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THE PROBLEMS OF EFFECTIVE FIRE SUPPRESSION OF VERTICAL STEEL STORAGE TANKS IN THE FUEL LAYER

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Abstract. *This article describes a process of oil and petroleum products extinguishing in the vertical steel tanks by supplying low expansion film-forming foam in the bottom of the tank directly into fuel the layer. It is summarized the problem of extinguishing fires in floating roof tanks or pontoon by subsurface suppression. The main problems of the article are: pollution of oil and oil foam, the foam during ascent to the surface of the reservoir, the formation of "pockets" inaccessible for suppression etc. Given examples of fires in storage tanks and tank park in recent years in Russia and abroad point the need to refine and improve the system of subsurface suppression.*

Keywords: *tank, fire suppression, flammable liquid, foam, piping, hose*

Today Russia has the tanks park for petroleum products with a total capacity of about one hundred million tons. But due to the economic reforms in the country the construction of reservoirs has virtually stopped. In addition, the available balance of tanks parks on the oil industry of the Russian Federation, 80 % of them require repairing and technology services at various levels. The percentage of reservoirs unfit for use gradually increases. Every year an increasing the number of tanks that work off their standard operation time. Therefore, every year almost 10 % of the tanks will leave from the technological mode works [12, 13].

Despite progress achieved in ensuring fire safety, petroleum storage tanks remain among the most hazardous sites. This is related with a number of reasons that are still unresolved [5]. Subsequently, there are fires, causing huge damage to existing businesses. Here are some of them [20]. Since May 2001 there was a major fire at the oil company "Lukoil" in oil refinery "LUKOIL-Petrotel" near the town of Ploiesti (Romania). The fire swept one petroleum tank in the immediate vicinity of fire source where there were five stationary tanks of fuel, technology installations, settlement of this enterprise employees. Fire was extinguished after 10 hours. In August, 2003 in Puertollano (Ciudad Real province, Spain) an explosion occurred at the oil refinery of the "Repsol YPF SA" company, followed by ignition the petroleum products containers. This fire lasted for about three days. In December, 2005 there were three explosions, followed by burning at the oil depot terminal Bansfield, located on north of London. Bansfield is the 5th largest UK oil depot terminal, which contains up to 5 % of the oil

products in the country. It is located in 40 km from London, and provides oil products to south-east England, including Heathrow Airport. Firefighting of 20 major fuel reservoirs continued over 60 hours. There was a fire in a steel tank of 10 thousand cubic meters for the gasoline storage in March, 2009 in Mozyr (Belarus), in the light oil products park of JSC "Mozyr Oil Refinery" of "Belneftekhim" concern. There were three thousand liters of AI-92 gasoline in this steel tank. Fire suppression lasted more than a day. In August, 2009, there was a major fire in Khanty-Mansi Autonomous District at the oil base "Konda", belonging to the enterprise of "Sibnefteprovod," it was burned a few oil tanks covering about 23 hectares. In the oil base stations there are 8 types of RVS-20000 tanks. Before this fire, the total amount of oil located on the base stood at 160 thousand cubic meters. Fire lasted two days. In October, 2009 on the Caribbean Petroleum Refinery near Catano (Puerto-Rico) it was exploded a few oil storage tanks, caused the devastating conflagration. The initial explosion destroyed 11 tanks, which emerged fire quickly spread to nearby gasoline, jet fuel and diesel fuel reservoirs. 21 of 40 refinery reservoirs were completely destroyed. The fire lasted several days. In September, 2010, the territory of JSC «Novo-Ufa refinery» in Ufa (one of the largest in Russia's primary oil refineries), there was an explosion and a fire broke out. In February of 2011 at the refinery in Baiji, 200 km from Baghdad, an explosion caused the cessation of Iraq's largest refinery. Baiji oil refinery (about 180 km north of Baghdad) daily produces 11 million liters of gasoline, 7 million liters of benzene and 4.5 million liters of kerosene. The plant started a huge fire.

As we can see on the examples of fires in oil bases, currently existing fixed fire protection systems of vertical steel tanks do not provide sufficient protection, not to mention the rapid fire suppression. About a quarter of total costs spent on the efficiency of such systems, but Russia has no reported cases of successful fire suppression tank only with the help of such facilities in recent years [12]. More often, a fire in the tank begins with a steam-air mixture explosion. Explosion brings to the roof undermining, so that is the failure of these systems at the initial time of the accident: 75 % of cases where foam generators were gone down, 25 % of cases where supply lines were failed [2, 3, 8]. Only by attracting mobile fire and other equipment fires in storage tanks were extinguished in the most unfavorable consequences of accidents [10, 11]. All this contributed to the new fire suppression technologies development. The most promising of which is fire-fighting by foam extinguishing into flammable liquid layer (subsurface suppression).

