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To cite this article: Yunpeng Zhang *et al* 2013 *J. Phys.: Conf. Ser.* **418** 012025

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Influence of relative humidity and temperature on quantity of electric charge of static protective clothing used in petrochemical industry

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Abstract. In this paper, the working principle of static protective clothing and its testing method of quantity of electric charge are introduced, and the influence of temperature and relative humidity on the quantity of electric charge (q_e) of static protective clothing is studied by measuring q_e of different clothing samples. The result shows that temperature and relative humidity can influence q_e of static protective clothing to some extent and the influence of relative humidity is bigger than that of temperature. According to experimental results, the relationship of q_e and relative humidity and temperature was analysed, and the safety boundary of quantity of electric charge is discussed. In order to reduce the occurrence of electrostatic accidents and ensure safe production and operation of petrochemical industry, some suggestions on choosing and using of static protective clothing are given for guaranteeing its static protective performance.

1. Introduction

As there are plenty of inflammable and explosive sites in petrochemical industry, fire accidents caused by static electricity are very easy to take place. Static electricity is mainly caused by friction, which can be generated by any activity. Static electricity almost exists everywhere and its voltage can be very high. When a person moves, large amount of electrostatic charges would be generated on his body. For the people working at the inflammable and explosive sites, to reduce the electrostatic charges on human body and prevent the occurrence of fire accidents, static protective clothing is very essential, while the electrostatic charges generated by the clothing itself are of vital importance for its safety performance. If the quantity of electric charge of the clothing is large enough, when it's being used at the inflammable and explosive sites, fire accidents may take place very probably. As a result, it's very significant to intensify the testing work for quantity of electric charge of static protective clothing.

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2. The working principle of static protective clothing and the testing method of its quantity of electric charge

Static protective clothing is a kind of working clothes widely used under inflammable and explosive circumstance, which is made of static protective textile. Static protective textile contains conductive fibre, which is mixed with other common fibre together symmetrically. The volume resistivity (ρ_v) of conductive fibre is $10^4 \sim 10^9 \Omega \text{ cm}^{-1}$, which is made of conductive material or sub-conductive material using metal or organic substance. According to the distribution type of conductive substance in the fibre, conductive fibre can be divided into three different kinds: homogeneous, overlaying and complex. Among them, the third kind is mainly in use.

The working principle of static protective clothing, which contains conductive fibre, is based on the leakage and neutralization of electric charge. When the textile is connected to the ground, the electric charges on it may neutralize as a result of corona discharge or leak to the ground through conductive fibre; if not, the electric charges may disappear because of corona discharge on the conductive fibre.

So far, an important index to judge whether the static protective clothing is qualified or not is its quantity of electric charge (q_e), and the testing method of q_e is as follows: firstly the clothes should be washed as the national standard Static Protective Clothing requires; then the clothes are put into the roller friction machine to be treated for 15 minutes; thirdly the Faraday cup is used to measure the quantity of electric charge, which should meet the demands listed in table 1.

Table 1. Technical demands for the quantity of electric charge.

Testing items	Technical demands	
	Class A	Class B
Quantity of electric charge (μC / piece of clothes)	<0.2	0.2~0.6

Generally speaking, environmental element can influence the quantity of electric charge of static protective clothing, especially relative humidity and temperature. However, what is the relationship between them? How do relative humidity and temperature influence the quantity of electric charge? To answer these questions, a testing experiment is made to study this problem.

3. Testing experiment

Physical research proves that the electrical characteristics of objects can be directly influenced by humidity and temperature. Under the condition of low temperature and humidity, the resistance of an object will increase significantly, so that the release speed of electrostatic charge will slow down and the release time will increase; in high humidity conditions, water may condensate (or be adsorbed) on the object's surface to form a thin water layer. This hygroscopicity enhances the conductivity of the material, especially for the materials that can absorb water vapor. As the temperature rises, the mobility of the free charge is enhanced, so that the conductivity of the material is increased.

To study the relationship between the quantity of electric charge of static protective clothing and environmental elements, especially relative humidity and temperature, a series of testing experiments were carried out.

Three samples (Sample 1, Sample 2 and Sample 3) were chosen randomly from the static protective clothes produced by different manufacturers. The relationship between relative humidity and temperature and q_e of static protective clothing was studied. The corresponding variation range of relative humidity and temperature was set according to the actual using conditions of static protective clothing. Each sample was tested for five times and the average of these five results was taken as the final result.

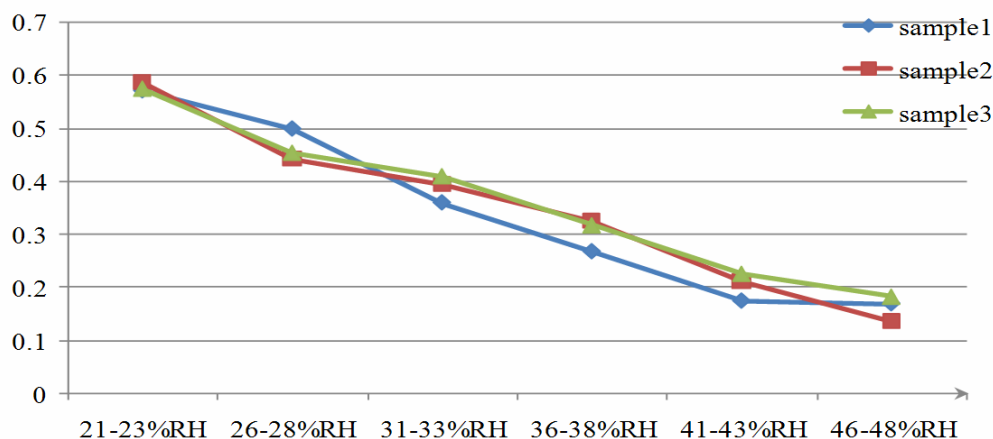


Figure 1. Quantity of electric charge under different relative humidity ranges (T : 16~17°C).

