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(71) Applicant: **Celanova, Ltd.**
Dublin 8 (IE)

(72) Inventors:
- **BELYAKOV, Vladimir Ivanovich**
  Mga, Leningradskaya obl., 187300 (RU)
- **RUSANOV, Vladimir Dmitrievich**
  St. Petersburg, 193224 (RU)
- **GOVOROV, Konstantin Vadimovich**
  Moscow, 121858 (RU)
- **GOLUBEV, Anatoly Dmitrievich**
  St. Petersburg, 192242 (RU)
- **SOLOVIEV, Vladimir Alexandrovich**
  St. Petersburg, 195297 (RU)
- **KUZNETSOV, Robert Alexandrovich**
  St. Petersburg, 193230 (RU)
- **KRAUKLISH, Igor Vikentievich**
  St. Petersburg (RU)
- **PEREPECHENKO, Boris Petrovich**
  Dzerzhinsky, 140056 (RU)
- **MILITSYN, Jury Alexandrovich**
  Dzerzhinsky, 140056 (RU)
- **MILEKHIN, Jury Mikhailovich**
  Dzerzhinsky, 140056 (RU)
- **KOROBENINA, Tatyana Pavlovna**
  Moscow, 109443 (RU)
- **PAK, Zinovy Petrovich**
  Moscow, 107113 (RU)
- **SOKOLNIKOV, Alexandr Sergeevich**
  Moscow, 107082 (RU)

(74) Representative:
Duffy, Assumpta Dympna et al
F. R. Kelly & Co.,
27 Clyde Road,
Ballsbridge
Dublin 4 (IE)

(54) METHOD OF EXTINGUISHING A FIRE AND A FIRE-EXTINGUISHING SYSTEM

(57) The disclosure relates to a method of extinguishing fires, a fire-extinguishing compound and a fire-extinguishing system. The proposed method involves the preparation of a fire-extinguishing composition containing an oxidant and a fuel-binder, placing the composition in the area of the seat of the fire, initiating a sustainable fuel oxidising reaction producing combustion products in finely dispersed aerosol form, and then allowing the aerosol medium to act on the seat of the fire. According to the invention, the compositions in the aerosol products of combustion act in the immediate area of the fuel oxidation reaction to reduce the level of toxins and lower the equilibrium temperature of complete oxidation of the fuel-binder combustion products. To achieve this, a reagent is introduced into the aerosol combustion products of the composition which promotes a reduction in the equilibrium temperature of the full oxidation reaction of the fuel-binder combustion products. The reagent used consists of thermal disintegration products of a low-energy supplementary fuel. Also proposed is a compound suitable for the proposed method. The system is provided with a reactor containing means for reducing the level of toxins in the area of combustion of the composition.

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Description

Field of the Invention

[0001] The invention relates to aerosol-forming fire-extinguishing means and may be used for suppressing the seat of fire in closed and open spaces and preventing the explosion of vapors and aerosuspensions of flammable liquids, combustibles, and materials.

Prior Art

[0002] Of all fire-extinguishing methods, the use of aerosol-forming fire-extinguishing compounds is most promising. This is due to the fact that this method involves an efficient flame-suppressing mechanism where, when the dispersed phase of aerosol enters the seat of the fire, the chain reaction of active radicals (active centers) forming in the fire area is broken. In this respect, each airborne particle absorbs the energy released in a recombination reaction involving active radicals, which, combined with their precipitation on the surface of airborne particle, results in an energy "deficiency" preventing the formation of new active radicals in the fire area. As the size of airborne particles decreases, the fire-extinguishing performance of their dispersed phase improves due to an increase in the total effective surface area of airborne particles and the consequent increase in the amount of active radicals retained by this surface. The action of airborne particles on active radicals in the fire area terminates the spread of thechemical reaction, and the gaseous phase of aerosol inhibits flame by diluting it, which also results in its suppression.

[0003] An aerosol medium may be formed by igniting a pyrotechnic composition consisting of components which either form gaseous-phase combustion inhibitors, together with a dispersed medium in the combustion process, or are themselves the combustion inhibitors. The solids or condensed liquids of the dispersed phase which are released during combustion contain salts, oxides, or hydroxides of, for example, alkali or alkali-earth metals, which considerably improves the fire-extinguishing performance of the aerosol's condensation phase.

[0004] Most fire-extinguishing methods involve common operations, namely: placing the aerosol-forming composition in the area of the seat of the fire, initiating (upon the occurrence or detection of the fire's flame) a sustainable combustion of the composition, producing products in a finely dispersed aerosol form, and then allowing the aerosol medium to act on the seat of fire.

[0005] The method of extinguishing fires in bulk by using the above operations is already known (SU, a.c. No. 1741816, A62C 2/00, 1992). With this method, the composition produces toxins and high-temperature products during the process of combustion, which restricts the application of the method to extinguishing to spaces without people and makes the method unusable in the conditions of, for example mines, stores, offices, vehicle cabins, etc. wherein fire-extinguishing devices are activated when people are close to the seat of the fire. In addition, with no cooling means provided, this method requires a considerable increase in the concentration of the combustion products of the aerosol-forming composition to ensure that the fire is extinguished, which makes this method impractical for fire-extinguishing in open spaces.

