

Article citation info: Ambriško, L., Marasová, D., 2026, Testing the physical and fire-related properties of fabric conveyor belts. *Journal of Civil Protection and Rescue*, 1(1), pp. 34-42. DOI: <https://doi.org/10.46544/at2chj48>

Testing the physical and fire-related properties of fabric conveyor belts

LUBOMÍR AMBRIŠKO^{1*}, DANIELA MARASOVÁ²

¹ Institute of Earth Resources, Faculty of Mining, Ecology, Process Control and Geotechnologies, Technical University of Košice, Park Komenského 19, 042 00 Košice, Slovak Republic, e-mail: lubomir.ambrisko@tuke.sk

² Institute of Logistics and Transport, Faculty of Mining, Ecology, Process Control and Geotechnologies, Technical University of Košice, Park Komenského 14, 042 00 Košice, Slovak Republic, e-mail: daniela.marasova@tuke.sk

*Corresponding author: lubomir.ambrisko@tuke.sk

Abstract:

This article deals with the testing of rubber-textile conveyor belts. Its objective is to determine the physical properties of the belts that dictate their suitability for practical application. Both tensile properties and electrical resistance, critical criteria for conveyor belt operation, were assessed. Maximum electrical resistance limits are prescribed, and the test verifies whether the belt is sufficiently conductive to prevent the accumulation of static electric charge during operation. Flame resistance tests were also conducted; these are essential for belts used in environments with fire risks, particularly in coal mines. The work focuses on the methodology of the individual experimental tests, covering everything from specimen preparation to the evaluation of test results. The tested rubber-textile belt (type P630/3 4+2) exhibited a tensile strength of 744 N.mm^{-1} , while the electrical resistance of the P2000/4 8+4 type belt was $49.94 \times 10^3 \Omega$. The P2000/4 8+4 belt did not meet the requirements for flame-resistant belts.

Keywords:

Conveyor belt, tenson, electrical conductivity, flammability.

1. Introduction

Belt conveying is one of the most important methods for the continuous transport of both bulk materials and unit loads. Currently, it is widely used in sectors such as mining, metallurgy, the energy industry, cement production, agriculture, logistics centres, and recycling facilities. Key advantages of belt conveyors include high transport capacity, the ability to transport materials over long distances, low energy consumption, and high operational reliability. Modern conveyor systems are capable of ensuring continuous material transport even under demanding operating conditions, with the conveyor belt serving as a critical component (Ryba et al., 2024; Andrejiová et al., 2025). Rubber-textile conveyor belts are the most common type used for bulk material handling. Their construction consists of rubber cover layers and a load-bearing carcass formed by textile plies. The combination of



flexible rubber and high-strength textile reinforcement provides the belts with high tensile strength, impact resistance, and favourable bending characteristics. Rubber-textile belts are primarily used for short to medium transport distances where high flexibility and ease of installation are required (Lemmi et al., 2021; Ambriško and Čabaníková, 2026). The reliability and service life of a conveyor belt are directly determined by its physical and mechanical properties. These properties significantly influence the belt's ability to transmit loads, withstand operational deformations, and ensure safe material transport throughout its service life (Lemmi et al., 2021; Ryba et al., 2024).

Determining the physical properties, which provide comprehensive information on material behaviour under complex stress conditions, is essential for evaluating material characteristics and, ultimately, quality. A conveyor belt is a composite structure made up of distinct materials. The properties of its individual components significantly influence the final characteristics of the belt itself and determine its suitability for its intended function and practical application.

