Experimental study on the electrostatic risk factors in the process of refueling and uploading meanwhile at filling stations

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***Abstract*—When the road tanker uploading fuel to underground oil tank, the fuel filling stations in China prohibit the dispenser deliver the fuel from underground tank and refuel the customer car (simultaneous delivery and customer fueling) in order not to influence with the metering accuracy in unloading. It is well reported that the filters, valves and elbows generally increase the amount of electrostatic charge on the fuel, so the possibility of electrostatic discharge as an ignition source must be considered at petrol stations. In this study, a number of test runs at different petrol stations were performed measuring the electrostatic charge of the oil, caused by refueling and uploading at the same time, when it come out of the nozzle by using the Faraday cage method. The extensive data shows that the charge density of the oil increases remarkably as the same time of the road tanker uploading oil to underground oil tank, and the maximum charge density can reach to more than －60 μC/m^3.The results indicate that there is an enhanced risk of electrostatic charging because of the delivery activity in some filling stations.**

I. INTRODUCTION

Petroleum products can become electrostatically charged when there is relative movement between the liquid and adjacent solids or there is a second immiscible phase[1-3]. Any elbows, valves and filters will generally increase the amount of charge when the fuel flows. Fuel is typically supplied by road tankers and transferred from the tankers through hoses, buried pipes and dispensers to the customer cars. In recent years, however, explosions and/or fires related to electrostatics-based reasons occasionally occur in customer fueling process at petrol stations[4]. According to the requirements of some standards in anti-static of preventing electrostatic accidents, a waiting period of at 10-15 minute should be followed to permit the charge to dissipate before the road tanker uploading fuel to underground oil tank, and the fuel filling stations in China prohibit the dispenser deliver the fuel from underground tank and refuel the customer car either during or immediately after the road tanker uploading fuel to underground oil tank (simultaneous delivery and customer fueling)[5].

In most case, the delivery line (from tank to dispenser) in China is pressure system via turbo pump in side tank at petrol service station (see Fig.1). The electrostatic hazards should be strictly avoided because the filling stations distribute high quantities of flammable liquids. A waiting period theoretically before refueling operation is necessary needed to permit substantial relaxation of the static charge generated by the uploading process and/or the movement of air, gas, or droplets in oil. As the same time of the road tanker upload fuel to underground oil tank, the oil companies anticipate and confirm whether the dispenser can deliver the fuel from underground tank and refuel the customer car, because there may be an enhanced risk of electrostatic charging arising from the process of simultaneous delivery and customer fueling. The present study, in this paper, focuses on the charging of the fuel, caused by refueling and uploading meanwhile at different petrol stations, when it come out of the nozzle by using the Faraday cage method with the aim of recommending suitable control procedures in the area of accident prevention and mitigation.

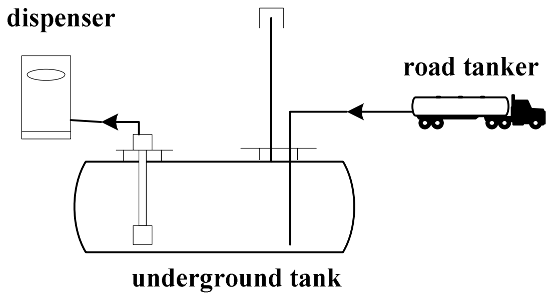

Fig.1 Schematic of a typical petrol station

Fig.2 Pictures of measuring the level of charge accumulation during refueling in China

II. Experimental procedures

The coexistence of a flammable atmosphere and electrostatic discharge necessary for ignition has involved either the uploading or refueling fuel at filling stations, so we should follow recognized procedures and guidelines to avoid the incident. However, if many of the risk factors are close to their safety limits, the chance of an ignition hazard during fuel handing operations would be greater than average. For this reason the electrostatic measurements of charge density caused by refueling and uploading meanwhile were undertaken at the output end of the fuel nozzle during refueling in China.

In order to study on the electrostatic risk factors during refueling and uploading at the same time, a series of test runs at different petrol stations were performed measuring the charge density of the oil when it comes out of the nozzle by using the Faraday cage method, as shown in Fig.2. The electrical conductivity of petroleum products was also measured by using a Model 1152 Digital Conductivity Meter (EMCEE) every five minutes. The principle features of the experiment were as follows:

(1) The charge density and/or electrical conductivity during a refueling process include the data obtained before and after the road tanker upload fuel to underground oil tank.

(2) Several clean stainless 200 L grounded tubs for storage of fuel were prepared, which was used to simulate different refueling process at the same time.

(3) Different petrol stations were used to test the charge of the fuel after the self-closing oil filler. A length of buried pipeline between the underground oil tank and filling nozzle may be longer than several meters, so about 50-100 L volume of fuel was first injected into a grounded tub, and then the fuel was injected into the Faraday cup quickly to measure the quantity of electrostatic charge during refueling (see Fig.2).