[0006] The method whereby fires are extinguished by placing, in a protected space, the aerosol products forming in the combustion of the pyrotechnic composition, in which the dispersed phase contains the salts of alkali or transition-group metals, and being cooled both in and outside the fire area is already known (SU, a.c. No. 2008045, A62C 3/00, 1994). The aerosol products are cooled by introducing a coolant which, in the fire area, appears as the thermal disintegration products of the lining of the reactor containing the pyrotechnic composition. For the coolant outside the fire area, an aerial or liquid coolant is used. The presence of the salts of alkali or transition-group metals in the aerosol products of combustion improves the fire-extinguishing performance of the condensed phase of aerosol, as compared with the previous example, but the inefficient means of cooling and the resulting high temperature of the combustion of the pyrotechnic composition both prevent reducing considerably the temperature of the aerosol products arriving at the seat of the fire, thereby reducing their fire-extinguishing concentration. Furthermore, the high level of toxins in the products of the composition combustion prohibits using this method in closed spaces in the presence of people, just as in the previous example.

[0007] The above fire-extinguishing methods make use of an aerosol-forming composition containing an oxidant, fuel-binder, and additives. However, the composition's formula does provides neither for an acceptably low temperature for the aerosol medium forming in composition combustion nor a satisfactorily low level of toxins to extinguish fires in closed spaces.

[0008] Of the aerosol-forming compositions for fire-extinguishing in the required conditions, the most suitable one is that including a supplementary fuel whose thermal disintegration products absorb energy released in fuel-binder oxidation and thereby cause the composition's combustion temperature to decrease somewhat (WO 92/17244, A62D 1/00, 1992). In the process of the composition's combustion, toxins such as CO, NH_3 and HCN form due to the incomplete oxidation of the fuel, which restricts using that composition as the fire-extinguishing compound. Furthermore, the ambient air further oxidizes some of the incomplete products of oxidation, which causes the temperature of the aerosol jet acting on the seat of the fire to increase and consequently reduces the effectiveness of the flame suppression.

[0009] The previous example also provides a fire-extinguishing system which includes a reactor for the placement and combustion of the above aerosol-forming composition and its ignition. That system, however, lacks a means for lowering the level of incomplete-combustion toxic products in the reactor, and so the aerosol jet emitted from the reactor heats up in the air through further oxidization of the incomplete-combustion products. To avoid this, the system must be used in combination with means to cool the aerosol jet, supplementary units including a gaseous-type or water cooler, for example for cooling the aerosol jet, which complicates fire-fighting operations and impairs the fire-extinguishing performance of aerosol-forming composition.

Disclosure of the Invention

[0010] It is an object of the present invention to develop a group of technical solutions to ensure that fires are extinguished efficiently and environmentally safely using the aerosol medium, in both closed and open spaces.

[0011] The objective is achieved due to the fact that in the method involving the preparation of a fire-extinguishing composition containing an oxidant and fuel-binder, placement of the composition in the area of the seat of the fire, initiating a sustainable fuel-oxidizing reaction producing combustion products in finely dispersed aerosol form, and then permitting the aerosol medium to act on the seat of the fire, according to the invention, in the immediate area of the fuel oxidation reaction, the level of toxins in the aerosol products of composition combustion is reduced and, simultaneously, the equilibrium temperature for complete oxidation of the fuel-binder combustion products is lowered.

[0012] The level of toxins in the aerosol products of the combustion of the composition may be reduced by introducing a reagent which concurrently promotes a reduction in the equilibrium temperature of the full oxidation reaction of the fuel-binder combustion products.

[0013] It is appropriate to cool the aerosol products of the composition's combustion prior to their action on the seat of the fire, this being achievable outside the area of the fuel oxidation reaction.

[0014] In some actual cases, it is appropriate to feed the part of the aerosol products of composition combustion into supplementary fire-extinguishing means to force, for example, a fire-extinguishing agent in the form of a liquid, gas, or powder out of reservoirs containing such agents so that this agent is fed into the seat of fire.

For the reagent promoting a reduction in the equilibrium temperature for a full oxidation reaction of the fuel-binder combustion products, the thermal disintegration products of the low-energy supplementary fuel which is introduced to the fuel-binder at the composition preparation stage may be used. This supplementary fuel may be introduced separately, or in combination with carbolic acid derivatives, or as a mixture including polymers, resins, and elastomers, in the form of individual components and their mixtures.

[0015] It is appropriate to use, for example, 4-hydroxybenzoic acid as the carbolic-acid derivative, and low-carbon and carbon-free polynitrogen compounds or organic or inorganic azides as the low-energy supplementary fuel. The azides used are azodicarbonate, guanidine, dicyanodiamide, melon, melamine, urea, urotropin, azobisformamide, semicarbazide, dihydroglyoxime, tetrazole, ditetrazole, and their derivatives, or their salts or blends.

[0016] For the oxidant, it is appropriate to use nitrates or perchlorates of alkali metals.

[0017] The objective of the invention is achieved further by the fact that, according to the invention, the fire-extinguishing compound consisting of the oxidant, fuel-binder, and additives also includes the supplementary fuel, promoting a reduction in the equilibrium temperature for the complete oxidation of the fuel-binder combustion products, with the components being used in the following ratio, wt %:

fuel-binder	1.5 to 1.8
supplementary fuel	3.0 to 25
additives	0.5 to 10
oxidant	the remainder

[0018] Various carbolic acid derivatives, polymers, resins, elastomers, or their blends may be used for the compound fuel-binder; in this respect it is advisable to apply the carbolic acid derivative in the form of 4-hydroxybenzoic acid.

