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ELECTROSTATIC FIELD AND CLEANING OF SHIP'S COMPARTMENTS FROM OIL PRODUCTS

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Abstract
The need to acknowledge the electrostatic condition onboard tankers is an obvious outcome of the information gathering we can perform, starting from the conditions of electrostatic storage and discharge of electric loads. The electric load distribution and the potential load distribution in different points onboard ship emulate the safety measure taking for electrostatic discharge under way and the thorough cleaning of cargo compartments onboard tankers. During cleaning with oil, sea or fresh water and then by compartment inerting measures are taken for the protection of ships against the effects of electrostatic field.
The paper is an attempt to analyzing the interaction between the electrostatic field and the activities to be undertaken onboard a ship when loading a new cargo.

INTRODUCTION

The electric loads that appear in oil products due to impurities, on the walls of conveyer pipe lines or of storage compartments are triggered by the nature of the contact surface and the hydrodynamic conditions of conveyance.

Load occurrence and their size depend on the shaping of the double electric stratum, which appears because of the preferential ion absorption.

On the edge between the liquid and the solid phase the properties of the oil product mass – homogeneity and isotropy- are disrupted. The anisotropic forces vary dependent on the distance to the limit phase. In the interface area are to be accumulated excess loads, of a certain sign, which leads to a excess load density, together with the appearance of a definite loaded particles orientation the result being the appearance of an electric field on this boundary. [1]

The type of electrostatic discharge, which appeared as a result of load accumulation, is determined through the electric field intensity that takes place in the electric field and through the non-homogeneity degree of the field [2].

The electric loading of oil products may be achieved through ionization – as a result of friction, through polarization of molecules – following the anisotropy of Van der Waals forces and the cleansing processes

After discharge, while cleansing oil products off tanks the following operations are to be performed: cleaning oil or other oil-like products off the walls by means water, water and steam, ventilation and gas free production.

The cleansing process raises the issue from an electrostatic point of view because during this process there is an accumulation and a continuous separation of the electric load.

In order to estimate the fire risks when cleaning cargo tanks we have established first the electrostatic conditions, namely the potential distributions and the electric fields in the vicinity of cleansing devices.

In the case of cleansing cargo tanks it has been noticed that at the surface of the water-oil product mixture, there is an oriented dipoles stratum. These dipoles make up a superficial field, which depends on the dielectric constant. Water being a highly polar material, the electric permittivity of oil products varies with humidity.

The parameter, which stipulates the production of electrostatic discharge, is the dielectric rigidity of the water-fuel fluid-air mixture. The water molecules orient themselves through the electric field and make up bridges along which electrostatic discharge is favored.
The electrostatic characteristics of water are altered by recirculation or by adding washing chemicals which may trigger a high electric potential.
We have learned from [3], [4], [5] that the values of the electric load density in an oil-like fluid, which enters the cargo tank at a flowing speed of up to 7 m/s, may rise up to 13-15$\mu C/m^3$ and that these values must be maintained below 0,1$\mu C/m^3$.
Due to the fact that the density of the electric load in the fuel liquid within the cargo tank decreases exponentially with the time, the ullage is not to be measured for 45-60 minutes.

THE ELECTROSTATIC DISCHARGES AND THE IGNITION CRITERIA FOR MIXTURES

The ignition of some mixtures of air and hydrocarbon vapors having an optimal composition requires the dissipation of at least 0,2 mJ of energy in an electric spark. In order to avoid the ignition of the mixture the space between the sky of the tank or the washing device and the mirror of fuel liquid must be greater than 2 mm, which implies a disruption potential of 5 kV.
The research done have highlighted the fact that the generating conditions of loads must be avoided because they lead to potential of more than 65kV for the volume densities of the load and of more than 35 kV for the surface densities of the load [6]. The results of the calculations done after solving the equations:

$$\rho_v = \rho \frac{\varepsilon_0 \varepsilon_r}{t \cdot \sigma}\left[1 - \exp\left(-\frac{t}{\varepsilon_0 \varepsilon_r}\right)\right] \tag{1}$$

$$\rho_{v_s} = 9 \cdot 10^{-10} \frac{W_{min}^{\frac{1}{4}} \cdot e^{-\frac{k}{4}}}{S \Delta \rho} \tag{2}$$

$$\rho_{v_a} = \rho \frac{\varepsilon}{\sigma t}\left[1 - \exp\left(-\frac{t \cdot \sigma}{\varepsilon}\right)\right] = \rho \frac{\tau}{t}\left[1 - \exp(-t\tau)\right] \tag{3}$$

