Can Velcro be used in potentially hazardous areas?

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This paper describes an experimental investigation into whether Velcro hook and loop fasteners can create an electrostatically hazardous situation when removed, and whether their use is acceptable in explosive environments or when handling electrostatic-sensitive devices and equipment. To answer these questions, we measured the charges and potentials of Velcro hooks and loops when separated and attempted to detect any discharges that may occur when they are being separated. The potential electrostatic hazards associated with the use of hook and loop fasteners are summarised and recommendations are given for the safe use of Velcro fasteners in hazardous areas.

1. Introduction

Velcro (called magic tape in Japanese) is often used as a fastener on clothing, wrist straps, footwear, etc. However, the materials used are insulating, such as nylon and polyester, so charges can accumulate on the Velcro surfaces. In addition, charge separation occurs when the hook and loop are removed, resulting in each hook and loop surface being charged. If the charge from this separation is high, it can create an electrostatically hazardous situation. One company has banned the use of Velcro (hook and loop fasteners) on clothing and footwear following expert advice. One of the authors was asked by this company whether this could cause any electrostatic hazards.

We, therefore, investigated experimentally whether Velcro fasteners could cause electrostatic hazards when removed, and then whether their use would be acceptable in an explosive environment or in an ESD-sensitive environment where electrostatic-sensitive devices and equipment are handled. Based on these results, we assess the electrostatic risk of using Velcro fasteners and recommend their appropriate use.

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2. Experiment

The surface potentials and charges of each hook part and loop part of samples of five products of Velcro hook and loop fasteners were measured immediately after the parts were separated. A Kasuga Denki model KSD 1000 electrostatic voltmeter was used to measure the surface potential measurement, and a Monroe Electronics model 284 NanoCoulomb meter with a 22B Faraday cup was used to measure the charge. Sample sizes and materials with experimental results are given in Table 1. As described later, the uneven charge separation observed may indicate that discharges occur when the parts are separated, so we also attempted to detect the presence of discharges using a Trek model 900 ESD event detector, and EMCO model 7405 E & H near-field probes with an oscilloscope. The Model 7405 includes 1-cm loop, 3-cm loop, and 6-cm loop, 3.6-cm sphere, and 6.0-mm stub-tip antennas. Experiments were carried out at the environmental conditions of 24.5 °C and 50%rh.

3. Results and discussion

The measured surface potentials are several kilovolts, which is not low enough to cause ESD problems for electrostatic-sensitive devices within ±10 volts. In addition, except for sample #1, these surface poten-

Table 1: Surface potentials and charges of Velcro hook and loop parts when separated.

		Hook			Loop		
Sample	Area, mm^2	Material	Potential, kV	Charge, nC	Material	Potential, kV	Charge, nC
#1	50×60	Polyester	−2.60	−12.7	Nylon	2.00	24.2
			−2.58	−12.4		6.30	33.4
#2	50×55	Polyester	−0.12	−0.90	Polyester	±0	0.10
			−0.20	−0.15		0.01	0.60
#3	50×50	Polyester	−0.01	−0.15	Polyester	0.01	0.06
			−0.01	−0.20		0.01	0.06
#4	50×55	Nylon	±0	−0.17	Nylon	±0	±0
			±0	−0.03		±0	−0.04
#5	50×55	Nylon	−3.50	−27.6	Nylon	1.02	11.3
			−3.10	−20.9		0.70	5.5

tials are not high enough to cause incendive brush discharges[2]. When one part has a positive potential and the other a negative one. This indicates that charge separation occurs and the charge accumulates, resulting in each part being charged when the parts separate. The nylon-polyester combination has the highest charge. Nylon is more prone to charge in our tests, even when both parts are nylon. In addition, the polarity of the measured charges also indicates that charge separation occurs. The resultant values accumulated on the parts are less than 60 nC which is the maximum acceptable transferred charge of a discharge in IIA Zone 0 hazardous areas, while the measured charges depend on the area of the Velcro. However, the absolute values of the charge separated are not the same. This may indicate that discharges occur during the separation of parts. We, therefore, tried to detect the discharges with the ESD detector or the antennas, but no discharges were detected because they were so weak. We will investigate how weak the discharges are by measuring the transferred charge that can be detected by these detectors when an earthed sphere approaches a charged insulating surface.

Nevertheless, when used as fasteners on clothing, wrist straps, etc., the area of Velcro is usually too small to cause a problem. The size limits in Refs[1–3] can be applied. One use that can cause concern is when a large area of velcro is used to attach removable patch labels to garments. If the area exceeds the limits, electrostatic dissipative velcro can be used, or the large piece of velcro can be replaced with several smaller pieces with gaps between each piece. When used on personal protective clothing for ATEX zones, Velcro is usually attached to electrostatic dissipative materials, which further mitigates the risk. The outermost clothing, which includes rainwear, worn in hazardous zones should be electrostatic dissipative. Insulating clothing creates a risk with or without Velcro. We recommend that any clothing should not be removed and Velcro unfastened when operating in a hazardous area.

References

1) IEC TS 60079-32-1, Explosive atmospheres – Part 32-1: Electrostatic hazards, guidance (2013).
2) A. Ohsawa, Electrostatic risk assessment (2023) (`https://www.researchgate.net/publication/320612230_Risk_assessment_of_electrostatic_ignitions`).
3) Technische Regeln für Gefahrstoffe 727: Vermeidung von Zündgefahren infolge elektrostatischer Aufladungen (2016).