Assessment of designing multi-fuel filling stations

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Abstract. The lack of design standards for fire-prevention distances between the ground tanks of reduced hydrocarbon gases (RHG) as part of multi-fuel filling stations to facilities not related to it and on the territory (MFS) between the buildings, structures and technological equipment is the urgent problem in the design and operation of these facilities. The article evaluates the parameters of hazardous factors of possible technogenic emergencies on the technological equipment of RHG sites for workers, fuel consumers and people who are in the residential area near multi-fuel filling stations (MFS) according to the existing method. The most dangerous design basis accidents, in which the largest amount of flammable gas and gasoline is released into the environment at the MFS territory, are considered. Technical solutions have been developed to eliminate the formation of a flammable environment at the facility, as well as measures to prevent the formation of ignition sources in a combustible environment.

1. Introduction

The requirements for the placement of RHG sites on the territory of a MFS in relation to existing buildings and structures are regulated by SP 156.13330.2014 (Russian normative document). This document is not included in the list approved by the Decree of the Government of the Russian Federation of December 26, 2014 No. 1521, taking into account Article 6 and part 6 of Article 15 of the Technical Regulations No. 384, therefore the requirements set forth in it cannot be mandatory in view of Part 3 of Article 16.1 Federal Law of December 27, 2002, No. 184 "On technical regulation". In accordance with the provisions of the Part 1 of Article 6 of Technical regulations No. 123-FZ, the fire safety of the protected object is considered to be ensured if the fire safety requirements established by the technical regulations adopted in accordance with the Federal Law "On Technical Regulation" are fully met, and the fire risk does not exceed permissible values established by this Federal Law. In accordance with the provisions of Part 1 of Article 69 of the Technical regulations No. 123-FZ, fire-prevention distances between buildings and structures must ensure that the fire does not spread to adjacent buildings and structures. It is allowed to reduce the fire-prevention distances from three buildings, structures and technological installations to the objects of protection indicated in the tables 12, 15, 17, 18, 19 and 20 of the appendix to this Federal Law (except for residential, public buildings, children's and sports grounds) when use of fire barriers provided in the Article 37 of this Federal Law.

In this case, the calculated value of the fire risk must not exceed the permissible value of the fire risk established by Article 93 of this Federal Law [1-9].

In accordance with Part 4 of Article 93 of Technical Regulations No. 123-FZ, the value of the individual fire risk as a result of exposure to hazardous fire factors at a production facility for people
in the residential area, a public business area or the recreational area near the facility should not exceed one hundred millionth in the year. For the production facilities where for people in the residential area, public business area or recreational area near the facility, ensuring the value of the individual fire risk of one hundred million per year and (or) the value of the social fire risk of one ten million per year is impossible due to by the specifics of the functioning of technological processes, it is allowed to increase the individual fire risk up to one millionth per year and (or) social fire risk up to one hundred thousandth per year, respectively. At the same time, means of alerting people in the residential area, public and business area or recreational area about a fire at a production facility, as well as additional engineering, technical and organizational measures to ensure their fire safety and social protection should be provided [10-16].

In accordance with Part 1 of Article 93.1 of the Technical Regulations No. 123-FZ, the development of technological equipment and related technological processes, the division of the technological scheme into separate technological blocks, its hardware design, the choice of the type of disconnecting devices and their installation locations, means of control, management and emergency protection must ensure, taking into account the elements of the fire safety system, not exceeding the values of the permissible fire risk for production facilities.

Therefore, the implementation of calculations of fire risks is a sufficient condition for justifying design decisions, taking into account part 6 of article 15 of the Technical Regulation No. 384-FZ, part 1 of article 6, article 69, articles 93-96 of the Technical Regulation No. 123-FZ.

In addition, the type 1 firewall is provided as a fire barrier between the module, the RHG site and the road, which is contrary to common sense.

2. Methodology

2.1. Calculation of the individual fire risk

Individual fire risk (hereinafter referred to as individual risk) for employees of an object is estimated by the frequency of damage to a certain employee of an object by hazardous factors of fire, explosion during the year [17-19].

The areas into which the territory of the object is divided are numbered as \( i = 1, \ldots, I \). The workers of the facility are numbered as \( m = 1, \ldots, M \). The employee number \( m \), uniquely determines the name of the employee's position, his category and other features of his professional activity, necessary for assessing fire safety. It is allowed to calculate the individual risk for an employee of the facility, referring it to one category of the most dangerous profession.