Subsurface suppression is a way of extinguishing of petroleum and petroleum product in the tank applying the low expansion film-forming foam in the bottom of the tank directly into the fuel layer [4, 7]. It was first used in Sweden, the United States began to apply this method since 1972 [14, 17]. Obviously, the subsurface foam supply method is the safest way to extinguish fires of the fire personnel and equipment.

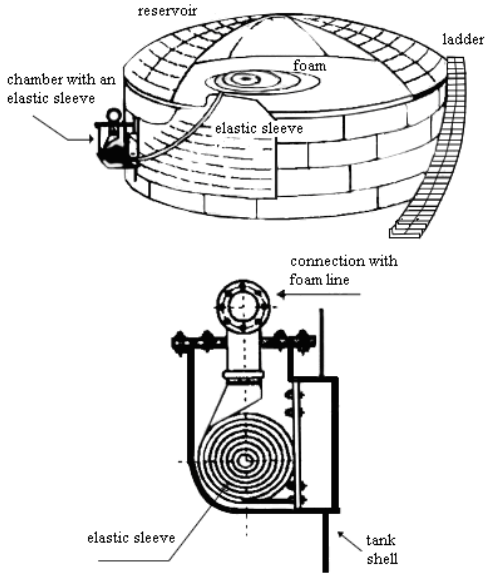

Fig. 1. Fire Extinguishing Systems for the foam supply in bottom of the tank through a flexible hose to the fuel surface

Suppression fires in a vertical steel tanks by applying the foam into layer is carried out in two ways. The first is to supply the low expansion film-forming foam from below through an elastic sleeve. The sleeve protects the foam from the interaction of flammable liquid. According to statistics, this method is very unreliable, because in 90% of cases the device for rolling sleeves is crashed. The second method is to supply the low expansion film-forming foam into the layer of combustible liquids through pipes mounted on the bottom of the tank. The second method has become the most reliable and simple in execution [9].

To use the subsurface suppression method, it must be equipped with a vertical steel tank piping. This system has its own difficulties and requires special skills in its equipment. Such a system is mounted on the bottom of the tank, thus is reliable and does not fail at the initial time of an accident in the steam-air explosion. It is confirmed by numerous fire tests on the existing vertical steel storage tanks in Almetyevsk, Perm, Astrakhan, etc. [13].

For the subsurface suppression method it is used a special foam from film-forming foam generator. These types of foam generators are made on the basis of fluoride such as "light water" allowing to form an aqueous film and to spread spontaneously on the surface of combustible liquids. They also have a long shelf-life guarantee. The U.S.A. fully switched to fluorinated foams use in applying subsurface method [18]. In addition, the studies have shown that this foam has a higher resistance to heating [15, 16, 19]. This is confirmed by testing different types of foam generators used in subsurface suppression system [6].

This fire suppression system is highly effective in the vertical steel storage tanks with fixed roof. In floating roof tanks (pontoon) subsurface suppression method has a number of significant problems.

If a fire occurred due to the steam-air mixture explosion, the floating roof (pontoon) can be completely or partially submerged in a flammable liquid. When fully submerged floating roof (pontoon), the system is covered on top and can lose its efficiency. Partially submerged floating roof (pontoon) brings to the "pockets" formation [1]. "Pocket" is the capacity where applying mechanical foam, combustion and heating of the liquid, heat and mass transfer occurs independently from the rest of the fuel in the tank [9]. In this case, a stationary system of fire protection tanks and a mobile fire-fighting equipment are ineffective in extinguishing such fires.

Another problem is the considerable pollution of the foam by petroleum products, which greatly impacts on the suppression efficiency. This is due to the fact that pressure influences on the subsurface suppression system at the tank bottom. To make the foam output it is necessary to create back pressure on the check valve. When it will trigger an acute introduction of the foam into a layer of combustible liquid. It induces the intensive mixing and thus reduces the extinguishing ability.

Fig. 2. Oil pollution by foam

To all other the subsurface suppression we do not know the amount of water that has passed with foam through a flammable liquid layer on burning surface. It should be noted that the raising foam on the surface is a very longtime process.

Subsurface foam supply method is not effective in extinguishing viscous oil products having a relatively high pour point temperature, as in this case it is very difficult to push the thickened layer of combustible liquids. In addition, it is ineffective in extinguishing polar liquids and petroleum products with alcohols mixture.

At the end of this article I would like to say that the fire safety of vertical steel tanks at refineries is a major task today. Only the modification and improvement of an existing subsurface suppression system can solve all the problems listed above and do industrial facilities safer.

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