

Investigation of the effect of container heat-shielding layers to fire-and-explosion hazard of gaseous medium. Development of methods of explosion-and-fire hazard reduction

Project goal: Acquisition of data on fire-and-explosion hazard of gaseous media formed at thermal decomposition of organic materials used for heat-shielding layers of containers and development of methods aimed at reduction of fire-and-explosion hazard through absorbers application.

Today there finds wide application the use - in storage and transportation of radioactive, chemically toxic and highly explosive materials - of containers having as structure compounds internal heat-shielding layers of organic materials. In the course of their running the occurrence of abnormal situations, namely fires of various intensity is possible. As a result of thermal effect there will be formed inside the container a gaseous medium consisting of products of thermal heat-shielding materials decomposition. As the products of decomposition contain combustible components, then, at accumulation of a sufficient amount of combustible materials, availability of the required amount of oxygen and achievement of spontaneous combustion there will take place gaseous medium inflammation. This may lead to different undesirable consequences. It should be mentioned that such consequences are possible at opening a container that was subject to thermal effect of fire in case of ignition source occurrence with the energy sufficient for gaseous medium inflammation in its volume. Thus, the containers with thermal shielding of organic materials represent additional danger under fire conditions. Here there arises a problem of developing the methods of safety increase and risk reduction at treating such containers that found themselves under the conditions of fire effect. At developing these methods there are required the data on the spectrum of gaseous chemical components from thermal decomposition of heat-shielding materials characterizing fire-and-explosion hazard of the gaseous medium formed. There are also needed the data on the values of spontaneous combustion temperatures and concentration limits of flame distribution for gaseous media formed under thermal decomposition of heat-shielding materials and their combinations, the data on kinetics of oxygen content change in a closed volume at heat-shielding materials decomposition in air medium. In connection with difficulties of theoretical estimation the peculiarity of getting the above-specified indexes consists in the experimental character of the corresponding researches.

Today the data on the fire and explosion hazard indexes are available chiefly as applied to individual combustible materials or mixtures with a limited number of components and, as a rule, are not related to thermal decomposition of specific organic materials. The applied methods of design estimate do not account in full measure the possibility of chemical interaction of gaseous medium components that may lead to the change of gaseous medium composition, acceleration or moderation of the process of combustion progress through the formation of catalysts or inhibitors. At the same time the application of such techniques makes it possible to substantially schedule the experimental works.

As preventive measures for reduction of fire-and-explosion hazard of gaseous media there is applied their phlegmatization through container filling with chemically inert gases – carbon dioxide, inert gases. However, the application of this method requires keeping the structure tightness and continuous control. Under fire environment this condition can hardly be observed because of thermal effect to the container structure components and pressure increase in its volume.

The advanced Project is aimed at development of technological solution not related to complication of the container design. Its main goal is to reduce fire-and-explosion hazard of gaseous media formed inside containers at thermal decomposition of the applied organic heat-shielding materials under fire conditions through binding released combustible components and air oxygen at temperature increase.

The Project realization will make it possible to substantially make a choice of materials for the container heat-shielding layers taking into account the fact of the possibility of abnormal situation occurrence dealing with the thermal effect of fire and reduce the risk at treating the containers subjected to such effect. This is acute today as the containers with heat shielding of organic materials have found wide application as to deliveries and storage.

Highly-qualified specialists in the field of physical and analytical chemistry, thermal analysis (experimental research of mass decrease kinetics and behavior of organic materials and their combinations at heating), thermal physics, design and computer simulation have united to work on the Project.

The expected results of the Project realization consist in getting the following data:

- Kinetics of mass variation and chemical composition of gaseous medium formed as a result of thermal decomposition of organic materials representing heat shielding of containers in a closed volume in air atmosphere as applied to conditions of different intensity fires.

- The values of distribution limits of flame and spontaneous combustion temperature for gaseous media formed at thermal decomposition of materials under study as applied to heating conditions inside the container.

- The values of time-temperature intervals of forming inside container the volumes of fire-and-explosion gaseous media depending on fire intensity and free container volume.

- The technique of calculating thermal modes and evaluating safety inside containers during fire taking into account formation of fire-and-explosion hazard gaseous mixtures.

- The data on the properties whose application contributes to reduction of fire-and-explosion hazard of gaseous media in containers through binding components characterizing combustibility and air oxygen.

The above-listed results of the Project realization can be used:

- for analysis of safety of existing containers having as structure components the heat-shielding layers of materials investigated at the given Project fulfillment;
- at designing containers with heat-shielding of organic materials as applied to fire conditions and for the purpose of increasing safety.

The work is of applied character. The scientific value of results consists in getting information on behavior peculiarities of gaseous medium formed inside the containers at thermal decomposition of organic heat-shielding materials related to spontaneous combustion.

The presented Project contributes to realization of the following ISTC goals and tasks:

- scientists and specialists involved in weapon activities are given the possibility to re-direct their activities to peaceful purposes;
- applied researches and development of technologies for peaceful purposes are supported;
- solution of national and international technological problems is assisted;
- transition to market economy meeting civil needs is supported.

To fulfill the Project one should necessarily solve the following problems:

- to get experimental data on chemical composition of gaseous medium formed at heating polymer heat-shielding materials in air atmosphere under the conditions of closed volumes, different intensity of heating, including the availability of materials binding basic components of gaseous medium.
- to determine indexes of fire-and-explosion hazard in gas media formed in the course of heating at the availability of absorbing materials and without them.

To get characteristics of polymers thermal decomposition and gaseous medium formation there will be used experimental methods of thermal analysis: differential-thermal and thermogravimetric, gas-chromatographic analyses, installations for determination temperature of spontaneous combustion and concentration limits of flame distribution. It is assumed that the following conditions for the experiments realization should be observed:

- heat-shielding materials: polyethylene, polystyrene, foamed polyurethane, wood saturated with fire [flame] retardant;
- intensity of heating: up to the temperatures from 400 to 800°C achieved on the heated (external) surface of the experimental model according to non-linear law with different rate.

We welcome the participation of foreign collaborators in the given Project what would be particularly useful as to

- discussion and refinement of the Project tasks;
- discussion of the obtained results and testing of the created models and programs.