new extinguishing methods and mechanisms.

Reliability of foam extinguishing and specifically that of subsurface suppression system was in no doubt since it was proved by foreign and domestic researches [1–5].

Foam extinguishing efficiency question has risen in recent years only. The scientific papers [8–10] mainly focus on correct arrangement and operation of existing foam extinguishing system.

MATERIALS AND METHODS

The paper uses traditional methods of foam extinguishing efficiency study regulated by national standards of the Russian Federation, such as: GOST R 50588-2012 “Foaming agent for fire extinguishing. General technical requirements and testing methods” and GOST R 53280.2-2010 “Automatic fire extinguishing units. Fire extinguishing agents. Part 2. Foaming agents for subsurface suppression of oil and oil prod-

ucts fires in tanks. General technical requirements and testing methods”.

Four brands of fluorinated foaming agents were used as objects of study. To rule out manufacturers claims, the name of three approved (biologically soft) foaming agents were changed (PO-1, PO-2 and PO-3). Foaming agent (biologically hard) “Light water” is currently prohibited for use, it is not produced or used in foam extinguishing systems, so the name is not changed [11–13].

STUDY RESULTS

The results of experimental studies of foaming agents surface activity are shown in Fig. 1–3. Fig. 1 and 2 show the dependencies of surface and interfacial ten-

sion of foaming agents PO-1, PO-2, PO-3 process solutions and that of the Light water. The graphs show an increase in the surface and interfacial tension of “biologically soft” foaming agents process solutions within a day of storage.

Results of spreading coefficients calculation and their dependence on the process solutions shelf time are shown in Fig. 3. The graphs show a decrease in the spreading coefficient of “biologically soft” foaming agents to zero values in a day, and to negative values in five days. Being a “biologically hard” foaming agent the Light water retains its surface activity performance throughout the entire two-month study period.

The results of studies of foam extinguishing efficiency depending on the shelf life of foaming agent process solutions are shown in Fig. 4–7. Extinguishing

Fig. 1. Dependence of surface tension on foaming agent process solution shelf time

Fig. 2. Dependence of interfacial tension on foaming agent process solution shelf time

Fig. 3. Dependence of spreading coefficient on foaming agent process solution shelf time

Fig. 4. Dependence of heptane flame extinguishing time and foaming agent PO-1 solution specific consumption on foam supply intensity

Fig. 5. Dependence of heptane flame extinguishing time and foaming agent PO-2 solution specific consumption on foam supply intensity

efficiency tests were carried out on the day of foaming agent process solutions preparation, in one day and in 60 days.

Process solutions of foaming agents PO-1, PO-2 and PO-3 decrease in their extinguishing efficiency in a day, which is confirmed by an increase in specific consumption. In 60 days the process solutions of “biologically soft” foaming agents failed to have required expansion ratio for successful subsurface suppression of heptane flame. The expansion ratio was less than 4 for all three solutions, no extinguishing or isolation of heptane surface was observed.

Test of the process solution made of prohibited “biologically hard” foaming agent “Light water” showed that main extinguishing performances do not depend on the shelf time for the entire range of observations. The graphs in Fig. 7 clearly demonstrate repeatability of test results in intervals from 0 to 60 days.

CONCLUSIONS

The studies have shown that foam quality determining fire-extinguishing capacity of foam extinguishing system changes over foaming agent process solu-

Fig. 6. Dependence of heptane flame extinguishing time and foaming agent PO-3 solution specific consumption on foam supply intensity

Fig. 7. Dependence of heptane flame extinguishing time and foaming agent "Light water" solution specific consumption on foam supply intensity

tion shelf life and depends on spreading coefficient structure, which is characterized by surface and interfacial tension values for foaming agent process solution [1, 14–20, 24, 25].

The process solutions made from modern (biologically soft) fluorinated foaming agents reduce their surface activity over time and become unsuitable for oil products subsurface suppression.

To maintain efficiency of the foam extinguishing system used to ensure fire safety of oil product warehouse premises and tank farms, age of the process solution in the circulating pipeline system should not exceed one day [21–28].

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