Problems of safety of gas systems in the places of residence of agricultural workers

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Abstract. The article presents the results of the analysis of emergencies that occurred in 2011-2020 in Russia as a result of improper operation of gas stoves in residential houses of rural residents, as well as the results of studying the circumstances that preceded the occurrence of these emergencies. Separate provisions of the relevant regulatory legal acts of Russia and departmental regulatory documents of Russia in relation to the placement of gas stoves and their operation in residential houses of rural residents are given. The ongoing gasification of rural areas of Russia, aimed at improving the quality of life of its population, will significantly change the lives of millions of people in rural areas, primarily those who still had to heat stoves with wood or coal, and at the same time will require solving the problem of preventing emergencies during the placement and operation of gas stoves, which is still relevant and unresolved in full.

1. Introduction
In modern conditions, blue fuel is not only a more environmentally friendly type of fuel, used, among other things, for heating water and heating in places of residence and stay of the population of Russia, but it is also much cheaper in cost than other options. Electric heating will cost for the owner of a residential building about ten times more expensive than gas heating. The installation of the gas tank allows not to depend on the central pipeline, but connecting to the central pipeline subsequently creates less hassle.

Emergencies associated with improper placement and operation of gas stoves in the places of residence and stay of the Russian population, including the rural population, occur with enviable regularity and often entail serious consequences: the death of people, injuries of various kinds by people, partial or complete destruction of buildings, thereby causing a negative public response. At the same time, they also entail additional unforeseen costs for the restoration of damaged and destroyed buildings, for the payment of monetary compensation to injured persons and families of deceased people, for the resettlement of citizens to a new home, etc.

This article presents a study of emergency situations that arose in 2011-2020 in Russia as a result of improper operation of gas stoves in the places of residence and stay of rural residents and the previous circumstances, as well as existing inconsistencies between the individual requirements of the relevant regulatory legal acts of Russia and departmental regulatory documents regarding the placement of gas stoves and their operation in the places of residence and stay of rural residents.
2. Materials and methods
The following materials were used for the study:
- statistical data on emergencies that occurred in 2011-2020 in Russia as a result of improper placement and operation of gas stoves in the places of residence and stay of rural residents, information about which is taken from open sources [1-7];
- requirements of national standards [8, 9] for combustible gases for industrial and municipal purposes, as well as for household appliances for cooking;
- fire-hazardous properties of combustible gases [10, 11] for municipal purposes used in household appliances for cooking;
- separate provisions of the relevant regulatory legal acts of Russia and departmental regulatory documents [12, 13, 14, 15] related to the protection of the population and territories of Russia from natural and man-made emergencies, to ensuring safety when using and maintaining of intra-house and intra-apartment gas equipment in Russia, to the safe use of gas to serve municipal needs in Russia.

3. Results and discussion
The study of the causes of emergencies indicated in Table 1 and arising in 2011-2020 in Russia as a result of improper operation of gas stoves in the places of residence and stay of rural residents allowed us to identify the following average patterns:
- each emergency ended with the death of about one person and injury to four more people, including about one child;
- 33% of emergencies were realized in the form of an explosion of a gas-air mixture, which led to a further fire;
- 43.5% of emergencies resulted in the destruction or damage of a building in which villagers lived or were located;
- in eleven cases, emergencies were realized in the form of an explosion of a gas-air mixture due to improper operation of gas-cylinder equipment;
- in six cases, emergencies were realized by the explosion of a gas-air mixture due to improper operation of a gas stove connected to a gas cylinder;
- in two cases, emergencies realized in the form of an explosion of a gas-air mixture arose due to unauthorized connection of gas equipment by rural residents;
- in four cases, emergencies realized in the form of an explosion of a gas-air mixture, arose due to a breach of tightness or damage to the gas pipeline connecting the gas cylinder to the gas stove;
- in 19 cases, emergencies occurred during the daytime, and in 20 cases they occurred at night, that is, during the period of stay of rural residents in their homes;
- in 37 cases, emergencies realized in the form of an explosion of a gas-air mixture took place directly in the places of residence of rural residents and only in two cases they took place in places of temporary residence of rural residents;
- in three cases, emergencies realized in the form of an explosion or a clapping of a gas-air mixture took place in rooms where the ventilated window openings were filled with single glazing and which was destroyed afterwards;
- in 17 cases, emergencies realized in the form of an explosion of a gas-air mixture took place in rooms with unventilated window openings or in which double-glazed windows were installed. The result of these emergencies were more serious consequences, including partial or complete destruction of the building.