The following workers, people, fuel consumers are considered:

- employees of MFS presence probability \( q_{m} = 1 \);
- fuel consumers all year round, with the exception of finding a tanker truck (hereinafter TT) LMF (liquid motor fuel) (once every 3 days for no more than 3 hours, for 4 types of fuel (for AC AI-95 taken into account in the calculations) and TT RHG (one time in 43 days for no more than 3 hours), it is prohibited to stay on the territory of the MFS at the same time of 2 TTs (clause 8.17 SP 156.13330.2014);

The probability of the presence of consumers on the territory of the MFS is calculated:

\[
q_{m} = \frac{23 \text{ days} \times 12 \text{ hours}}{365 \text{ days} \times 24 \text{ hours}} = 0.32, \tag{1}
\]

- people in the residential area (territory, buildings and structures) near the MFS, the probability of presence \( q_{m} = 1 \);
- people in buildings and structures located in the residential area, taking into account the production calendar with 247 working days and a 40-hour week, is 1970 hours per year.

The probability of the presence of people in the residential area is calculated:
The individual fire risk for employees and people in the territory and in the residential area near the MFS, based on calculations of the potential fire risk, will be:

- for employees on the territory of the MFS:
  \[ R_n = q_n \cdot \tau = 1.3 \times 10^{-6} \text{ (per year)} \]  
  \hspace{1cm} (3)

- for fuel consumers located on the territory of the MFS:
  \[ R_n = q_n \cdot \tau = 3.2 \times 10^{-6} = 8.34 \times 10^{-7} \text{ (per year)} \]  
  \hspace{1cm} (4)

- for people in the residential area near the MFS:
  \[ R_n = q_n \cdot \tau = 9.91 \times 10^{-12} = 9.91 \times 10^{-12} \text{ (per year)} \]  
  \hspace{1cm} (5)

The individual fire risk for workers in the building of the operator's control room of the MFS and people in the buildings and structures of the residential area near the MFS, based on calculations of the potential fire risk, will be:

- for MFS employees located in the control room building:
  \[ R_n = q_n \cdot \tau = 4.62 \times 10^{-8} = 4.62 \times 10^{-8} \text{ (per year)} \]  
  \hspace{1cm} (6)

- for people in the public building on the street Stalevarov, 1G near the MFS:
  \[ R_n = q_n \cdot \tau = 2.24 \times 10^{-8} = 9.3 \times 10^{-9} \text{ (per year)} \]  
  \hspace{1cm} (7)

- for people in garages on the street Stalevarov, 1G near the MFS:
  \[ R_n = q_n \cdot \tau = 2.24 \times 10^{-8} \text{ (per year)} \]  
  \hspace{1cm} (8)

2.2. Calculation of the social fire risk

The social fire risk for people in the residential area near the MFS will be:

- on the territory of the residential area: \( S = 9.91 \times 10^{-12} \text{ (per year)} \);
- in the public building: \( 1K - S = 9.91 \times 10^{-12} \text{ (per year)} \);
- in garages: \( 1G - S = 6.68 \times 10^{-9} \text{ (per year)} \).

3. Results

Calculations have established that the values of the individual and social fire risk for workers, fuel consumers and people in the residential area near the MFS do not exceed the standard values of the individual fire risk established by part 1, part 4, part 4.1, part 5 of Article 93 of the Federal Law of July 22, 2008 № 123-FZ "Technical regulations on fire safety requirements", when performing organizational and technical measures aimed at training personnel in actions in case of fire and social protection of employees, compensating for their work in conditions of increased risk.