Under the influence of external loading, a solid body changes its shape and dimensions – that is, it undergoes deformation. Mechanical properties describe the relationship between the magnitude of the applied force (or stress) and the resulting deformation; they characterize the changes in a body's shape and dimensions caused by external loads. Mechanical properties include those determined through uniaxial tensile testing. The mechanical properties of conveyor belts are assessed through testing, and the required specifications are defined by standards as well as technical and technological regulations. Requirements for conveyor belts depend on their specific application; consequently, both the complete belt and its individual components must undergo testing. A conveyor belt consists of various materials; for example, the rubber compounds forming the cover and adhesive layers belong to a group of materials exhibiting complex mechanical behaviour under stress. The following test methods are used to evaluate the fundamental properties of conveyor belts featuring a textile carcass and rubber cover layers (Marasová et al., 2006):

- dimensional – belt width, edge cover width, total belt thickness, total cover layer thickness, length of the unjoined belt, length of the joined belt,
- functional – transverse stiffness, longitudinal stiffness, low-temperature flexibility, mechanical joint strength,
- physical – tensile properties, adhesion between plies, adhesion between plies and cover layers, electrical conductivity,
- fire-related – flame resistance, resistance to ignition and burning over a surface gas burner, resistance to friction-induced ignition,
- special – resistance to heat, low temperatures, oil, etc.

The operational safety of belt conveyors is a critical factor, particularly in the mining, tunnelling, energy, and chemical industries. In these applications, emphasis is placed not only on the tensile properties of the conveyor belts but also on their fire-resistance characteristics and ability to dissipate electrostatic charges. Consequently, specially designed flame-retardant conveyor belts are used to minimize the risk of fire ignition and propagation in the event of conveyor failure. Flame-resistant conveyor belts are manufactured using special rubber compounds containing flame retardants, halogenated or halogen-free additives, and suitable fillers that reduce the material's flammability. A key requirement is that the belt self-extinguishes once the ignition source is removed or that it prevents the spread of flame. In Europe, fire safety requirements for conveyor belts are primarily verified in accordance with the STN EN ISO 340 (2022) standard, which defines flammability tests and belt classification based on fire risk levels. The need for flame-resistant belts arises from the nature of the working environment. Underground mines present an elevated risk of fire due to factors such

as friction between the conveyor belt and structural components, bearing overheating, drive malfunctions, or the presence of combustible dust and methane. Analyses of mining accidents have shown that conveyor belt fires pose a significant risk to both worker safety and the continuity of mining operations. Consequently, the fire-resistant properties of belts are considered just as important as their strength parameters. Assessments of flame-retardant properties typically involve flame propagation tests, glow tests, and heat resistance tests. During these tests, parameters such as the time required for the specimen to self-extinguish, the extent of damage following flame exposure, and any tendency for sustained combustion are monitored.

In addition to fire safety, the electrical conductivity of conveyor belts is a crucial operational parameter. The movement of the belt over rollers and drums generates an electrostatic charge due to the triboelectric effect. If this accumulated charge is not dissipated into the surrounding environment, an electrostatic discharge may occur. In environments containing flammable gases, vapours, or dust, such a discharge can trigger an explosion or fire. Electrical conductivity in conveyor belts is achieved using conductive rubber compounds or appropriate conductive fillers – most commonly, highly conductive carbon black. Recent research also explores the application of carbon nanomaterials, such as graphene or carbon nanotubes; these materials enable the desired conductivity to be achieved with lower filler content while maintaining the rubber's favourable mechanical properties (Wang et al., 2024). Key parameters in evaluating electrostatic properties include the electrical resistance of the belt surface and the electrical resistance between opposing electrodes placed on the conveyor belt surface. The international standard STN EN ISO 284 (2025) establishes maximum permissible electrical resistance values that must be met for a belt to be classified as antistatic. Meeting these requirements ensures the adequate dissipation of electrostatic charges generated during operation.

Electrical conductivity and flame resistance are interconnected properties of conveyor belts. Underground applications typically require compliance with both criteria, as electrostatic discharge can serve as an ignition source for fires or explosions. Consequently, the design of modern safety conveyor belts focuses on optimizing the composition of the rubber cover layers to maintain the necessary mechanical properties, wear resistance, and antistatic characteristics, while simultaneously ensuring high resistance to flame propagation.