In the national standard [8] it is recorded that in Russia the concentration limits of ignition (for methane) of natural combustible gas mixed with air are in the range from 4.4 to 17.0% by volume and its acceptance is carried out during transfer from the supplier to the consumer in accordance with the procedure established by the relevant agreement.

The national standard [9], which applies to household gas appliances for cooking and establishes requirements for freestanding and built-in appliances operating on natural or liquefied petroleum gas, provides that:
- the use of a gas-powered cooking appliance leads to an increase in temperature and humidity in the room and, in this regard, good ventilation should be provided in the kitchen room due to open natural ventilation openings or an installed mechanical ventilation device;
- with intensive and prolonged use of the gas-powered cooking appliance, additional ventilation is required by opening a window and effectively ventilating the kitchen room or turning on the mechanical ventilation device;
- if the delivery set of the device includes parts intended for adjustment to a different gas family or to a different pressure, it is necessary to provide complete clear instructions for replacing parts, cleaning, setting up and testing the device, as well as for sealing after setting up;
- the largest (without specifying its capacity) possible gas cylinder for cooking appliance should be specified in its operating manual.

Table 1. Statistical data on emergencies that occurred in 2011-2020 in Russia as a result of improper placement and operation of gas stoves in the places of residence and stay of rural residents.

| Time period | Total number of emergencies | Including the number of explosions that caused a fire | The number of dead people/including children | Number of injured people/including children | Number of destroyed and damaged buildings |
|-------------|-----------------------------|-----------------------------------------------------|-------------------------------------------|------------------------------------------|-----------------------------------------|
| 2011        | 4                           | -                                                   | 8/1                                       | 55/2                                     | 2                                       |
| 2012        | 3                           | 2                                                   | 3/2                                       | 5/2                                      | 2                                       |
| 2013        | 4                           | 2                                                   | 10/4                                      | 9/2                                      | 2                                       |
| 2014        | 3                           | -                                                   | 1/-                                       | 9/-                                      | 1                                       |
| 2015        | 2                           | -                                                   | -                                         | 4/-                                      | -                                       |
| 2016        | 1                           | 1                                                   | 2/1                                       | -                                        | 1                                       |
| 2017        | 9                           | 3                                                   | 4/-                                       | 23/-                                     | 4                                       |
| 2018        | 6                           | 1                                                   | 1/1                                       | 22/8                                     | 3                                       |
| 2019        | 6                           | 3                                                   | 1/1                                       | 17/5                                     | 2                                       |
| 2020        | 1                           | 1                                                   | -                                         | 4/1                                      | -                                       |
| Total       | 39                          | 13                                                  | 30/10                                     | 148/20                                   | 17                                      |

At the same time, this document does not establish requirements for cylinders for liquefied gases and gas pressure regulators for them.

The reference book [10] shows the properties of natural gas, including fire-hazardous: it consists of methane (CH\textsubscript{4}) 93.05%, ethane (C\textsubscript{2}H\textsubscript{6}) 2.73 %, propane (C\textsubscript{3}H\textsubscript{8}) 1.04 %, butane (C\textsubscript{4}H\textsubscript{10}) 0.22%, hydrogen (H\textsubscript{2}), hydrogen sulfide (H\textsubscript{2}S), carbon dioxide (CO\textsubscript{2}), nitrogen (N\textsubscript{2}), helium (Ne) and other inert gases; it has no color and odor; its explosive concentrations of a gas-air mixture are in the range from 4.5 to 13.5% by volume; it is 1.8 times lighter than air, so it rises up when leaking.

The reference book [10] shows the properties of butane (C\textsubscript{4}H\textsubscript{10}), including fire-hazardous: it is a colorless and odorless combustible gas; its concentration limits of flame propagation in the air are in the range from 1.8 to 9.1% by volume; it is twice as heavy as air, so it falls down when leaking.

