Fire retardant device for pipeline and cable duct

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Abstract. The present article reviews different patented devices of heat-fire protection system of pipeline and cable duct of bulkhead having used fibrous and retardant intumescent materials. Their structures and fillers are considered, benefits and drawbacks are defined. The improved design for duct of bulkhead is offered. It is characterized by advanced equipment reliability, technological and fire retardance effectiveness. It is specially noted that breakthrough fire-fighting technology is introduced in the new device. It implies the usage of fire retardant material, providing with thixotropic properties or high viscosity. In proof of the device efficiency the article reviews the experiment conducted on the model of a fire-retardant device.

1 Introduction

Fire is one of the most uncontrollable and dangerous power. Being highly significant for human's life, on the one hand, it tightly bounds to life threatening, on the other hand. Every year hundreds of people die in a flame. Accidents take place because of different reasons. They can be child's games with matches, lack of care while welding or working with gas cylinders, safety violation, equipment failure, negligence, natural disasters and others. Fire doesn't have mercy on anybody. Modern science pays great attention to the safety of human life [1,2]. Nowadays, there are a lot of devices that help to reduce the risk of deaths in the event of a fire [3,4]. These devices proved to be effective [5] in most cases but some buildings require more effective protection. For instance, higher requirements are imposed to fire-retardant facilities in buildings and structures (fire walls, dividing walls), in industrial facilities with increased fire risk, in strong ship bulkheads [6], etc. Under the circumstances it is crucial to ensure the duration of fire protection of pipeline and cable duct of bulkhead, in other words the time required to take measures to resist the spread of fire and put it out. Moreover, isolation of fire and live parts is vital not only in industrial area but at civil as well. A human being cannot quickly notice a fire if he is asleep. While the delay of fire spreading of the flame can save a person's life. So, solving the problem of localization and shutting down the fire both in industrial and civil buildings and structures are highly significant for the mankind.

Authors from all over the world have been dealing with these problems. One of the foreign scientists' (US Grant 6105334) fire retardant devices is a heat-resistant box designed

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to protect lighting devices. Exterior surfaces are made with metal, materials for interior ones are selected from range of cementitious and intumescent materials. The lighting enclosure can be employ both in residential and in commercial buildings with applicable codes in the field of firestop systems for ceiling or floor penetrations. Other authors (US Grant 3913290) developed a mechanism for wrapping the load-bearing I-shaped elements to increase their fire resistance. In this case, the butt ends of the shelves appeared to be the most protected. They are strengthened by additional protective bands of a wide section complementary to homogeneous covering. Other authors (US Grant 5103609) suggested an easy-to-install protective ring with the liner made of material which expands quickly and uniformly in case of fire, tightly covering all the holes that are located nearby. The liner is represented moldable putty which consists of heat absorbing and intumescent materials. This appliance includes a collar that effectively transport the heat to inner areas where fire-resistant putty takes place. The attention should also be drawn to the device from american patent number 4276332 which completely insulates the cables.

In this particular case the space between the metal box and the cables is filled with foaming material. Units of the box are made prefabricated and assemblable. Each unit has joining sides which offset from each other and provide rigidity to the continuous system. A protective block for electrical cables laid in close proximity to walls is also proposed by other authors (US Application 20110042121). This invention has not only interior and exterior surfaces of the coating but also special connection structure which secure one cable protection block to another. Another continuous protective invention (US Grant 4942903) may include a protective hose consisting of a combination of foaming and non-foaming fire-retardant materials. This device is preferably used for carrying fuel.

There are various national heat-fire protection devices made of fibrous materials, foamed materials and intumescent materials. The authors of the patents proposed the following: a two-layer fire and heat-shielding material consisting of a layer of metal foil and a layer of mineral or ceramic fibers, composite fire retardant of optimal thickness, a fireproof shield case containing flexible outer (fireproof) and intermediate (heat-resistant) layers of fibrous materials, heat-resistant (up to 750°C) non-flammable thermal protective coating with increased adhesion to metallic, concrete plastered, brick surfaces. Some studies are devoted to the development of heat-fire protection devices for the drives of the shut-off and regulating valves of pipelines. Russian patent number 2519984 describe rigid box which is made as an opened volume. Inner surfaces of the volume are laid with fire-protective covering. Frame of the box has walls that are made of composite panels. Bottom of the box is made of magnesite panel. This invention can be used for fire safety in conduits, reservoirs and other equipment of industry and gas-collecting stations, gas processing plants, underground storage facilities, line sections of main line pipeways and not only.

