Testing the electrostatic characteristics of polypropylene fabric with metallic yarns, intended for use in coal mines threatened by the explosion hazard. Part 2: Tests in coal mine

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Abstract. The aim of this paper was to assess the electrostatic safety of polypropylene fabric with metallic yarns intended for use in coal mines. Such fabrics have not been used in the Polish mining industry yet. The tests conducted have been divided into two subgroups: laboratory tests and tests in a coal mine. This paper presents the results of tests in a coal mine, where we have focused on the resistance-to-ground in some specific situations. Bags made of fabric at the roadway face were tested, as well as the roll of fabric during transport and carried by a miner. The results obtained allow the reliable assessment of the risk of using fabrics with metallic yarns in the explosive atmosphere which often occurs in coal mines.

1. Introduction

The main objective of the work was to assess the risk of using fabric with metallic yarns for mining applications. In the laboratory tests [1] the problems with measuring the resistance of fabric with metallic yarns were highlighted and discussed. We also presented the results of charge transfer tests and the impact of washing and mechanical stress on the resistance and resistance-to-ground at the manufacturer’s site [1]. Resistance-to-ground was measured for two cases: empty bags and bags filled with just prepared material. Most of the results were of order $10^4 \, \Omega$. However, since the fabric is intended for use in coal mines, it is important to verify resistance-to-ground in the place where the fabric is to be used.

The material to be tested was a composite in which conductive yarns made of stainless steel were present inside a matrix of highly resistive base fabric (polypropylene), as shown in Figure 1.

Figure 1. Structure of the fabric tested.
2. Tests in a coal mine

During the tests in a coal mine we focused on measurements of the resistance-to-ground in some specific situations.

Tests were carried out for two different cases in the roadway face: empty bags (1), bags filled with material just prepared (2), as well as bags filled with hardened material within 300 m of the roadway face (3). Environmental conditions were as follows: temperature 25°C and relative humidity 70% at the roadway face and temperature 29°C and relative humidity 70% 300 m from the roadway face. The above-mentioned conditions are shown in Figure 2. These conditions, as well as contamination of the fabric surface with carbon dust, had significant impact on the obtained results. Measurements were taken with Metriso2000 resistance-meter with point electrode - resistance probe-model 850. The resistance probe of weight 2.2 kg was located directly on the surface of the fabrics, which had not previously been cleaned. The results are summarized in Table 1. The worst results of resistance to ground were obtained for hardened material-filled bags, however all the results were below $10^6 \Omega$.

![Figure 2. Conditions of resistance-to-ground measurements in the coal mine at the roadway face.](image)

| No of single result | Empty bags | Bags filled with material just prepared | Bags filled with hardened material |
|---------------------|------------|---------------------------------------|-----------------------------------|
| 1                   | $< 1.0 \times 10^3$ | $1.3 \times 10^3$ | $3.87 \times 10^4$ |
| 2                   | $< 1.0 \times 10^3$ | $1.1 \times 10^3$ | $2.10 \times 10^3$ |
| 3                   | $< 1.0 \times 10^3$ | $< 1.0 \times 10^3$ | $1.46 \times 10^5$ |

Both transportation of the roll of fabric on wheels and carrying it by a miner were found to give the worst cases for the resistance-to-ground, as shown in Figures 3 and 4. In the case of transportation, the fabric was placed on steel and on wood. When carried, the miner was standing just on the floor as well as on wood. Measurements were taken again with Metriso2000 resistance-meter with point electrode - resistance probe-model 850. The probe was placed on the roll of fabric at three points, spaced evenly along its length. Environmental conditions where as follows: temperature 9°C and relative humidity 64%. Results of measurements are summarized in Tables 2 and 3.
Table 2. Results of resistance to ground in transportation of the fabric roll.

| Point number | $R_g$ [Ω] Fabric placed on steel | $R_g$ [Ω] Fabric placed on wood |
|--------------|---------------------------------|---------------------------------|
| 1            | $3.74 \times 10^6$             | $4.04 \times 10^7$              |
| 2            | $1.73 \times 10^7$             | $3.36 \times 10^6$              |
| 3            | $2.12 \times 10^7$             | $7.18 \times 10^7$              |

Table 3. Results of resistance-to-ground of fabric roll carried by a miner.

| Point number | $R_g$ [Ω] Standing on the floor | $R_g$ [Ω] Standing on wood |
|--------------|--------------------------------|---------------------------|
| 1            | $3.13 \times 10^6$             | $4.33 \times 10^6$        |
| 2            | $3.08 \times 10^6$             | $4.49 \times 10^6$        |
| 3            | $2.75 \times 10^6$             | $5.64 \times 10^6$        |

When transported or carried by a miner all the measurements obtained from the fabric roll were above $10^6$ Ω, but did not exceed $10^8$ Ω. All the resistance-to-ground measurements obtained in the coal mine are presented in Figure 5.
3. Results
Tests were carried out in the roadway face for two different cases. Those tests gave results below $10^6 \, \Omega$. Both transportation of the roll of fabric on wheels and carrying by a miner were found to give the worst case for the resistance-to-ground. Results obtained in those situations were above $10^6 \, \Omega$, but did not exceed $10^8 \, \Omega$. It can be clearly seen that the results of resistance-to-ground measurements during material transport and carrying it by a miner are higher than the results obtained at the roadway face. This is caused by the higher relative humidity and higher coal dust contamination in the roadway face than in other places of the mine.

4. Conclusion
The tested material was a composition of conductive yarns made of stainless steel and highly resistive base polypropylene fabric. Verification of the resistance-to-ground for some specific situations in a coal mine, where the fabric is intended for use, was most important for us in assessing the fabric. The results obtained indicate that this fabric was reliably earthed and would not be expected to pose any threat associated with static electricity in the coal mine environment.

References
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