Current research pays particular attention to the interplay between tensile, electrical, and fire-resistance properties. Increasing the content of flame retardants or conductive fillers often leads to changes in tensile strength, elasticity, or wear resistance. Maintaining electrical conductivity throughout the conveyor belt's service life remains a significant challenge; operational wear of the cover layers, rubber oxidation, mechanical damage, and exposure to moisture can alter the distribution of conductive fillers within the rubber matrix. The result is a gradual increase in the electrical resistance of the belt surface, which can lead to reduced operational safety (Wang et al., 2024). The fire safety of conveyor belts remains a critical issue, particularly in mining operations. Belt conveyor fires can result in extensive damage to property and equipment, the interruption of extraction activities, and, in extreme cases, threats to the lives of workers. Barros-Daza et al. (2022) demonstrated that the progression of a conveyor belt fire is significantly influenced by the geometry of the conveyor route, the position of the belt, and the airflow velocity within mine workings.

This paper aims to determine the physical and fire-related properties of conveyor belts. In addition to tensile properties, fire-related and electrostatic characteristics constitute a significant group of parameters influencing the operational safety of conveyor systems.

2. Materials and methods

Experimental research was conducted on rubber composites – specifically, Transbelt-type rubber-textile conveyor belts – designed for use in gravel and sand operations, lime and cement plants, thermal power stations, the mining industry, raw material extraction and processing, landfills, docks, and the manufacturing and agricultural sectors (Ambriško et al., 2016). Belt testing was carried out at the Testing and Verification Workplace for Rubber Products at the Faculty BERG of the Technical University of Košice. Test specimens were cut from the belt material using an Atom SE 25 hydraulic press equipped with a cutting die (Fig. 1).



Fig. 1 Atom SE 25 hydraulic press and cutting die



Fig. 2 Type A test specimen with marked gauge length

2.1 Tensile test

Type A test specimens (Fig. 2) were prepared for tensile testing and tested using a Zwick Roell Z030 testing machine (Fig. 3). To measure the elongation of the test specimen during the test, the tensile testing machine is equipped with a videoXtens extensometer, which operates on a non-contact strain measurement principle. A detailed description of the testing procedure is provided in (Ambriško and Čabaníková, 2026). The test involves subjecting the specimen to tensile loading at a constant speed ($100 \text{ mm} \cdot \text{min}^{-1}$) until rupture, while measuring the applied force and the deformation – specifically, the elongation of the gauge length within the working section of the specimen. Three specimens were prepared for the test, cut in the longitudinal direction of the P630/3 4+2 conveyor belt. The belt has a strength of $630 \text{ N} \cdot \text{mm}^{-1}$, a carcass containing three polyamide (P) plies, and cover layer thicknesses of 4 mm (top) and 2 mm (bottom). Tensile strength is determined by recording the maximum force F_r at the moment of specimen rupture and subsequently dividing it by the original specimen width b_i . The belt strength f_s is calculated according to STN EN ISO 283 (2023) as follows:

$$f_s = \frac{F_r}{b_i} \quad (1)$$

where F_r – load on the test specimen at the moment of rupture [N],
 b_i – width of the working part of the specimen [mm].

Elongation at break is the extension of the specimen at the moment of failure; it is calculated according to STN EN ISO 283 (2023) as follows:

$$\varepsilon = \frac{L_2 - L_1}{L_1} \cdot 100 \quad (2)$$

where ε – elongation [%],

L_1 – initial gauge length [mm], $L_1 = 100$ mm,

L_2 – gauge length at break [mm].



Fig. 3 Zwick Roell Z030 testing machine

2.2 Flammability characteristics of conveyor belts

This test determined the direct-flame resistance of the P2000/4 8+4 rubber-textile conveyor belt (including its cover layers) using three rectangular test specimens measuring (300 ± 5) mm by (25 ± 1) mm. The test is performed by clamping the specimen vertically – aligned with its longitudinal axis – into the holder of the Wazau apparatus (Fig. 4a, b). The apparatus's burner is tilted at a 45° angle, with the burner nozzle positioned 50 mm from the bottom edge of the specimen (Fig. 4c). The belt has a tensile strength of 2000 N.mm^{-1} , a carcass consisting of four polyamide (P) plies, and cover layer thicknesses of 8 mm (top) and 4 mm (bottom).