[0019] Low-carbon and carbon-free polynitrogen compounds or organic or inorganic azides such as azodicarbonate, guanidine, dicyanodiamide, melon, melamine, urea, urotropin, azobisformamide, semicarbazide, dihydroglyoxime, tetrazole, ditetrazole, and their derivatives, or their salts or blends with varying ratios may be used as the low-energy supplementary fuel for the compound.

[0020] In all cases it is appropriate to use nitrates or perchlorates of alkali metals as the oxidants in the preparation of the composition, due to their low price.

[0021] The compound may contain the following metals as additives: aluminum and magnesium, individually or their blends or alloys; in this respect, the latter may incorporate also the metals of 1^{st} and 2^{nd} groups, copper, iron, and metal hydrides. It makes sense additionally to incorporate catalytic and processing additives in the form of oxides of copper, iron, zinc, manganese or chromium in the compound.

The objective of the invention is further accomplished due to the fact that, according to the invention, the fire-extinguishing system containing a reactor for the placement in the fire-extinguishing composition containing the oxidant and the fuel-binder, the ignition that initiates the composition's combustion producing the combustion products in the form of finely dispersed aerosol acting on the seat of the fire is provided with means installed in the reactor and intended to reduce the level of toxins in the area of the composition's combustion, and this ignition is implemented so as to be in thermodynamic interaction with the seat of the fire and thereby to ignite the composition automatically in cases of ambient temperature increase caused by fire, with the possibility of implementing the above means for reducing the level of toxins in the area of the composition's combustion in the form of the reactive-type reactor component promoting a reduction in the equilibrium temperature for complete oxidation of the fuel-binder combustion products.

[0022] The fire-extinguishing system may be equipped with means for cooling the aerosol products of the composition's combustion prior to their action on the seat of fire, with the possibility of arranging these cooling means outside the area of the fuel oxidation reaction. It is also appropriate to equip the fire-extinguishing system with means for feeding a part of the aerosol products of composition combustion into the supplementary fire-extinguishing means to force, for example, a fire-extinguishing agent in the form of liquid, gas, or powder out of the reservoirs containing such agents so that this agent is fed into the seat of fire.

[0023] The low-energy supplementary fuel in the form of, for example, carbolic acid derivatives, polymers, resins, elastomers, or their blends added to the fuel-binder is suitable for the reactive-type reactor component. Of the carbolic acid derivatives, the most suitable one is 4-hydroxybenzoic acid.

[0024] The low-carbon and carbon-free polynitrogen compounds or organic or inorganic azides such as azodicarbonate, guanidine, dicyanodiamide, melon, melamine, urea, urotropin, azobisformamide, semicarbazide, dihydroglyoxime, tetrazole, ditetrazole, and their derivatives, or their salts or blends are appropriate for the low-energy supplementary fuel.

[0025] The above features relate to technical solutions composing a single group being characterized by the underlining common objective of the invention and are essential due to fact that each of these features influences the relevant technical result which, in combination with other technical solutions, ensures the accomplishment of the invention's objective.

[0026] Thus, reducing the level of toxins in the aerosol products of the composition's combustion in the immediate area of the fuel oxidation reaction ensures not only the formation of an aerosol improved toxicological properties of combustion products, but a reduction in the temperature of the aerosol jet acting on the seat of the fire as well. This is due to the fact that reducing the level of toxins in the combustion products of the aerosol-forming composition decreases the temperature to which the aerosol jet heats up after leaving the area of the fuel oxidation reaction, through further toxin oxidation in the air. By simultaneously lowering the equilibrium temperature of the full oxidation reaction of fuel-binder combustion products, the process of the flame oxidation of the aerosol-forming composition may be converted into a stage of nonflame gasification, or, at least, the dimensions of the flame area of the fuel-binder oxidation reaction may be decreased with a resulting improvement in the fire-extinguishing performance.

[0027] Used in the implementation of the method, the compound that contains a supplementary fuel which promotes a reduction in the equilibrium temperature of the full oxidation reaction of the fuel-binder combustion products, the compound components in the above-mentioned weight ratio allow a reduction in the level of toxins in the resultant aerosol by further oxidizing the incomplete-combustion products of the fuel-binder in the immediate area of the reaction, As a result, the level of toxins in the aerosol jet entering the seat of the fire is reduced, promoting a reduction in the temperature to which the jet heats up due to further oxidation of the toxins by atmospheric oxygen. Furthermore, selecting the type of supplementary fuel makes it possible to decrease considerably the lower limit of the fire-extinguishing concentration of aerosol and thereby ensure an acceptable rate of consumption for the aerosol-forming compound when extinguishing open fires.

[0028] Used as a supplementary fuel, separately or in combination with various carbolic-acid derivatives, such as 4-hydroxybenzoic acid both in its pure form and in blends with polymers, resins, and elastomers contained in the fuel-binder compound, low-energy fuel permits the intensification and control of the compound's combustion process and, as a result, an increase in the outflow of the finely dispersed portion of gas-aerosol mixture produced by combustion, which results in improved fire-extinguishing performance by the compounds and a reduced temperature for their combustion.

[0029] Using low-carbon or carbon-free polynitrogen compounds, such as dicyanodiamide, in the low-energy supplementary fuel permits the combustion process to achieve, simultaneously, improved fire-extinguishing performance, further decreases in combustion temperature, and better oxidation of combustibles, i.e., to ensure a further decrease in the toxicity of combustion products.