Leads to the conclusion that the production of inflammable electrostatic discharges are expressed depending on the surface potential but we must take into account the field force which appears on the liquid mirror.
Electrostatic discharges may appear either in a wreath or in a spark. The results we obtain regarding the occurrence of fire due to electrostatic discharge on the surface of some mixtures of fuels and water are presented in [7].
In the case of fuel substance negatively loaded, we have noticed two types of discharges. The first resides in a shinning channel, which appeared on the discharge trajectory and then extended on the liquid mirror.
The second occurred under the shape of a spark. The apparition of Taylor cones – small conic distortions, has permanently accompanied both discharges on the fuel surface due to the distribution of the electric field.
In the case of positively charged fuel substances we have noticed only electrostatic discharges by Corona effect, of low energy, which are accompanied by an alternating current hum, and are visible as a dim luminescence – the current is rendered auto-stable by means of this current.
Corona discharge will be accompanied by a leakage of electric loads towards the vicinity of the liquid surface. This load leakage determines a certain neutralization of the volume load in the

liquid.
The extension to which the neutralizing action of the load may prevent the aftermath of electric discharge depends on the electric current, which appears mixture ratios inside the liquid.
The draining electric current at the walls of the cargo tank on the mixture surface due to the relaxation of the electric load at a density of 0,1μC/m3 and a conductivity of 3pS/m will be of 2·10-5A.

DIMINISHING ELECTROSTATIC CONDITIONS FOR THE

Using a vertical thread near the washing device nozzle has led to the alteration of electrostatic conditions and to the prevention of discharge production. The presence of the thread has reduced the electric field 4 times at the most on the top of the nozzle, reaching 200 kV/m. The experiments performed [10] have shown that the occurrence of an electrostatic discharge in the nozzles of the washing device may be avoided by using stress relieving screens, conditions under which the accumulated load density in the mass of the mixture does not go beyond 0,8 μC/m3. In the case of using the stress relieving system with discharge points in the wreath around nozzles, we have obtained reductions of about 6 times both for the electric field and the surface potential.
Both for the vertical thread and for the stress relieving system it is necessary that the materials used should have a resistivity high enough to limit the energy corresponding to the electric discharges at values lower than the ignition values.
The parameter, which regulates the production of electrostatic discharge, is the dielectric rigidity of the vapor mixture on the surface of this mixture.
The dielectric rigidity is diminished by the existence of water in oil-like substances, because water molecules orient themselves in the electric field (polar molecules) and make up bridges along which there is a high chance of discharge.

ELECTROSTATIC RISKS WHEN CLEANSING CARGO TANKS

The cleansing process of cargo tanks, which is performed after each unloading raises some issues because during this process there appears an accumulation and a continuous separation of the electric loads. It has been noticed [11] that on the surface of the mixture, there is a layer of dipoles oriented so as to get a surface potential, with the "negative" edge on the outside and the "positive" edge on the inside of the liquid which leads to the occurrence of a certain tension.
Under the action of the field made up of oriented dipoles, the anions which are to be found in the liquid attract themselves mutually with the positive poles of the dipoles making up a negative cloud of the double absorption layer at the separation surface liquid-vapors-inertial gas or air.
On the basis of Cohen's rule , applied in the formula by Beach, we can account for the occurrence of the mechanism of electrostatic loading of hydrocarbon fluids and the supplementary occurrence of electric loads at the separation limit of two liquids or of the liquid phase as opposed to the gaseous one during charging-discharging of oil products, cleaning cargo tanks or barbotation (movement) of the mass product in the cargo compartments while underway.

CONCLUSIONS

The sedimentation potential depends on the quantity of water dispersed but it doesn't depend on the dispersion degree. The presence of water has led to an increase in the volume load density. When 6%volume of water was added, the values recorded by the devices measuring the intensity of the electric field have risen by means of a factor varying between 2 and 10.

The electric charging of the mixture is very low (E<1,5Kv/m) for high conductivity values, so that, for a value of more than 50ps/m, it may be considered safe from an electrostatic risk point of view. In the cargo compartment the surface potential must remain below 3,5 kV, the volume density of the load must be under 0,1μC/m3 and the intensity of the electric field must be under 28kV/m.

The cleaning equipment, the gear and auxiliary facilities will be in conformity with the norms and provisions regarding the avoidance of fire by means of using a stress relief wreath and a draining pipe.

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