The reference book [11] shows the properties of methane (CH\textsubscript{4}), including fire-hazardous: it is a colorless and odorless combustible gas; its concentration limits of flame propagation in the air are in the range from 5.28 to 14.1% by volume; it is 1.8 times lighter than air, so it rises up when leaking.

At the same time, propane or butane contained in cylinders for gas appliances, in case of leakage, will accumulate in the lower part of the kitchen room and one and a half to two times faster than methane,
will create an explosive concentration in a mixture with air. Removing these propane or butane vapors from the lower part of the kitchen room is almost impossible in a natural way, since open natural ventilation openings are located in the upper part of the room and are able to remove only methane vapors when it leaks. And electric motors of compressors of household refrigerators and other kitchen equipment, together with the "lower baseboard wiring" of electrical wiring, as possible sources of ignition, supplement the gas (steam) air mixture with air and create a so-called "fire triangle", creating an actual fire hazard.

According to [12]:
- prevention of emergencies is measures carried out in advance aimed at minimizing the risk of emergencies, as well as at preserving people's health, reducing the amount of environmental damage and material losses in case of their occurrence;
- Russian citizens have the right to protection of life, health and personal property in case of emergencies;
- Russian citizens are obliged to observe safety measures in everyday life, as well as to prevent violations of safety requirements that may lead to emergencies.

According to [13]:
- replacement of the equipment that is part of the inra-house gas equipment is carried out by a specialized organization as part of the execution of an agreement on maintenance and repair of inra-house gas equipment. At the same time, payment for these works is carried out by the owner of this equipment, independent replacement of the specified equipment by its owner without the involvement of a specialized organization is not allowed;
- the proper maintenance of smoke and ventilation ducts is provided by the owner of the household by checking their condition and their functioning or by concluding an agreement for their inspection, as well as, if necessary, for cleaning and (or) repair with the organization carrying out the specified work.

In [14], the minimum requirements for the places of residence and stay of rural residents with the presence of household gas appliances are given:
- at the entrance to single-flat residential buildings, including residential buildings of blocked development, as well as to premises of buildings and structures in which gas cylinders are used, a fire safety warning sign with the inscription “Flammable. Gas cylinders”;
- when using household gas appliances, it is prohibited: operation of household gas appliances in case of gas leakage; connecting parts of gas fittings with the help of a spark-forming tool; checking the tightness of connections using open fire sources.

The fulfillment of the following requirements of the approved [15] "Instructions for the safe use of gas to serve municipal needs", ensuring the safe use of gas by owners (users) of households in relation to inra-house gas equipment, is possible with the following additions:
- paragraph 4.20 with minimum values of the safe distance from furniture and other flammable objects and materials to the gas stove;
- paragraph 4.21 with minimum values of the multiplicity of air exchange and the rate of air inflow, the cross-sectional area of the grate or the height of the gap between the door and the floor, as well as the cross-sectional area of special supply devices in the outer wall (window);
- paragraph 6.29 with minimum values of the safe distance from furniture and other flammable objects and materials to household gas-using equipment.

The joint participation of local government and rural residents themselves in the work on replacing gas stoves with expired service life with modern ones, the use of composite gas cylinders, the installation of gas pollution detectors, the dismantling of plastic windows with double-glazed windows, the maintenance of ventilation ducts of exhaust natural ventilation, the inadmissibility of connecting to them hoods from gas stoves, and other measures will ensure the safe operation of gas stoves both at the enterprises of the agro-industrial complex of Russia and in their residential area.

4. Conclusion
After the conducted research, it can be concluded that:
only a joint partnership of local governments and rural residents of Russia themselves can ensure the safe installation and operation of gas stoves, both at the enterprises of the agro-industrial complex of Russia and in their residential area;

− it is necessary to make appropriate additions and changes to certain regulatory legal acts and departmental regulatory documents that exclude the above inconsistencies regarding the placement and operation of gas stoves, both at the enterprises of the agro-industrial complex of Russia and in their residential area.

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