[0030] Used as oxidants, nitrates or perchlorates of alkali metals like potassium and sodium or their blends in compounds containing low-energy supplementary fuel in combination with carbolic-acid derivatives promote the formation of K_2O, Na_2O, KOH, NaOH, K_2CO_3, Na_2CO_3, KCl, NaCl, and similar solid particles in combustion products and further improve the fire-extinguishing performance of the aerosol component of the compound combustion products. Using such oxidants produces combustion products with a higher content of inert gases like nitrogen and carbon dioxide, which further improves the compounds and fire-extinguishing medium in their fire-extinguishing performance and toxicological properties, respectively.

[0031] When introduced to the fuel-binder, the polymers, resins, and elastomers in diverse combinations with various carbolic acids improve the cohesive bonds between the compound particles, allowing the fabrication of large-size units with a capacity up to and exceeding 100 kg. In this respect, the strength of the units is considerably improved.

[0032] Contained in the fire-extinguishing compounds, metal additives like aluminum and magnesium in the form of individual components or their mixtures or alloys - and the latter may also incorporate the metals of the 1^{st} and 2^{nd} groups, such as copper, iron, and metal hydrides - permit an increase in the flammability of compounds and a controllable rate of compound combustion.

[0033] The introduction to the compound of processing additives improves its flow properties, and the catalytic additives in the form of copper, iron, zinc, manganese, chromium oxides improve the toxicological properties of combustion products, that is, contribute to decreasing the CO, NH_3, HCN levels in these products.

[0034] The proposed fire-extinguishing system, which incorporates a reactor in which the fire-extinguishing compound and the means for reducing the level of toxins in the area of combustion of the composition are placed may treat both enclosed and open fires. Implementing the ignition so as to enable it to be in thermodynamic interaction with the seat of the fire permits self-activation of the system in fire, thereby improving its fire-extinguishing performance.

[0035] The invention will now be described with reference to the table containing the experimental investigation results for the proposed compound and the most similar prior-art compound at to their fire-extinguishing performance, combustion temperature, and the levels of toxins.

Corroboration of the Invention's Feasibility

[0036] The fire-extinguishing method is implemented as follows:

[0037] First, the aerosol-forming fire-extinguishing composition is prepared in the sequence of required operations to ensure the necessary aggregate state of the composition. Thus, to prepare the composition charge of solid-phase fuel, the powder components, including the oxidant for which nitrates or perchlorates of alkali metals are preferably used, and the fuel binder are ground and blended, then the component mixture is compacted using the so-called "blind" method to obtain a charged cartridge in the required shape. To prepare the liquid- or thickened-phase composition, the component mixture is dissolved in the liquid agent, adding thickeners, as required. The aggregate state of the composition is chosen depending on the way its being placed in the area of the seat of the fire. Thus, if being placed in a protected area beforehand, the composition may be used in any of the above-mentioned aggregate states. If placed in the seat of an incipient fire by, for example, throwing the composition towards the seat, a composition prepared in a thickened state is preferable.

[0038] Once the composition has been prepared and placed in the seat of the fire, the sustainable oxidizing reaction which produces the combustion products in aerosol form is initiated in the composition fuel. The fuel oxidizing reaction may be initiated remotely by effects occurring in the seat of fire, which is preferable for fire-extinguishing in closed spaces where the initiating function is performed by the temperature increase sensed by the fire-extinguishing device which is placed in the protected space beforehand. If thrown towards the seat of fire, the composition may be ignited at various points in the trajectory, including those within the space of fire and above it.

[0039] In the composition's combustion, its fuel-binder oxidizes, producing combustion products in aerosol form. Due to incomplete fuel oxidation, the gaseous phase of aerosol contains toxins, mainly in the form of carbon monoxide, ammonia, and cyanides, which oxidize further in air and thereby increase the temperature of the fire-extinguishing medium acting on the seat of the fire. To avoid this undesirable effect, the level of toxins in the aerosol products of the composition's combustion is reduced in the immediate area of the fuel oxidation reaction and, simultaneously, the equilibrium temperature of the full oxidation reaction of the fuel-binder combustion products is lowered. The latter operations cause the heat released in composition's combustion to decrease considerably, resulting in toxicologically improved reduced-temperature aerosol fed in the fire area.

[0040] Reducing the level of toxins in the aerosol products resulting from the composition's combustion is achievable in various ways, for example, by introducing a reagent promoting a reduction in the equilibrium temperature of the full oxidation reaction of the fuel-binder combustion products. In doing so, the level of toxic carbon-monoxide in the aerosol is reduced by terminating the fuel oxidation reaction, with the involved carbonic-core formation process leading to an acceleration in the oxidation of carbon monoxide. The level of other toxins is reduced through chemical reactions proceeding between the reagent and the other components of fire-extinguishing composition at the lowered temperature of its combustion.

[0041] For the reagent promoting a reduction in the equilibrium temperature of the full oxidation reaction of fuel-binder combustion products, the thermal disintegration products of low-energy supplementary fuel introduced in the fuel-binder at the composition preparation stage are suitable. Then the energy released in the area of fuel oxidation reaction goes into the disintegration of the low-energy supplementary fuel, resulting in a reduced temperature for the composition's combustion. Further chemical reactions between the thermal disintegration products of the low-energy supplementary fuel and the fire-extinguishing composition products lead to the formation of nontoxic products of combustion.