One more fire retardant device of current conductors should be mentioned. The authors proposed the creation of a composite coating, which includes an epoxy resin with a hardener as a binder, and intumescent graphite as a filler.

A bulk sealing device (Fig. 1) of increased reliability is also known; it provides the highest degree of resistance to fires and explosions, accepted by the authors as the prototype. On each side of the bulkhead the device is structurally made in the form of two hemisphere-shaped bodies: external and internal. The space between them is filled with the fire extinguishing powder "Volgarit-ABC" or the compound "Splotera EP-120". They extinguish the fire and prevent its spreading as a consequence. The efficiency of such a technical solution is reduced due to the possibility of penetration of fire through the bulkhead; it appears as far as the insulation of the cable or pipeline sealant is burned out.

Fig. 1. Device for group passage of cables through a bulkhead. RU Grant 55217

According to the prototype the device comprises a rigid box made in the form of an open container, the internal volume of which is filled with a special high-viscosity material; when exposed to a temperature above 150°C, it begins to turn into a foam-silicate mass having a low conductivity. In this case, the object to be protected can be made in the form of a shut-off valve; its case and a main shaft are connected to the plug.

The bottom of the box is made of a rigid magnesite panel, the walls of the frame are made of multilayer panels. Under the bottom of the device a bearing centre is placed; it includes a mounting pad with a shaft connected to the main shaft of the plug. Between the bottom and the panels of the box there are gaskets of soft fire-resistant material fixed to the multilayered panels of the box with heat-resistant glue; for its mechanical strength the box is reinforced with a steel hard bar, for having an opportunity to remove it, the box is also equipped with the handles. All these features provide increasing of its operational capabilities and faultless performance.

General drawbacks of the analogs and the prototype are the absence of elements preventing the depressurization of the route as it passes through a strong and hermetically sealed bulkhead due to the burnout of the gaskets or cable sheath, as well as the low effectiveness of fire protection with the use of fibrous materials.

Despite the fact that the description of the device proposed by the authors will be carried out from the point of view of its use in ship bulkheads, this invention can undoubtedly be applicable in the construction of industrial buildings and power structures.

Fire-hazardous industrial shops of an industrial enterprise often directly border the administrative zone. In this case, the building is subject to increased requirements for the degree of fire resistance. Under the circumstances, the wall separating two zones should provide long-term protection [7] of the administrative zone in the event of a fire in the workplace. In addition, cables can be laid in the wall for which the problem of burn-out of insulation and the formation of space for the transfer of fire is also relevant, as for ships.

2 Methods

An experiment has been conducted to test the device described in the article. The prototype model of the fire retardant device consisted of a steel thin-walled glass with a diameter of 37 mm (Fig. 2) and a length of 60 mm (Fig. 3) with a wall thickness of 0.5 mm. In this case, the inner walls of the glass were laid with 1 mm thick asbestos cardboard. Inside the glass, a flame retardant composition consisting of 84.8% of the glycerol-hardening mass obtained from glycerin and tetroethoxysilane was pressed in a molar ratio of glycerol /

tetroethoxysilane 3/1, potassium carbonate 8.0% mass and aerosil A-175 7.2% mass. In the center of the glass with a flame retardant composition, a steel tube was inserted, which was dampened from one side by an outer diameter of 6 mm with a wall thickness of 1.5 mm and a length of 100 mm to a depth of 45 mm. The end of the glass was wrapped with foil and a thermocouple was put in a pocket (6 mm diameter tube). The test sample was placed in a muffle furnace preheated to 1000°C and then temperature and time readings were recorded: 100°C – 6 minutes; 200°C – 15 minutes; 300°C – 20 minutes.

