

AN APPLICATION OF GAS-AEROSOL TOOLS FOR FIRE PROTECTION OF SEA OIL-PRODUCING PLATFORMS

Sergey N. Kopylov, Sergey A. Koltsov, Elena V. Nikonova, Vassily A. Uglov
All-Russian Scientific Research Institute for Fire Protection
VNIPO 12, Balashikha District, Moscow Region, 143903 Russia

ABSTRACT

Investigations of possibility of application of gas-aerosol fire suppression system for fire protection of sea oil-producing platforms were carried out. Technical characteristics of the sea platform (project 4133, Kravtsovskoe oilfields, Baltic sea, Russia) are described. The following scenarios of fire are possible in the enclosures of the platform: 1 – a fire caused by combustion of gasoline and/or oil; 2 – an explosion of combustible mixture of gasoline and/or oil vapours with air followed by destruction of technological equipment and development of fire according to scenario 1. Several types of the generators were tested as potential source of ignition for combustible gas (or combustible vapour) – air mixture. It was obtained that the generators SOT-2M-KV (manufacturer: Kaskad JSC SPA) and AGS-8 (manufacturer: Granit-Salamandra Company) are not able to ignite stoichiometric propane – air and gasoline – air mixtures. It is necessary to mention that the ignition of stoichiometric propane – air mixture was observed for some types of generators. It was showed by the experiments that possibility of destruction of the generator and temperature of the aerosol are critical parameters which should be taken into account when the generator is tested as potential ignition source.

INTRODUCTION

The main purpose of the presented paper is an estimation of possibility of application of gas-aerosol fire suppression systems for fire protection of sea oil-producing platforms. Gas-aerosol tools of fire suppression are widely used now as an alternative for brominated substances in total flooding applications. Fire extinguishing agent (a mixture of fine dispersed aerosol and inert gases) produces by combustion of some solid fuels in special generator. Despite of differences in these fuels they contain as a rule inorganic oxidisers and salts (KNO_3 , KClO_4 , KCl) and organic or inorganic combustibles (Mg, epoxycombinations) [1]. As a result of combustion of such complex fuel a gas-aerosol composition is generated. A gaseous phase of this composition consists mainly from N_2 and CO_2 , and a solid phase contains K_2CO_3 , KHCO_3 , KCl [2]. The solid phase acts on a flame similarly to fire extinguishing powders, but it has sufficiently high efficiency due to a high dispersibility of particles (mean diameter of particles less than $5 \mu\text{m}$ [3]). Such fine particles hardly can be generated by mechanical dispergation.

But if the generators are used in potentially explosive atmospheres (for example, at oil-producing platforms) it is necessary to have in mind, that the fuel burns in the generator at a temperature $1500\text{-}2000^\circ\text{C}$. This circumstance causes the necessity of cooling of producing aerosol in the generator. Besides that, the generator of fire extinguishing aerosol (GEA) remains a potential ignition source for combustible gaseous mixtures due to the following reasons: temperature of fire extinguishing aerosol at nozzles of the generator can be more than 500°C ; temperature of external surface of the generator can be more than 100°C ; liquefied products of chemical reaction with the temperature more than 500°C can flow out from the nozzles of GEA; the penetrating of combustible gases and/or vapours into the GEA

can cause their ignition when the generator is being put into operation [4,5]. Accordingly, the method of estimation of igniting ability of the GEA for atmospheres containing combustible gases and/or vapours should be developed.

CHARACTERISTICS OF THE SEA PLATFORM

According to [6], sea oil-producing platform (project 4133, Kravtsovskoe oilfields, Baltic sea, Russia) consists of two constructions: VS1 – module for the staff, VS2 – energetic module and technological module, which are connected by covered bridge with a length 70 meter. In conjunction with Russian normative documents, the fire suppression system should be designed for the following enclosures of the platform:

VS1:

Diesel generator room (volume 134.3 m³, combustible: diesel fuel, oil);
Battery room (volume 21.1 m³, potentially explosive atmosphere (hydrogen));
Power control room (volume V=23.3 m³);
Room with auxillary equipment (volume 25.24 m³).