[0042] Low-carbon and carbon-free polynitrogen compounds, for example, dicyanodiamide, melon, melamine, urea, urotropin, are suitable as low-energy supplementary fuel. With such supplementary fuel used, introducing additionally, in the compound of above-mentioned reagent, the combustion products of carbolic acid derivatives, for example 4-hydroxybenzoic acid, as well as polymers, resins, and elastomers which may be incorporated as individual components, or their blends in the fuel-binder results in an improvement in, as compared with the most similar previous method, the fire-extinguishing process in respect of all three aspects, namely: fire-extinguishing performance, combustion temperature, and the level of toxins, as shown the table attached herein.

[0043] The aerosol entering the seat of the fire covers the fire area and comes in contact with the flame, resulting in the realization of the previously described mechanism of suppressing the physical and chemical processes of combustion.

[0044] Reducing the aerosol temperature through feeding the reagent facilitating a reduction in the equilibrium temperature of the full oxidation reaction of fuel-binder combustion products, into the area of fire-extinguishing composition combustion, permits improving further the fire-extinguishing system performance through feeding a part of the aerosol products of the composition's combustion into the supplementary fire-extinguishing means to force the fire-extinguishing agent in the form of liquid, gas, or powder out of reservoirs containing such agents so that this agent is fed into the seat of fire.

[0045] The temperature of the aerosol leaving the area where it forms is sometimes insufficiently low to permit efficient fire-extinguishing. In such cases, the aerosol products of the composition's combustion may be cooled prior to action on the seat of the fire. Cooling in such cases is preferably implemented outside the area of the fuel oxidation reaction by, for example, introducing water or brine to the aerosol.

[0046] The proposed fire-extinguishing method may be realized by using as the fire-extinguishing composition a compound consisting of the oxidant, fuel-binder, additive, and supplementary fuel, facilitating a reduction in the equilibrium temperature of the full oxidation reaction of the fuel-binder combustion products, with the above components being used in the following ratios, mass %:

fuel-binder	1.5 to 1.8
supplementary fuel	3.0 to 25
additives	0.5 to 10
oxidant	the remainder

[0047] For the supplementary fuel in the compound, the low-energy fuel may be used separately or in combination with fuel-binder components such as carbolic acid derivatives, polymers, resins, elastomers, or their mixtures, and, in cases where carbolic acid derivatives, for example, are used, 4-hydroxybenzoic acid is suitable. Low-carbon and carbon-free polynitrogen compounds or organic or inorganic azides such as azodicarbonate, guanidine, dicyanodiamide, melon, melamine, urea, urotropin, azobisformamide, semicarbazide, dihydroglyoxime, tetrazole, ditetrazole, and their derivatives, or salts are may be used as low-energy fuel for the compound.

[0048] Nitrates or perchlorates of alkali metals are used for the oxidant in the compound in all cases of its preparation.

[0049] For the additives to the compound, metals - aluminum and magnesium in the form of individual components or their blends or alloys; in this respect, the latter may additionally include the metals of the 1st and 2nd groups, such as copper, iron and metal hydrides - are used. The compound may also contain processing and catalytic additives in the form of oxide of copper, iron, zinc, manganese or chromium.

[0050] The grounds for establishing the ranges for the above component content are shown in the attached table. The first column of the table provides a list of substances used in the proposed fire-extinguishing compound and divided into the groups relating to the oxidant, fuel-binder, the supplementary fuel which promotes a reduction in the equilibrium temperature of the full oxidation reaction of the fuel-binder combustion products, processing and catalytic additives. The lower items in the column contain the following names - fire-extinguishing performance, combustion temperature, and the level of toxins - of the performance of the fire-extinguishing process under examination. The second and further columns numbered 1 to 25 provide the mass percentage values for the content of specific components used in the fire-extinguishing compound sample under testing and the values of fire-extinguishing process performance.

[0051] As evident from the table, using the fuel-binder in a mass ratio of less than 1.5 % makes the test samples actually incombustible (sample 15), while increasing the fuel-binder weight ration above 18 % impairs the fire-extinguishing performance of the compound (sample 16). Thus the proposed fuel-binders are applicable only in the ratios varying from 1.5 to 18.0 wt %.

[0052] The table data also give grounds for varying the mass content of supplementary fuel in the fire-extinguishing compound within only a limited range. Thus, with content below 3 mass % and above 25 mass %, the fire-extinguishing process performance on average does not exceed that of the most similar previous example (samples 17 and 18), while using the supplementary fuel in the fire-extinguishing compound in the ratio within the range of 3 to 25 mass % improves this performance considerably (samples 1 to 14). Note that the fire-extinguishing process performances for samples 19 to 22 where the supplementary-fuel mass content of the fire-extinguishing compound does not fall outside the permissible range are far from satisfactory. However this result cannot call into question the validity of the established range of 4 to 23 mass %, as it relates to the compounds with a fuel-binder content falling outside the above-mentioned optimized range of 1.5 to 18.0 mass %.
It is worth noting, as to the 0.5 to 10 mass % range established for the additives in the fire-extinguishing compound, that actually any point of this range corresponds to the fire-extinguishing process performances that are improved, compared with the most similar previous example (samples 2 to 5, 8, 11, 12). Below the lower limit of this range, a similar effect is accomplished for compounds with high content of low-energy supplementary fuel (samples 1, 6, 9, 10, 16), that is, within the non-optimized combination of components. Exceeding the upper limit of the established range impairs the ignition of the fire-extinguishing compound.

[0053] As for the oxidant content of the compound, it has been shown experimentally that the ratio may vary for the oxidants of nitrates or perchlorates of alkali metals. The ratio affects only the applicability of compounds. Thus, with a higher level of chlorides in the aerosol, the compound is more suitable for extinguishing class A fires and, with increased content, it may be used for extinguishing class B fires.