The measures to prevent the formation of a combustible environment include:

- the use of a technological system for receiving, storing and issuing RHG, which has certificates of the customs union and the permit for use on the territory of the Russian Federation issued by Technical Supervision of Russia;
- the use of the tank car ACT - 10 UN;
- equipment of the RHG discharge area with flanging at least 150 mm high;
- application of the RHG vapour recirculation system when draining fuel from storage tanks into a tanker truck;

\[ q_{\text{in}} = \frac{197 \text{ hours}}{8760 \text{ hours}} = 0.224 \]  
\hspace{1cm} (2)
• use of double-walled RHG storage tanks with filling of the inter-walled space with inert gas;
• the use of RHG tanks with piping, equipped with electromagnetic valves, ball valves, safety and non-return valves, control and measuring devices;
• the use of constructive fire protection for the RHG tank with piping, ensuring the integrity of the protection and its thermal insulation ability during the time and under the operating conditions of the tank (pipeline), when it is exposed to water during extinguishing a fire, as well as during 60 minutes of possible fire exposure to it fire;
• reservoirs, sections of gas pipelines of the liquid phase of RHG, limited by shut-off devices, which during operation or actions to localize an accident can be closed on both sides, are equipped with safety relief valves with RHG vapour discharge to the waste pipe of the technological system vertically upwards;
• use of fuel dispensers for RHG, equipped with burst couplings, equipment for removing the vapor phase;
• installation of the RHG module on a safety island with a height of at least 0.2 m;
• measures to prevent RHG from spilling into the sewerage system (hydraulic locks on receiving wells, creating slopes and obstacles to prevent RHG from entering the receiving wells, sealing the covers of water supply and sewerage wells);
• the application of the RHG vapour concentration control system is based on a gas analyzer-signaling device for explosive gases and vapors complete with convection sensors for propane, interlocked with the RHG pumps to turn off the technological systems when 10% NKPRP is reached, are installed at a distance of 50-100mm from the site level at RHG dispensers; at the site near RHG storage tanks and equipment for pumping RHG; at the TT RHG site;
• application of emergency protection of the technological system of the RHG section, which includes:
  • a system to prevent overfilling of the tank (the maximum filling level should not exceed 85% of the internal geometric volume of the tank).
  • a system for automatic control of the concentration of RHG vapours at the site for the TT, technological site for storage of RHG, filling islands;
  • a fire detection system (manual explosion-proof fire detectors at the area where fuel is drained from the TT);
  • system of constant automatic control of excess pressure on the pressure line of the RHG delivery pump, "dry running" of the pump;
  • TT grounding control system;
  • a system for continuous monitoring of the tightness of the inter-wall space of fuel tanks;
  • video surveillance system.

Measures to prevent the formation of ignition sources in a combustible environment include:

• the use of explosion-proof electrical and non-electrical equipment in hazardous areas, taking into account the class of the zone and the group of the explosive mixture (including in accordance with the certificate of the customs union);
• grounding of technological equipment;
• lightning protection of the MFS territory;
• making connections of electric cables in explosive areas through explosion-proof couplings;
• technological systems are equipped (regardless of automatic shutdown) with manual power switches for equipment located in the control room and near the pumps (compressors);

Measures to ensure the evacuation of people to a safe zone in case of an accident include equipping the territory and buildings of the gas station with a warning system by submitting text messages about the need to evacuate people from the territory of the MFS, while the system will be activated
automatically by the "Fire" signal from the automatic fire alarm system, the signal "Gas contamination", "Accident" from the automated process control system and remotely.

4. Conclusions
The article provides information that emergency protection of the RHG storage and dispensing area will automatically cut off the power supply to the pump of the technological system, close the bottom valve in the event of a fire, when the maximum permissible concentration of RHG vapours is exceeded, depressurization of double-walled tanks, and an open ground circuit.

When the automatic protection systems of one of the sections of the MFS (RHG and LMC sections) are triggered, interlocks are performed for safety automation and emergency protection systems between these sections, ensuring the termination of operations for filling the tanks with fuel and issuing it to the consumer at all technological sections of the MFS.

Implementation of organizational and technical measures:

- in terms of personnel training, the use of intrinsically safe tools, restricting access to unauthorized persons, informing visitors about the prohibition of smoking and the use of open fire on the territory of the MFS;
- to designate the zones of disembarkation and embarkation of passengers for the RHG section;
- imputation to drivers for the RHG site is not located near the gas station until the final refueling of the car;
- to prevent damage to the module and the gas station, an island is provided at a height of 200 mm from the road surface with sides (metal arcs).

The results obtained can be used in the development of regulatory documents on fire safety, including special technical conditions, in the part concerning the standardization of fire-prevention distances between the ground tank of RHG to objects that are not related to it and on the territory of MFS between buildings, structures and technological equipment during design and operation.

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