VS2 (energetic module):

Boiler room (volume 645.0 m³, potentially explosive atmosphere (diesel fuel vapours));
Fuel tanks enclosure (volume 71.0 m³, combustible: diesel fuel);
Electrotechnical enclosure 1, volume 416.0 m³;
Electrotechnical enclosure 2, volume 533.0 m³;
Machinery room, volume 1040.0 m³, combustible: diesel fuel);
Ventilation channel of machinery room, volume 804.0 m³.

VS2 (technological module):

Enclosure for the main circulation system, volume 1062.0 m³, potentially explosive atmosphere (oil vapours));
Enclosure for cementing complex, volume 526.0 m³;
Transformator room, volume 178.5 m³;
Pump control station, volume 460.5 m³;
Drillhole equipment control station, volume 282.0 m³;
Power control room 1 (volume V=47.0 m³);
Power control room 2 (volume V=144.0 m³);
Pumping system room (volume 504.0 m³, potentially explosive atmosphere (oil vapours)).

It is easy to see from the presented description that the platform has enclosures with technological equipment containing oil and diesel fuel; some of these enclosures have potentially explosive atmospheres, containing oil or diesel fuel vapours. The following scenarios of fire are possible in the enclosures of the platform: 1 – pool fire caused by combustion of gasoline and/or oil; 2 – an explosion of combustible mixture of gasoline and/or oil vapours with air followed by destruction of technological equipment and development of fire according to scenario 1. Besides that, formation of combustible hydrogen-air mixtures are possible in the battery room (VS1).

According to presented scenarios of fire, the modern generators of fire extinguishing aerosol can be effectively used for fire suppression at the platform, because they are most efficient for the fires caused by combustion of inflammable and deflagrable liquids and electrical insulation.

GENERATORS

But it is necessary to have in mind that all types of the generators, which can be used as a part of fire suppression system of the platform, should satisfy specific demands attributed to marine objects. In particular, the GEA should be able to withstand to strikes with acceleration 5g and frequency (40...80) strikes per a minute, and also to vibration with a range of frequencies from 2 to 100 Hz; the generator should be designed for application at humidity 98 %. Table 1 represents the types of GEA, which satisfy to these demands.

Table 1. Technical characteristics of generators of fire extinguishing aerosol

Generator	Mass of fuel, kg	Operation time, sec	Temperature of gas-aerosol composition, °C	Diameter x length, mm	Protected volume, m ³	Mass of generator, kg	Manufacturer
SOT-2M-KV	1,6	40	120	167x179	21	5,3	Kaskad JSC SPA
AGS-7/1	3,25	80	270	172x360	65	5,8	Granit-Salamandra Company
AGS-7/2	6,7	160	270	172x500	134	10,5	Granit-Salamandra Company
AGS-8/1	3,25	80	120	220x220	65	10	Granit-Salamandra Company
AGS-8/2	6,7	160	120	220x350	134	19	Granit-Salamandra Company

But it was also showed above, that for application at the sea oil-producing platform the GEA should be tested as ignition source for potentially explosive atmospheres, containing vapours of oil or diesel fuel. The investigation has been carried out in the presented work.

EXPERIMENTAL

The experiments were in the sealed enclosure with a volume 25 m³. The enclosure was organized as a metal framework covered by polyethylene film. The generators SOT-2M-KV, AGS-7/1, AGS-8/1 were tested. The following experimental procedure was used: the generator was arranged with the nozzles downward at height 1 m from the level of the floor in the centre of the enclosure. After that the enclosure was filled by combustible gas through a tube with an outlet at the level of ceiling in the central part of the enclosure. For the enclosure to be filled by vapours of deflagrable liquid two open vessels with appropriate combustible liquid were arranged in the enclosure. The experiments were conducted with model combustible mixture 4 % vol. propane – (1.3-1.7) % vol. diesel fuel vapours – air. Three measurements of combustible gas (and combustible vapour) concentration were made at various points of the enclosure to control the homogeneity of atmosphere in the enclosure. After that the generator was put into operation. The procedure was repeated 10 times for each

type of the generator. It was recognized that the generator was not able to ignite tested combustible atmosphere if ignition did not occur in all tests.