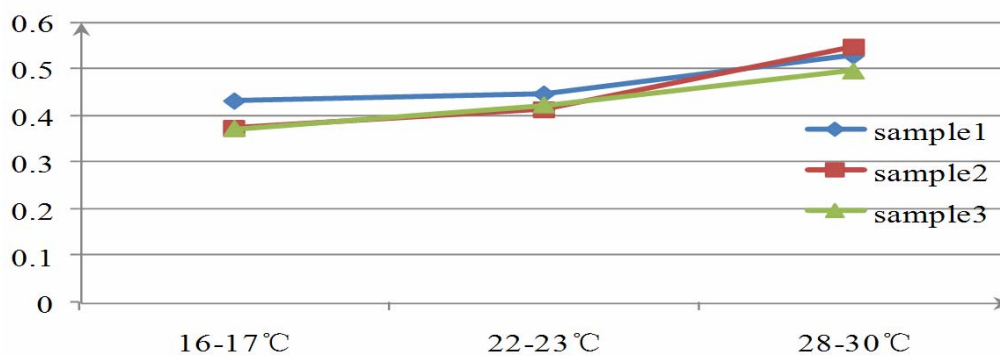


Figure 2. Quantity of electric charge under different temperature ranges (Relative humidity: 23~25%).

Figure 1 shows that when the temperature is constant, the quantity of electric charge tends to decrease with the relative humidity increasing gradually. Figure 2 shows that when the relative humidity is constant, the quantity of electric charge tends to increase with the temperature increasing gradually. What's more, the influence of relative humidity on the quantity of electric charge of static protective clothing is bigger than that of temperature on it.

To some extent, this can verify the phenomenon that in winter there is large quantity of electrostatic charges on human body while in summer it's the opposite. In winter, the temperature is very low and the air is very dry, when the clothes rub against with themselves or with the human body, many electrostatic charges will be generated. Under the condition of low relative humidity, corona discharge is difficult to go on. If the charges can't be led to the ground, they will gather up on the human body. In summer, the relative humidity is very high. Under this circumstance, corona discharge is easy to carry on, for which electrostatic charges will decrease gradually. As a result, electrostatic charges are difficult to gather up.

The technical demand for quantity of electric charge of static protective clothing is below "0.6 μC / piece of clothes" in the national standard (in China). This data is figured out from the minimum ignition energy data of most inflammable gas, about 0.25 mJ, so the data "0.6 μC / piece of clothes" could be a safety boundary for static protective clothing. If the quantity of electric charge of a piece of static protective clothing is more than 0.6 μC , it may be a dangerous source. While from the testing data it could be seen that under the condition of low relative humidity, the quantity of electric charge

of a piece of static protective clothing could be very high, nearly $0.6\ \mu\text{C}$ (the dangerous boundary). According to the data in figure 1, if the relative humidity gets lower, the quantity of electric charge may be larger than $0.6\ \mu\text{C}$, so it will be dangerous. While if it is tested under the circumstance as the national standard “Static protective clothing” demands ($25\pm 5^\circ\text{C}$, $35\pm 5\%\text{RH}$), its quantity of electric charge is about $0.4\ \mu\text{C}$, less than $0.6\ \mu\text{C}$. So if the standard is taken as the only judging basis, this may be unreasonable. To judge the safety performance of static protective clothing, it may be more reasonable to test the clothing under the corresponding condition just as the clothing is used and the element of different places and seasons should be taken into consideration.

4. Conclusion

From the results of the testing experiments, it can be concluded that to some extent, relative humidity and temperature can really influence the quantity of electric charge of static protective clothing, and the influence of relative humidity is bigger than that of temperature. When the temperature is constant, with the relative humidity increasing gradually, the quantity of electric charge tends to decrease; when the relative humidity is constant, with the temperature increasing gradually, the quantity of electric charge tends to increase. As the quantity of electric charge of static protective clothing can be seriously influenced by relative humidity, it may be more reasonable to test the clothing in the corresponding condition just as the clothing is used.

Considering safety problem, petrochemical industry should choose static protective clothing as strictly as possible. Additionally, some suggestions about the using of static protective clothing are necessary for petrochemical industry:

(1) At the inflammable and explosive sites with dry weather, it is forbidden to put on or put off static protective clothing.

(2) When static protective clothing is in use, the upper garment and the lower garment should keep in touch as well as possible and they should be used with anti-static shoes together. Further more, strenuous exercise is not advisable.

(3) Static protective clothing is not anti-static forever. After it is be used for a period of time, an additional anti-static test is very essential. If it is not qualified, it should not be in use any longer.

Acknowledgments

The project was supported by National Key Technology R&D Program (2012BAK03B00), we thank for their support.

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