[0054] The analysis of table data shows that:

- the test compounds surpass the most similar previous example in fire-extinguishing performance;
- the test compounds feature a lower combustion temperature than that of the most similar prior example;
- the combustion products of test compounds have better toxicological properties (decreased content of CO, NH_3, HCN) than those of the most similar previous example);

[0055] The above results show that using the fire-extinguishing composition of said formula truly promotes a reduction in the equilibrium temperature of complete oxidation of the fuel-binder combustion products, this technical solution being accomplished by introducing to the fire-extinguishing composition a supplementary fuel with the above-described properties.

[0056] The essence of the invention, in respect of the composition, is explained with reference to the samples of its preparation.

Example 1.

[0057]

Composition, mass %	sodium nitrate	68
	4-hydroxybenzoic acid	17
	urea	15

68 g of sodium nitrate, 17 g of 4-hydroxybenzoic acid, 15 g of urea are transferred to a mixer. The blend is mixed for 1 hour. The cartridges of required shape are molded using the resultant mixture through "blind" molding under the specific pressure of 1500 kgf/cm^2.

Example 2.

[0058]

Composition, mass %	epoxy resin	5
	potassium nitrate	70
	4-hydroxybenzoic acid	10
	dicyandiamide (DCDA)	14
	industrial oil	1

[0059] 70 g of potassium nitrate, 10 g of 4-hydroxybenzoic acid, 14 g of DCDA are transferred to a mixer and the blend is mixed for 10 to 15 minutes. Then 5 g of epoxy resin and 1 g of processing additives (in this case, the industrial oil) are added. The blend is mixed for 15 to 20 minutes. The cartridges in the required shape are molded from the resultant mixture using the hydraulic press under the specific pressure of no less than 1000 kgf/cm^2 and are then cured for 24 hours at 40 to 50 °C.

Example 3.

[0060]

Composition, mass %	potassium nitrate	60
	sodium nitrate	8
	4-hydroxybenzoic acid	9
	phenol-formaldehyde resin	8
	dicyandiamide (DCDA)	12
	CuO	2
	fluoroplastic-4	1

The process of preparation is similar to that in example 1.

[0061] Fire-extinguishing performance (FEP, g/m^3), combustion temperature (Tc, °C), the levels of CO, NH_3, HCN in the combustion products were estimated based on the samples fabricated using "blind" molding.

[0062] Testing the compounds for the fire-extinguishing performance was performed using the following procedure. The weighed portion of the test compound was combusted in a closed space (0.04 m^3). After distributing the aerosol over the volume for 60 seconds, a burning sample of polymethyl methacrylate (organic glass) was introduced to the area. Upon the set of tests with various quantities (the weighed portions) of test compound, its minimum weighed portion after combustion of which the organic glass burnt in the volume for at least 1 s was determined. The minimum fire-extinguishing concentration for the test compound was determined by division of the minimum weighed portion by the volume.

[0063] The temperatures of the compound's combustion were determined using a contact thermoelectric method, with chromel-alumel thermocouples. The thermojunction diameter of the thermocouples used was 100 µm.

[0064] Analysis for toxic products - CO, NH_3, HCN - in the combustion products of compounds was performed using a chromatograph with a heat conduction detector. Chromatographic column: glass, packing type, 2.4 m in length, 2.5 m in internal diameter. Stationary phase: zeolite of 0.14 to 0.25 mm fraction. Carrier gas (helium) flow: 30 cm^3/min. Column temperature: 32 °C.

[0065] Injection volume: 1 cm^3. The chromatograms were recorded with a TLI-4601 recorder.

[0066] The following fire-extinguishing system was used for the implementation of the method invented.

[0067] The system includes a reactor for the placement of the fire-extinguishing composition which consists of the oxidant and the fuel-binder. The composition is fired by the ignition to give the combustion products a finely dispersed aerosol form. In addition to the oxidant and fuel-binder, the reactor contains the means to reduce the level of toxins forming in the area of the composition's combustion. The ignition is implemented so as to be in thermodynamic interaction with the seat of the fire and thereby to ignite automatically the composition in case of ambient temperature increase caused by fire. This thermodynamic interaction may be implemented in the form of various-design devices, for example, in the form of a temperature sensor with an actuator, including the fire-extinguishing composition ignition and provided with a disabler to disable, if required, the thermodynamic interaction and to allow remote ignition of the composition by command or manually.

[0068] The means for the reduction of the level of toxins forming in the area of the composition's combustion may be implemented in the form of the reactive-type reactor component promoting a reduction in the equilibrium temperature of the complete oxidation of the fuel-binder combustion products, and, for the reactive-type reactor component, the low-energy supplementary fuel may be used either separately or in combination with the carbolic acid derivatives, polymers, resins, and elastomers, or their mixtures. One suitable carbolic acid derivative is 4-hydroxybenzoic acid, and the low-energy supplementary fuel may involve low-carbon and carbon-free polynitrogen compounds or organic or inorganic azides such as azodicarbonate, guanidine, dicyanodiamide, melon, melamine, urea, urotropin, azobisformamide, semicarbazide, dihydroglyoxime, tetrazole, ditetrazole, and their derivatives, or their salts or blends.

[0069] The system operates in the following manner.

