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Simulation test research on incendive ESD in tanker cargo

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Abstract

This paper, considering an explosive accident of a tanker last year in China, analyzes and evaluates the safety property of electrostatics on tanker cargo during the drainage of ballast water. Based on the simulation test investigation and theoretical analysis about this accident, the current paper indicates that the tanker exploded probably because the steam pipe fixed in the cargo leaked. A lot of steam sprayed and a very high static field was formed in the cargo. An insulated conductor (a copper rod or flashlight) happened to fall into the tank. Some ESD spark caused the explosion. This paper proposes some suggestions to avoid such an accident.

Keywords: Tanker statics; Incendive ESD; Tanker explosion-proof; Safety evaluation

1. Introduction

Explosion accidents on tankers or OBO ships caused by ballast water take place from time to time around the world [1,2]. An empty tanker with a loading capacity of 32 000 tons exploded last year in China. The tanker was berthed at a wharf with the ballast water being discharged through pump pipes. When the drainage of the ballast water in No.2 center cargo was almost complete, an explosion took place. The whole ship slanted to the left and then sank into the bottom of the sea. There was some

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ballast water in No.2 center cargo (about 50 tons), in No.5 center cargo (about 1000 tons), in No.2 left cargo (about 100 tons) and in No.3 right cargo (about 100 tons).

The steam through a row of pipes was used to heat the remaining crude oil, some of which was on the wall of the cargo and on the surface of the water. The saturated steam pressure was 5 kg/cm^2. It had been heated for 2 h before the explosion.

At the time the explosion took place, drainage work was in operation with the porthole opened. Two sailors on duty were working on the deck (they both died in the accident). Eight persons were killed in this accident.

It was a fine day. The wind of Beaufort force 5 blew from the stern to the stem with a wind speed of about 10 m/s.

There were no activities involving fire on the ship. Sailors were not allowed to smoke while working. It was clear that this accident was not caused by fire.

2. Simulation test and analysis

2.1. Simulation test during drainage of ballast water

During the period of 1967–1972 several large OBO ships exploded because of the strong static field formed by the shaky ballast water [1,2]. When a ship sails in stormy waters, the waves set up by the shaking of the ballast water are similar to those when the cargo is being washed and can engender a high electrostatic field in the cargo. The maximum space potential in the cargo can reach about –50 kV. Such a strong field can surely cause an explosion. The explosion of this tanker, however, could not be caused by the shaking of the ballast water because the tanker was berthed at the wharf on that day. The wind force was only 5 m/s. The ballast water could not engender a strong static field as the tanker was in a smooth position.

Although the ballast water does not shake, there is a layer of oil on the surface of the ballast water being discharged since there is some remaining oil. With the continuous discharge of the ballast water, liquid surface comes down constantly and is slightly stirred. Thus, a static field is formed in the cargo.

In this case, two situations may take place.

The first situation: A copper rod might be dropped into the cargo by a sailor so as to measure the level of the ballast water. The copper rod obviously becomes an insulated conductor.

Bustin and Dukek indicate that the capacitance in the free space of the long and thin isolated metal conductive object can be calculated from the following formula [3]:

$$c = 2\pi\varepsilon_0 a \frac{(1 - b^2/a^2)^{1/2}}{\ln[a/b + (a^2/b^2 - 1)^{1/2}]} a > b, \tag{1}$$

where a is the rod length (m), and b the rod width (m).