

Emergencies Due to Improper Operation of Gas Stoves in Apartment Buildings and Their Prevention

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Abstract — in various regions of the Russian Federation, accidental explosions of natural gas due to improper operation of gas stoves in apartment buildings with death or injury of people cause a wide public response. It is difficult to restore (dismantle) building structures damaged by natural gas explosion and, if necessary, then to relocate people to other dwellings. Combustion products resulting from the subsequent fire enter the surrounding environment and create more danger for people. Prevention of natural gas explosion with proper operation of gas stoves in apartment buildings is still an urgent and not yet fully solved problem. Various options are offered, such as replacement of a gas stove with an electric stove, installation of a gas alarm in the kitchen, installation of a solenoid valve on the gas pipeline, and a number of others. In this article, we applied an analytical method to study emergency prevention associated with improper operation of gas stoves in apartment buildings; the paper presents the analysis of natural gas explosions in apartment buildings in the Russian Federation in the period from 2009 to 2018 (inclusive). At the same time, circumstances preceding those natural gas explosions are studied. The article analyzes requirements of the Russian Federation's normative legal acts to premises with gas stoves. The study reveals unsolved problems with ensuring safety of people when using gas stoves in apartment buildings in the Russian Federation.

Keywords: *ventilation duct, gas stove, gas-air mixture, easy-to-discharge anti-explosion design, natural gas*

I. INTRODUCTION

In different regions of the Russian Federation, accidental explosions of natural gas in apartment buildings resulting in death or injury of people cause a wide public response.

At the same time:

"The dwelling is inviolable. No one shall have the right to enter a dwelling against the will of persons residing therein except in cases established by Federal law or based on a court decision" [1, article 25];

"Everyone has the right to housing. No one may be arbitrarily deprived of a home" [1, part 1 of article 40].

II. MATERIALS AND METHODS (MODEL)

A. *Natural gas explosions in apartment buildings and ways to prevent them*

Information about natural gas explosions in apartment buildings in the Russian Federation during the period from 2009 to 2018 inclusive (table), was available at open sources [2, 3, 4, 5, 6].

TABLE I. INFORMATION ABOUT NATURAL GAS EXPLOSIONS IN APARTMENT BUILDINGS IN THE RUSSIAN FEDERATION (2009-2018)

Period of time	Indicators						
	Number of explosions, total	Including explosions that caused:				at the same time:	
		fire occurrence	damage of exterior walls of building	destruction of window glass	relocation of people to other dwellings	killed, men	injured, men
2009	34	14	25	9	10	44	73
2010	22	6	14	8	6	14	37
2011	12	5	6	6	3	2	22
2012	7	6	6	1	2	14	43
2013	6	2	3	3	3	13	10
2014	12	2	5	7	5	16	44
2015	9	2	7	2	3	14	45
2016	5	2	4	1	2	12	10
2017	29	8	18	11	5	23	56
2018	23	11	13	10	1	11	70
TOTAL	159	58	101	58	40	163	410

The analysis of information (table) revealed the following regularities:

1) The majority (55.9 %) of natural gas explosions occurred in the evening and at night, namely during the presence of many people in their homes. At that time, load on ventilation ducts of the exhaust natural ventilation increases. Applied for low-rise construction option of installation of two separate exhaust ventilation ducts (cross section of each, as a rule, not less than 14 x 14 cm or 196 cm²), leading from one apartment to the roof of the building, did not cause any problem for other apartments and was safe, but took up a lot of space when laying a large number of exhaust ventilation ducts in the brick wall and required regular cleaning of these conduits. In construction of residential buildings with a height of nine floors or more two schemes of exhaust natural ventilation prevail:

- vertical ventilation conduits from apartments are placed to the common horizontal ventilation conduit located in the attic, the air from which is released into the atmosphere through a single vertical ventilation conduit, 2.0 m above the roof of the building;

- vertical ventilation conduits from apartments are connected by parallel ventilation satellite conduits (cross section, as a rule, 12 x 27 cm or 324 cm²) to the common vertical ventilation shaft (section, as a rule, 27 x 46 cm or 1242 cm²) 2.0 m above the roof of the building. These schemes of exhaust natural ventilation are less safe in operation and require high-quality insulation (to avoid condensation, premature damage to materials and even the appearance of mold). It is advisable to increase cross section of satellite conduit (in connection with the increasing number of connected ventilation ducts) and cross section of a common vertical shaft (in order to avoid creation of reverse thrust of air and prevent air return in the top floor apartments).

2) Most part (63.5 %) of the occurred explosions of natural gas led to damage or destruction of building designs (walls, partitions, floor structures). This was the case in kitchens with plastic windows (of insulated glass units), with low breathability and acting as air supply devices. In them, it is difficult to adjust the position of opened shutters

(which is mandatory when operating gas stoves in the kitchen), residents open them only briefly to ventilate the premises.

3) Smaller part (36.5 %) of occurred explosions of natural gas was accompanied by destruction only of windows in kitchens. This was the case in kitchens with a conventional double-leaf window with a single glazing thickness, usually 3 mm, and with an openable (small) casement window (section 35 x 64 cm or 2240 cm²), which functioned as an easily ejectable anti-explosion structure (in case of extinguishing the flame at burners of gas stove, formation of a dangerously explosive concentration of gas-air mixture and explosion of natural gas).