[0070] If intended to extinguish fires in closed spaces, the system is placed in a room beforehand and, in case of fire, activated automatically or by command from a common room-security station. The temperature increase in the protected space automatically enables the mechanism of thermodynamic interaction with the seat of the fire, initiating thereby the sustainable combustion of the composition producing combustion products in the form of a finely dispersed aerosol which enters the seat of the fire and suppresses the flame. The aerosol may be fed to the seat of the fire using various methods, for example, through aerosol outflow occurring across a part of or the entire surface of reactor, which results in the distribution of the aerosol over the entire protected space. Alternatively, the aerosol may flow out of the reactor through a pass in the form of a nozzle, resulting in a directed jet which will have an additional blowing action on the seat of fire, due to ram pressure. The last alternative allows the aerosol to be cooled in a simpler way, for example, by injecting coolant (water and other fire-extinguishing liquids) into the jet.

[0071] In process of the composition's combustion, the means provided in the reactor to reduce the level of toxins in the fire area are activated. With these means implemented in the form of a reactive-type reactor component promoting the reduction in the equilibrium temperature of the complete oxidation of the fuel-binder combustion products, the toxicologically improved and cooled aerosol, which poses no hazards to persons in the protected space, leaves the reactor and, depending on temperature requirements, may be partially fed into the supplementary fire-extinguishing means to force the fire-extinguishing agent - in the form of liquid, gas, or powder - out of reservoirs containing such agents so that this agent is fed into the seat of the fire.

[0072] Using, as the reactive-type reactor component, low-energy supplementary fuel both separately and in combination with carbolic acid derivatives, polymers, resins, and elastomers, or their blends, that is, with low-cost and available materials, provides the simplest approach to manufacture a fire-extinguishing system with the required properties, while the use of 4-hydroxybenzoic acid as the carbolic acid derivative, and low-carbon and carbon-free polynitrogen compounds or organic or inorganic azides as the low-energy supplementary fuel improves the performance of this system.

Industrial Use

[0073] The above-disclosed method, compound, and system for extinguishing fires may be successfully used to suppress flames when gaseous, liquid, and solid combustibles are ignited in stationary rooms, on railway and motor vehicles, river and sea vessels, aircraft, to prevent explosions in spaces containing methane-air mixture, for example, in mines, as well as to extinguish fires in large open areas. The method is proven on articles up to 100 kg and more in mass and on sets of systems arranged as thermodynamically linked systems or looped with electric cables.

Table

Composition (wt %) and properties	Proto-type	1	2	3	4	5	6	7	8
Oxidant: KNO_3	70	68	73	68	70	60	60	60	
$NaNO_3$						6			34
$KClO_4$							8		34
$NaClO_4$								8	
Fuel-binder									
4-hydroxybenzoic acid		17	4		10	9	12	12	
Phenol-formaldehyde resin	11			6		8	5	5	8
Epoxy resin				5	5				5
Coolant: DCDA	19		19	20	14	12			
Melem									15
Melamine								15	
Urea		15					15		
Urotropin									
GDA									
Processing additives				1	1				
Catalyst: CuO			4			3			
Fe_2O_3									4
ZnO									
$K_2Cr_2O_7$									
MnO_2									
Minimum value of fire-extinguishing concentration, FEP, g/m^3	25	14	16	20	18	20	17	18	19
Combustion temperature, Tc, °C	1000	850	920	950	860	800	870	950	960
Level of toxins, $\mu g/m^3$: CO	730	210	180	340	210	300	280	220	250
NH_3	70	42	35	54	30	44	38	35	42
HCN	12	2	3	6	4	3	6	4	3

Table (continued)

9	10	11	12	13	14	15	16	17	18	19	20	21	22
68	68	68	68	68	73.5	74	65	76	62	90	60		
												38	
													30
												30	38
17	6						9	6	9	5	17	18	9
	6	6	6	6	1.5	1	6	5					4
	6	5	5	5			5	3	3		3		5
		10		9	20	20				5	20		
			9					4	25				
							15						
	14	10		9									
15												9	
		1	1	1				2	1				
					5	5							
								3					
		2											
			2									5	
													4
16	19	18	18	17	15		26	24	24	28	24	22	24
850	800	940	960	950	970		1050	1080	980	110	1050	920	980
250	260	320	280	270	200		880	700	890	400	810	350	380
43	41	48	33	38	28		75	80	85	75	84	61	70
3	4	5	4	5	3		10	11	4	6	6	7	4

Claims

1. The method of extinguishing a fire, involving the preparation of a fire-extinguishing composition which contains an oxidant and fuel-binder, the placement of the composition in the area of the seat of the fire, the initiation of a sustainable fuel oxidizing reaction which produces combustion products in a finely dispersed aerosol form, and then allowing the aerosol medium to act on the seat of the fire, characterized in that, in the immediate area of the fuel oxidation reaction, the level of toxins in the aerosol products of the composition's combustion is reduced and, simultaneously, the equilibrium temperature for the complete oxidation of the fuel-binder combustion products is lowered.

2. The method according to claim 1, characterized by the fact that the level of toxins in the aerosol products of the composition's combustion is reduced by introducing a reagent promoting a reduction in the equilibrium temperature of the full oxidation reaction of the fuel-binder's combustion products.

3. The method according to claims 1, 2, characterized by the fact that the aerosol products of the composition's com-

bustion, prior to action on the seat of the fire, are cooled outside the area of the fuel oxidation reaction.

4. The method according to claims 1, 3, characterized by the fact that a part of the aerosol products of the composition's combustion is fed into supplementary fire-extinguishing means to force a fire-extinguishing agent in the form of liquid, gas, or powder out of reservoirs containing such agents so that this agent is fed into the seat of the fire.