Fig. 2. Cut of the test sample

Fig. 3. Side-view of the test sample

3 Results and Discussion

As it was noted above, the main objective of the device presented in the article is to provide hermetic state and working capacity of pipeline and cable duct of strong bulkhead in the event of extreme temperatures and effect of fire within a standard time. The usage of protecting cover was offered to solve this issue.

The use of a detachable protecting cover is suggested to solve this task. A liner of a solid material is provided between the cover and the cable or pipeline connection. In addition, a composition with thixotropic properties and high viscosity is used. At high temperature, this composition is converted to foamed silicates with low conductivity and low mechanical strength so that it can be easily removed after heat exposure. In substitution virgin material can be pressed into the disassemblable cover without any difficulties. The parting planes of the connectors in the casing are mutually perpendicular and parallel to the cable piping connection.

The general scheme of thermic protector for the cable and pipeline duct of a solid bulkhead is shown in Figure 4. Figure 5 displays an enlarged cut of the device in section A-A of Figure 4.

The thermic protector comprises a glass 2 which is fixed and hermetically sealed on the bulkhead 1 with hermetically sealed electrical conductors to which plug connectors 3 with a tightly connected cable 4 are connected on both sides of the bulkhead 1.

Each plug connector 3 is enclosed in a protecting cover 5, the inner surface of the last is lined with a multi-layer fire-resistant coating 6 with the inclusion of asbestos fabric. The cover 5 consists of two joining half-cases 7 and 8 (Fig. 5), connected by means of a locking device 9. The half-cases 7 and 8 are fixed in a closed state by a sleeve 10 with an annular rib 11, which is fitted into the corresponding annular groove of the protecting cover 5.

A liner 12 made of two half-liners is installed in the space between the plug-in connector 3 and the protective cover 5. In this case, the planes of the connector of the protecting cover 5 and the liner 12 are made parallel to the cable crossing axis 13 and mutually perpendicular.

Semi-liners are made of a consistent material with increased energy consumption during thermal destruction coming with appearing of foam glass, which has a low conductivity. The

efficiency of foam glass as a flame retardant is confirmed by the research of Russian and foreign authors [8 - 12].

Fig. 4. General scheme of thermic

Fig 5. Enlarged cut of section A-A

The device functions as follows.

When the plug 3 is connected to the cable 4, an annular sleeve 10 is preliminarily installed on the cable 4. After the installation of the plug-in connector 3 is completed, the half-liners are laid on it from both sides to form a single liner 12. Then, two half-cases 7 and 8 are installed on top of it under observance of perpendicularity of the liner connectors 12 and the protecting cover 5. The projecting connector of one of the half-cases (the ribbon ledge) should be located in the corresponding groove of the second half-case, ensuring the creation of the integrity of the protective cover 5 after installation, for example on the sleeve 10, whereupon the cover 5 finally places on the bulkhead 1.

During the heat or fire impact on the cover 5, the liner 12 becomes a foam glass, preventing the plug connector 3 from breaking down during the specified time.

It is also possible to restore the fire-retardant device, since during the repair period the foam glass easily falls to pieces on exertion.

The use of a fire retardant device in conjunction with the proposed fire retardant composition results in a significant increase in the fire-retardant properties of the protected objects. It demonstrates the achievements of the stated fire protection objectives and the working capacity of the described device.

4 Conclusions

Thus, the fire retardant device for pipeline and cable duct of strong bulkhead proposed by the authors is characterized by a simpler design and higher indicators of reliability, manufacturability and efficiency through the use of a new technology to counter fire. This technology is based on the use of a fire retardant material with thixotropic properties and high viscosity, which at high temperatures becomes a foam-silicate with low conductivity and low mechanical strength. The protecting cover is made disassembled, and the composition filling the space between the cover and the pipeline or cable connection is easily removable. So, it is possible to dismount foam-silicate, which was produced in the event of a fire and press virgin material into the disassemblable cover.

The efficiency of using the proposed device is confirmed by the experiment, where steel thin-walled glass with asbestos cardboard and flame retardant composition in it was placed in a muffle furnace preheated to 1000°C. Results was recorded by the agency of thermocouple which was put in a pocket in centrum of the prototype model. Areas of device usage can be extended. The benefits of this invention are obvious for the construction industry, but the specificity of its use in buildings and facilities needs further study.

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