4) 36.5 % of occurred explosions of natural gas were accompanied by fire, which entered the surrounding airspace and created additional hazards for people.

5) 25.2 % of natural gas explosions caused the state of disrepair of the apartments and necessitated the relocation of people to other dwellings.

6) Each natural gas explosion resulted, on average, in the death of one person and injuries to three people

7) Natural gas explosions in case of improper operation of gas stoves in apartment houses represent emergency situations. They are a natural consequence of: annulment of previous regulatory requirements to the premises for intra-apartment gas equipment, including gas stoves; insufficient monitoring of operation and maintenance of intra-apartment gas-powered equipment; inefficient informing the public about the hazardous properties of natural gas and its safe use; replacement of metal gas pipeline with rubber hose in order to remove gas-stove from the nearest air vent on the exhaust ventilation conduit; connecting up powerful fan from the vent hood over gas stove or connecting up corrugated duct having a cross-section of 200 cm² to the individual exhaust air conduit with cross section 196 cm², which excludes the possibility of air removal from the subceiling space of the kitchen. A proposed option:

- replacement of a gas stove with an electric stove is not consistent with the ongoing gasification of the regions of

the Russian Federation and causes residents' dissatisfaction due to more expensive energy source;

- in the kitchen, installation of gas alarm or solenoid valve on the supply pipeline does not stop the supply of natural gas (in case of damage to the supply pipeline located inside an apartment building).

Prevention of natural gas explosions with proper operation of gas stoves in apartment buildings is still an urgent and not yet fully solved problem. In the future this can be eliminated by fulfilling the relevant requirements of regulatory legal acts of the Russian Federation [7÷12]. And item 92 "Rules of a fire-prevention in the Russian Federation" approved [10] authorizes only one cylinder inside a building in volume no more than 5 liters connected to a gas stove of factory production. The used ventilation units of high factory readiness with the same cross-section of ventilation satellite conduits are effective for ensuring air exchange volume (25 m³ / h) in the bathroom, shower, toilet and combined wet units, but are ineffective to ensure air exchange (100 m³ / h) inside a building with gas-using equipment (gas stove), specified in paragraph 9.2 SP 54.13330.2011 "SNiP 31-01-2003" residential apartment buildings", included in the "List of national standards and codes of rules (parts of such standards and codes of rules), application of which on a mandatory basis ensures compliance with the requirements of the Federal Law "Technical regulations for the Safety of Buildings and Structures", approved [12]. To use natural gas safely, users (owners) of premises in apartment buildings must comply with the requirements of the "Instructions for safe use of gas for municipal needs" (hereinafter – the Instructions), approved [13], [14], including:

- item 4.21 of the Instruction, effective performance of which is impossible until it includes minimum values (air exchange rate, air inflow rate, cross-sectional area of an air vent or height of a gap between a door and a floor, cross-sectional area of special air supply devices in an external wall or in a window);

- item 4.20 of the Instruction, effective performance of which is impossible until it includes minimum values (safe distance from furniture and other flammable subjects and materials to a gas stove);

- items 4.20 and 6.29 of the Instruction effective performance of which is impossible until it includes minimum values (safe distance from furniture and other flammable subjects and materials to a gas stove);

- point 4.6 of the Instruction effective performance of which is impossible until it includes minimum values (volume of the cylinder with liquefied hydrocarbonic gas inside the premises of apartment house). If there is a cylinder leakage of propane or butane, which are heavier than air, their vapors will not rise up either to air vent of exhaust ventilation conduit or to vent hood powerful fan above the gas stove;

- item 6.30 of the Instruction effective performance of which is impossible until it includes minimum values (safe distance from the cylinder with liquefied hydrocarbon gas to the household refrigerator which is necessarily present in kitchen and in which there is electric equipment, the most part of which is located in its bottom part). If a cylinder of

liquefied petroleum gas (propane, butane or a mixture thereof) leaks, vapors will accumulate in the lower part of the kitchen room and create an explosive gas-air mixture there and, with the next automatic activation of compressor of the household refrigerator, it is likely to spark, followed by ignition of this explosive gas-air mixture [15];

- items 6.34 and 6.34.3 of the Instruction prohibiting owners (users) of the premises in apartment buildings to use gas stoves, in the absence of air inflow in the quantity necessary for complete combustion of gas, including due to the lack of or being in closed position, adjustable window sash, vent sash, casement window, special air supply devices in exterior walls or windows, closed position of louver of grille on the conduit in the room in which gas equipment is installed [16]. Effective implementation of these requirements is possible after taking into account minimum values (air exchange rate, air inflow rate, cross-sectional area of an air vent or the height of the gap between the door and the floor, the cross-sectional area of special air supply devices in the outer wall or window).

III. RESULTS AND DISCUSSION

Obligatory public - private partnership to replace gas stoves with expired service life, installing gas detectors in kitchens, installing electromagnetic valves on supply gas pipelines, dismantling plastic window units (with insulated glass units) in kitchens, maintaining ventilation conduits of exhaust natural ventilation and connecting up gas stove hoods to them, removing vertical gas pipeline from apartments and entrance of an apartment building (on the outer wall in a special ventilated niche with a placed in it crane of gas supply to each apartment, which, if necessary, is easier to block), and as well introducing corresponding appropriate amendments to regulatory legal acts of the Russian Federation will provide safe operation of gas stoves in apartment houses.

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