(4) The same fuel flow velocity was used, and the filling nozzle positioned 150 mm away from the Faraday cup was maintained in the test.

III. Results

Seven petrol filling stations in the five provinces in China were selected to test the level of charge accumulation during refueling. Two types of fuel, diesel and gasoline, were measured. The maximum charge density obtained during refueling process was shown in Table 1.

Table 1: Charge density and conductivity of fuel measured at different filling stations

Area	Fuel	Maximum charge density（μC/m³）		Fuel conductivity（pS/m）		
		before uploading	afer uploading	before uploading	fuel in tanker	maximum
Jiangsu	diesel	-13.4	-14.2	60	56	60
Shanxi	gasoline	-7.2	-7.3	70	68	73
Shanxi	diesel	-4.5	-15.1	29	26	29
Shaanxi	gasoline	-2.4	9.1	30	27	30
Shaanxi	diesel	0.7	-68.7	3	2	72
Shandong	gasoline	1.9	2.2	8	7	9
Beijing	gasoline	-26.9	73.6	187	186	187

A total of 7 test runs were undertaken with the main controlled variables being flow velocity and experimental procedures. The two tests in Shaanxi and Beijing described in this paper are representative because the charge density of fuel obviously increased with the increasing time of uploading process, where the fuels used were the diesel and gasoline, respectively.

Figure 3 shows the time dependences of charge density ρ and conductivity σ for the diesel during the simultaneous uploading and refueling process at a filling station in China's Shaanxi province. The condition for this test were 12 ℃ and 26.4%RH. In this test, the results of ρ for the diesel after the self-closing oil filler continually raised with the increasing uploading time until the maximum value, -68.7 μC/m^3, was reached., What's more, the value of ρ decreased with the time, and decreased to -9 μC/m^3 in 15 minutes after the completion of the unloading operations. However, the values of σ for the diesel were 3 pS/m in underground oil tank and 2 pS/m in road tanker before uploading. With the time of uploading increasing, the σ increased from about 3 pS/m to 72 pS/m.

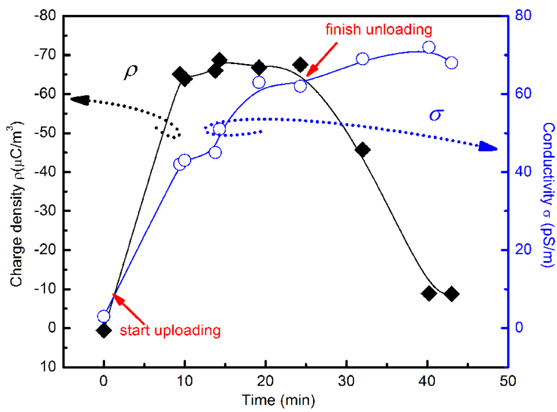

Fig.3 Change in charge density and diesel conductivity during the simultaneous uploading and refueling process in China's Shaanxi province

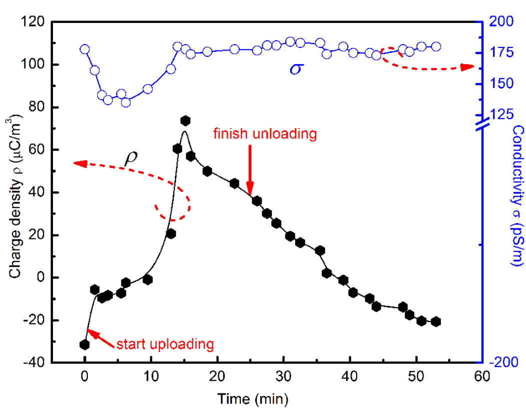

Fig.4 Change in charge density and gasoline conductivity during the simultaneous uploading and refueling process in Beijing

Figure 4 shows an example of how the charge density ρ and conductivity σ developed as a function of time during a test run for the gasoline at a filling station in Beijing. The conditions for this test was 23.6 ℃ and 40.9%RH. During the course of the test, the largest ρ was -26.9 μC/m^3 before uploading the gasoline to underground oil tank and 73.6 μC/m^3 in the uploading process (the σ of the gasoline was about 180 pS/m). The increased charge amount of gasoline caused by refueling and uploading at the same time maybe enhance the risk of incendiary electrostatic discharge under various conditions.

IV. CONCLUSION

Most of the incidents at petrol stations have been linked to incendiary electrostatic discharge from unbounded metal components. In this study, the charge amount of gasoline and/or diesel caused by refueling and uploading meanwhile were undertaken at the output end of the fuel nozzle during refueling in China. The charge density of the fuel increases accidentally as the same time of the road tanker uploading oil to underground oil tank, and the maximum charge density can reach to more than -60 μC/m^3. The results indicate that maybe there is an enhanced risk of electrostatic charging because of the delivery activity at some filling stations.

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