REPLACEMENT OF HALON IN FIRE EXTINGUISHING SYSTEMS

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As effective fire suppression agents, halons are widely used in fire-extinguishing systems, especially in means of transportation (ships, airplanes and so on). However in 1987, the Montreal Protocol on substances that deplete the ozone layer was signed providing for controls on the consumption and also further reduction of halons. According to it, concern has risen regarding their replacement by substances that do not deplete the ozone layer. The All-Union Fire Research Institute for Fire Protection (VNIIPO) has developed such fire suppression agents as self activating extinguishing compositions (SAEK). Their production is being planned at one of the Soviet enterprises.

To compare fire extinguishing effectiveness of SAEK and that of halons, laboratory and full-scale total flooding tests of highly combustible and combustible liquids were carried out in chambers of 260 m^3 volume. The results of comparative tests are given in Table I

TABLE I

No.	Fuel	Volume, m^3	Fire Suppression Agent	Concentration of FSA, gm^{-3}
1	acetone	0.25	Halon 2402	180
2			SAEK	40
3	heptane		Halon 2402	I90
4			SAEK	40
5	polyurethane foam	"	Halon 2402	300
6			SAEK	80
7	diesel fuel	14	Halon 2402	300
8			SAEK	50
9	ethanol	57	Halon 2402	210
10			SAEK	54
11	diesel fuel	260	Halon 2402	240
12			SAEK	54

Fire extinguishment time (from the moment of formation of flame extinguishing concentration in the volume) varies as a function of the volume up to 20 seconds in Halon 2402 tests and up to 10 seconds in SAEK TESTS.

According to the above results flame extinguishing concentration of SAEK is one-fourth to one fifth as much as that of Halon 2402 when used in total flooding Considering specific quantity of metal per structure, the total mass of a SAEK suppression system can be further reduced. For example, to protect a room of 260 m^3 volume from fire, where tanks with diesel fuel are located, a halon system has a mass of 321 kg (No. 11 in Table 1) as compared with a SAEK system having a mass of 34 kg, which is about one-ninth as much.

One of the most important requirements for fire suppression agents specifying the possibility of their usage in residential rooms is a low toxicity at flame extinguishing concentrations. The Leningrad branch of VNIIPO has developed methods for expert assessing toxicological exposure of living beings to fire suppression agents. For these purposes, a metal chamber of 1 m^3 volume with thin walls is used. It is separated from a gas chamber with white mice by a closure device. In the chamber there is a test fire in the form of a cylinder of 60 mm in diameter into which 0.1 liter ethanol is poured. 3 minutes after its ignition a fire suppression agent is fed into the chamber. M e r the extinguishment, axial fans are switched on and the closure device in the gas chamber is opened. During a 15 minute exposure, gas samples near mice are taken for analysis, when the number of motionless animals and the number of dead animals are determined. Simultaneously, the time when it occurred is identified. The use of flame extinguishing agents can be permitted in residential rooms if the media containing flame extinguishing concentrations cause neither loss of motor capacity nor death of the animals under a 15-minute exposure. Test results are given in Table 2.

TABLE 2. RESULTS OF TOXICOLOGICAL TESTS OF SOME FIRE EXTINGUISHING SUBSTANCES UNDER "ACUTE" EXPOSURE.

Flame Extinguishing Substance	Toxicological Effect, %	
	Death, E	Immobility
Halon 1301	0	0
Halon 1201	0	0
Halon 2402	0	14.6
CO_2	10.4	95.8
SAEK	0	0

Observation of the animals subject to SAEK flame extinguishing concentration for 2 weeks and subsequent autopsy did not know any changes in their bodies. **A** similar result was obtained for one SAEK concentration twice the flame extinguishing one, while 50% of the tested animals lost motor capacity only at 260 gm^3 concentration, which exceeds flame extinguishing one by 4.3 times. It should be noted that SAEKs do not undergo thermal destruction (when exposed to flame) whereas halons in similar situations, even Halon 1301, release harmful substances. The investigations allow one to conclude that SAEK toxicity does not exceed that of Halon 1301 and thus can be recommended for use in residential rooms.

SAEK ability to prevent explosions of gas-air mixtures was tested experimentally in a cylindrical chamber of 22.4 liters volume. Results showing concentrations of methane-air and hydrogen-air mixtures are presented in Table **3**

TABLE 3 MAXIMAL INERTING CONCENTRATIONS OF SOME FIRE EXTINGUISHING AGENTS

Flame Extinguishing Substance	Maximal Inerting Concentrations, gm^3	
	CH_4-Air Mixture	Hydrogen-Air Mixture
Nitrogen	*520*	800
Halon 2402	*325*	I700
Halon 1301	*320*	1600
SAEK	*50*	*230*

It can be seen from the Table that the inerting efficiency of SAEKs is 6-10 times as much as that of widely used fire extinguishing substances.

Improvement of fire extinguishing systems owing to the introduction of SAEK allows to widen the use of total flooding in case of fires in vehicles of different types and in aircraft, in particular. It is well-known that existing aircrafi halon suppression installations designed for engines and cargo compartments are too cumbersome. Moreover, standard fire tests of aircraft engine developed by IIyushin Design Office showed that the mass of a suppression installations based on SAEK can be reduced by more than 5 times.

With the purpose of an investigation of searching gaseous compositions to be alternative to halons, VNIIPO has developed the Procedure of Experimental Definition Fire-Extinguishing Concentrations. Analysis of obtained experimental data has shown that fire-fighting efficiency of well-known inert gases increase in the order of Ar, N_2, He, CO_2, CF_4, and SF_6. By this means,

SF_6 is the most effective extinguishing substance from the known inert gases. Its thermal-physical properties are near to Halon 1301, but its fire-fighting efficiency is three times as low as the last one.

Accordingly it was interesting to study the possibilities of increasing the fire-fighting efficiency of SF_6 by means of producing combined composition with addition of a little quantity of Halon 1301 as the most near by its thermal-physical properties. Experimental definition of fire extinguishing concentrations of combined composition. Carried out with the use of developed procedure has shown that according to the relation between the compositions components, the strengthening of fire-extinguishing properties of each of the components takes place in some of other degrees. The strengthening of fire-extinguishing properties of each of the components is more characteristic for the composition containing 75% of CF_4 and 25% of Halon 1301. The obtained combined composition is far in excess (approximately in 1.5 times) of BF_6 and is more ecological pure than Halon 1301 is.

By this means was estimated that from the well-known inert gases, SF_6 has the most fire-fighting efficiency. **A** combined composition containing SF_6 and Halon 1301 has been proposed