5. The method according to claims 2, 4, characterized by the fact that, for the reagent promoting a reduction in the equilibrium temperature of the full oxidation reaction of the fuel-binder combustion products, the thermal disintegration products of the low-energy supplementary fuel which is introduced into the fuel-binder at the composition preparation stage are used.

6. The method according to claim 5, characterized by the fact that the combustion products of various carbolic acid derivatives, as well as their mixtures with polymers, resins, and elastomers which are introduced into the fuel-binder at the composition preparation stage in the form of individual components and their mixtures, are used additionally.

7. The method according to claim 6, characterized by the fact that 4-hydroxybenzoic acid is used as the carbolic acid derivative.

8. The method according to claims 5, 6, 7, characterized by the fact that the low-carbon and carbon-free polynitrogen compounds or organic or inorganic azides are used as the low-energy supplementary fuel.

9. The method according to claims 8, characterized by the fact that azodicarbonate, guanidine, dicyanodiamide, melon, melamine, urea, urotropin, azobisformamide, semicarbazide, dihydroglyoxime, tetrazole, ditetrazole, and their derivatives, or their salts or blends are used as the low-carbon and carbon-free polynitrogen compounds.

10. The method according to claim 8, characterized by the fact that nitrates or perchlorates of alkali metals are as the oxidant.

11. The fire-extinguishing compound consisting of the oxidant, fuel-binder, and additives, characterized by the fact that it includes the supplementary fuel promoting reduction in the equilibrium temperature of complete oxidation of the fuel-binder combustion products, the components being used in the following ratio, mass %:

fuel-binder	1.5 to 1.8
supplementary fuel	3.0 to 25
additives	0.5 to 10
oxidant	the remainder

12. The compound according to claim 11, characterized by the fact that it contains the carbolic acid derivatives, polymers, resins, and elastomers, and their blends, as the fuel-binder.

13. The compound according to claim 12, characterizing by the fact that it contains 4-hydroxybenzoic acid as the carbolic acid derivative.

14. The compound according to claims 11, 12, 13, characterized by the fact that it contains low-energy fuel as a supplementary fuel.

15. The compound according to claim 14, characterized by the fact that it contains the low-carbon or carbon-free polynitrogen compounds or organic or inorganic azides as the low-energy fuel.

16. The compound according to claim 15, characterized by the fact that it contains azodicarbonate, guanidine, dicyanodiamide, melon, melamine, urea, urotropin, azobisformamide, semicarbazide, dihydroglyoxime, tetrazole, ditetrazole, and their derivatives, or their salts as the low-carbon and carbon-free polynitrogen compounds.

17. The compound according to claim 16, characterized by the fact that it contains nitrates or perchlorates of alkali metals as the oxidant.

18. The compound according to claims 11, 17, characterized by the fact that it contains metals such as aluminum and magnesium in the form of individual components, or their blends or alloys, as the additives.

19. The compound according to claim 18, characterized by the fact that the alloys of aluminum and magnesium include additionally the metals of 1st and 2nd groups, copper, iron, and metal hydrides.

20. The compound according to claim 19, characterizing in that it contains additionally the catalytic and processing additives.

21. The compound according to claim 20, characterizing in that the catalytic additives include oxides of copper, iron, zinc, manganese, chromium.

22. A fire-extinguishing system including a reactor for placing the fire-extinguishing composition consisting of the oxidant and the fuel-binder, the ignition-initiating composition, producing combustion products in the form of a finely dispersed aerosol acting on the seat of the fire, characterized by the fact that it is provided using means installed in the reactor and intended to reduce the level of toxins in the area of the composition's combustion, and said ignition is implemented so as to be in thermodynamic interaction with the seat of fire and thereby to ignite the composition automatically in cases of ambient temperature increases caused by fire

23. The system according to claim 22, characterized by the fact that said means for reducing the level of toxins in the area of the composition's combustion are implemented in the form of a reactive-type reactor component which promotes a reduction in the equilibrium temperature for the complete oxidation of the fuel-binder combustion products.

24. The system according to claims 23, 24, characterized by the fact that it is equipped with the means for cooling the aerosol products of the composition's combustion prior to their action on the seat of fire, with arranging these cooling means outside the area of the fuel oxidation reaction.

25. The system according to claims 22, 24, characterized by the fact that it is equipped with the means for feeding a part of the aerosol products of the composition's combustion into the supplementary fire-extinguishing means to force a fire-extinguishing agent in the form of liquid, gas, or powder out of the reservoirs containing such agents so that this agent is fed into the seat of the fire.

26. The system according to claims 23, 24, 25, characterized by the fact that it includes low-energy supplementary fuel as its reactive-type reactor component.

27. The system according to claim 26, characterized by the fact that it includes additionally the carbolic acid derivatives, polymers, resins, elastomers, or their blends.

28. The system according to claim 27, characterized by the fact that it includes 4-hydroxybenzoic acid as the carbolic acid derivatives.

29. The system according to claims 26, 27, 28 characterized by the fact that it includes low-carbon and carbon-free polynitrogen compounds or organic or inorganic azides as the low-energy supplementary fuel.

30. The system according to claim 29, characterized by the fact that it includes azodicarbonate, guanidine, dicyanodiamide, melon, melamine, urea, urotropin, azobisformamide, semicarbazide, dihydroglyoxime, tetrazole, ditetrazole, and their derivatives, or their salts, as the low-carbon and carbon-free polynitrogen compounds.