Measurements of Potential Hazard During Storage of Diesel Fuel at the Tank Battery

N G Zhuravleva[1], A F Shcherbina[2], M E Pankratova[3], E Yu Aleksandrova[3], A A Trotsenko[3]

[1]Murmansk Marine Biological Institute

183010, Murmansk, Vladimirskaya street, 17, Russia

[2]Plekhanov Russian University of Economics

125993, Moscow, Tverskaya street, 11, Russia

[3]Murmansk Arctic State University

183038, Murmansk, Kommuny street, 9, Russia

The enterprises of the oil refining industry produce and store many petroleum products of different brands of various purity and quality classes. The production and processing of petroleum products become more complicated with the continuously increasing rate of extraction of raw materials. Accidents that occur during storage and processing have serious consequences. Special reservoirs for the collection and preparation of petroleum products are widely used and are the main facilities of the warehouses of transport enterprises, heat and power plants, construction, and industrial enterprises. In this regard, there is an acute problem of ensuring safety during the transportation and storage of petroleum products.

The planned use of the container pre-defines its volume and design features. Emergencies can arise in case of various types of depressurization of equipment and tanks, overflows, violation of operating rules, and during repair work. Prevention of emergencies by developing physical and mathematical models based on accurate measurements is the most important task for engineers. The fact that petroleum products have the highest class of fire and explosion hazards and considering the intensification of all technological processes make the existing issue more actual.

Materials and methods

- The target object (storage of diesel fuel at the Krasny Neftyannik oil depot in St. Petersburg) has the warehouse of petroleum, oil, and lubricants (POL), which is used for receiving, storing, preparing, and continuous supply of consumers with diesel fuel.
- Diesel fuel is pumped through process pipelines (aboveground and underground) from reservoirs to storage tanks, from which it is delivered to consumers by pumping.
- Considering the location of sites, technological equipment, utilities, and the specifics of production, the target enterprise can be divided into several components:
- The tank battery consists of 3 metal tanks with a volume of 10,000 m^3 each, vertically placed and surrounded by the earth embankment with dimensions of 60x140x1.7 m (with a partition separating one tank).
- The station for pumping fuel and lubricants (pumping station for light oil products with pumps (4 pcs.) and coarse filters (4 pcs.)).
- When carrying out work on the territory of the enterprise - at the sites of railway overpasses, in the tank battery, in the premises of the pumping station of fuels and lubricants, where hazardous substances (fuel oil, diesel fuel, gasoline, kerosene, technical oils) are processed, there can be up to 9 people. The number of the largest working shift is 22 people.

Results and discussion

According to calculations, the following types of accidents are possible at this facility:

Formation of a cloud of a fuel-air mixture (FAM) (scenario C_1):

Depressurization → spillage → evaporation of the liquid phase → formation of a cloud of fuel-air mixture → deflagration → impact of an air-blast wave (air blast).

Instant ignition of the pool (scenario C_2):

Depressurization → pool → pool fire (jet fire) → thermal impact on people and buildings.

Pool fire with delayed ignition (scenario C_3):

Depressurization → pool → pool fire (jet fire) → thermal impact on people and buildings.

Explosion inside equipment (scenario C_4):

Formation of a vapor-gas phase (VGP) and the appearance of an ignition source → explosion inside equipment → formation of air-blast and fragmentation of equipment → impact of air-blast and equipment fragments on people.

The most likely scenario is $C_{3\text{-}2} = 1.35 \times 10^{-5}$ 1/year: Partial depressurization of the pipeline → pool → pool fire → thermal impact on people and buildings.

The most dangerous scenario is $C_{1n\text{-}3} = 2.74 \times 10^{-8}$ 1/year: Depressurization → spill → LF evaporation → formation of a cloud of fuel-air mixture → deflagration → air-blast impact.

- **Conclusions:**

1. The “event trees” were built, according to which, certainly, such types of accidents as FAM explosion, pool fire, jet fire, an explosion inside equipment, an explosion inside a building are possible at this enterprise. As a result of calculations, it was established that the most probable accident will occur with partial depressurization of the pipeline and the formation of a pool fire with a probability of 1 casualty.
2. The assessment of the industrial safety and risk of storage of diesel fuel at the target object was carried out. The value of the individual risk is $R = 1.95*10^{-5}$, which is higher than the standard value of $R_s = 1.0*10^{-6}$, therefore, the level of ensuring the safety of people in case of fires does not meet the requirement. The social risk value is $S = 9.5*10^{-6} > 10^{-7}$.
3. The most significant factors influencing the risk indicators are:

- timeliness of taking measures to warn personnel about emergencies and making appropriate decisions;
- proper implementation of duties, strict adherence to safety requirements when working with hazardous substances;
- the amount of substance escaped from the emergency unit with full or partial depressurization.

Thank you for your attention!