

Petroleum fuels (gasolines, kerosenes, diesel fuels, etc.) are dielectrics. During the operations of decantation, pouring, and pumping through large pipelines and hoses, they are electrified. The accumulation of electrostatic charges in the volume of a fuel in reservoirs, different vessels, and equipment constitutes a serious danger in industrial processes. Cases of the ignition and explosion of petroleum fuels resulting from discharges of static electricity are known in practice.

In recent years, there has been increased interest in the electrification of petroleum products. However, the accumulation of experimental data is still insufficient, and there is no complete concept with respect to this phenomenon.

### THEORETICAL CONSIDERATIONS

The electrification of petroleum fuels is due to the presence of certain types of impurities, mainly electrolytes whose molecules in a hydrocarbon medium are capable of dissociating into ions. The mechanism of electrification comes down to the fact that ions of the same sign existing in a liquid are adsorbed on the surface of a solid (the wall of a tube), while ions of the opposite sign are distributed in the volume of the liquid. With movement of the liquid, the electric charges distributed in its volume are entrained by the flow and, together with the liquid, accumulate in the receiving reservoir. The adsorbed charges on the wall of the tube are freed, and if the tube is metallic and grounded, are neutralized.

Kosman and Gavis [1] proposed a theory of the formation of charges in liquid dielectrics with their turbulent flow through tubes; the theory is based on the transfer of ionic charges by diffusion, conductivity, and convection. According to the theory, the value of the current force,  $i$ , of the electrification of the flow of a liquid in a pipeline with radius  $a$  and length  $L$  is determined from the equation:

$$i = \pm \frac{\pi \epsilon \epsilon_0 R T v}{2 N F} \text{Nu} \left( 1 - \frac{n}{n_0} \right) \left[ 1 - \exp \left( - \frac{L}{v \tau} \right) \right], \quad (1)$$

where  $\epsilon$  and  $\epsilon_0$  are the dielectric permeabilities of the liquid and of a vacuum, respectively;  $R$  is the universal gas constant;  $T$  is the absolute temperature of the liquid;  $v$  is the mean rate of movement of the liquid;  $N$  is the transfer number of ions of opposite sign;  $F$  is the Faraday number;  $\text{Nu}$  is the Nusselt number;  $n_0$  and  $n_w$  are, respectively, the concentrations of ions in the volume of the liquid and on the surface of the tube wall;  $\tau$  is the relaxation time of the liquid.

It is assumed in Eq. (1) that the specific conductivity of the liquid,  $\gamma$ , is equal to:

$$\gamma = \frac{2 n_0 D_M F^2}{R T}, \quad (2)$$

while the effective thickness of the diffusion layer,  $d$ , that is, the thickness of the layer of liquid near the wall, closely bound to the surface, is equal to:

$$d = \frac{2a}{\text{Nu}}, \quad (3)$$

where  $D_M$  is the coefficient of molecular diffusion.

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