RESULTS AND DISCUSSION

The following results were obtained. When the generator AGS-7/1 was put into operation the ignition of combustible mixture by fire extinguishing aerosol has been occurred. It is necessary to note that mean temperature of the aerosol for this type of the generator doesn't exceed 270 °C (see Table 1). Temperature of self-ignition for propane in air is equal to 470 °C; temperature of self-ignition for vapours of diesel fuel in air is equal to 330 °C [7]. Probably the effect of ignition of combustible mixture by aerosol can be explained by presence of "hot particles" in the gas-aerosol flow which have the temperature substantially higher than the temperature of self-ignition of the combustibles. It is possible also that the ignition occurred due to action of liquefied products of chemical reaction in the generator, which flew through nozzles of the GEA during its operation. Some additional experiments will be organized in the nearest future to clarify the factor responsible for ignition in described case.

As to the GEA SOT-2M-KV and AGS-8/1, the ignition of combustible mixture didn't occurred in all the experiments. It is interesting to mention that liquefied products flew through nozzles of the generator during its operation.

To investigate the consequences of destruction of the GEA in combustible gaseous atmosphere special experiment was organized. The generator AGS-8/1 was modified: conjunction between a body of the GEA and sealing with nozzles was weakened; as a result, a destruction of the generator occurred when it was put into operation; direct contact of combustible mixture with reacting fuel in destructed generator caused the ignition of the mixture.

Thus, it was shown that the GEA can be the ignition source and cause a fire at the object with presence of combustible gaseous atmospheres; the possibility of destruction of the generator, liquefied products of chemical reaction in the GEA and the temperature of the aerosol are the critical parameters. Accordingly, the method of estimation of igniting ability of the GEA for atmospheres containing combustible gases and/or vapours should be developed. Authors suppose that it would be quite desirable to introduce this method to the Standards for condensed aerosol fire suppression system (in particular, to ISO Standard which is created by working group of SC8 TC21 ISO). The test method proposed in the presented paper can be used as a prototype.

According to the obtained results, the generators SOT-2M-KV and AGS-8/1 were recommended for the using as a part of fire suppression system for sea oil-producing platform. The following main recommendations should be realized:

1. Vapours of gasoline, diesel fuel and oil should not penetrate to the GEA;
2. Due to high penetrating ability and low temperature of self-ignition of hydrogen it is not recommended to use the generators SOT-2M-KV and AGS-8/1 in the battery room (VS1);
3. Construction of the generator should prevent its destruction;

4. It is necessary to avoid direct contact of liquefied products of chemical reaction in the GEA with surface of pools of diesel fuel, gasoline and oil. The using of additional vessels is recommended to collect these products;
5. The generators SOT-2M-KV and AGS-8/1 should be able to withstand to mechanical influence (strikes, vibration) caused by operation of the equipment of the platform;
6. It is desirable to avoid direct contact of the aerosol flow during the operation of the GEA with obstacles in protected enclosure.

CONCLUSIONS

1. Investigations of possibility of application of gas-aerosol fire suppression system for fire protection of sea oil-producing platforms were carried out. The following scenarios of fire are possible in the enclosures of the platform: 1 – a fire caused by combustion of gasoline and/or oil; 2 – an explosion of combustible mixture of gasoline and/or oil vapours with air followed by destruction of technological equipment and development of fire according to scenario 1.
2. The test method for estimation of igniting ability of the GEA for atmospheres containing combustible gases and/or vapours was proposed.
3. Several types of the generators were tested as potential source of ignition for combustible gas (or combustible vapour) – air mixture. It was obtained that the generators SOT-2M-KV (manufacturer: Kaskad JSC SPA) and AGS-8 (manufacturer: Granit-Salamandra Company) are not able to ignite stoichiometric propane – air and gasoline – air mixtures.
4. The ignition of combustible gaseous mixture was observed for some types of generators. It was showed by the experiments that possibility of destruction of the generator, liquefied products of chemical reaction in the GEA and temperature of the aerosol are critical parameters which should be taken into account when the generator is tested as potential ignition source.

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