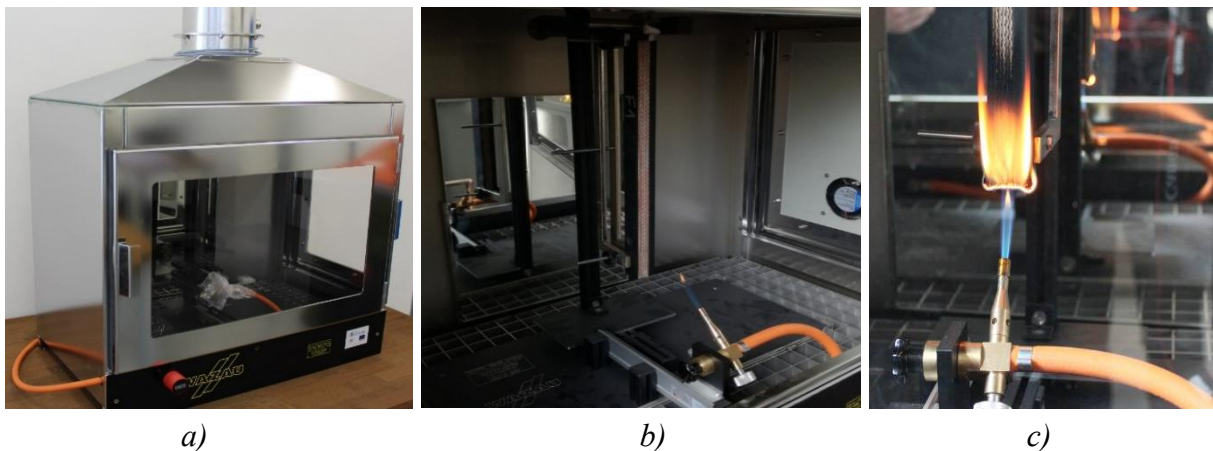


Fig. 4 Laboratory-scale flammability testing: a) Wazau apparatus, b) specimen clamped in the chamber before the test, c) close-up of the specimen during the test

The flame of a propane Bunsen burner at a temperature of $(1000 \pm 20) ^\circ\text{C}$ is applied to the test specimen for 45 s and then rapidly withdrawn so as not to affect the specimen's combustion. From this moment, the duration of after-flame and after-glow is measured over a period of 60 s. The test result is the sum of the after-flame times for the series of tests, which must not exceed 45 s, with no single specimen burning for longer than 15 s (STN EN ISO 340, 2022). Signs of any combustion are monitored for a further 60 s with the airflow in the Wazau apparatus chamber switched on.

2.3 Electrical conductivity of belts

This test measures the surface electrical resistance of a test specimen through which an electric current at a specified voltage (10 V) is passed using electrodes. A square test specimen measuring (300×300) mm, cut from the full thickness of the P2000/4 8+4 belt, was prepared for the test. The test was performed using a Tera-Ohmmeter TO 3 device (Fig. 5). Prior to measurement, a contact agent based on polyethylene glycol M600 (STN EN ISO 284, 2025) was applied to the specimen's surface. The electrical resistance of the specimen was recorded after 60 s.



Fig. 5 Tera-Ohmmeter TO 3 device

3. Results and discussion

The tensile properties of the conveyor belt under investigation are presented in Fig. 6. The full-thickness tensile strength f_s and elongation at break ε were determined for all three test specimens (1-3). The resulting tensile curves, documenting the uniaxial tensile loading of the specimens, are shown in Fig. 7. All specimens failed within the gauge length (between the reference marks), rendering the results valid. The tensile properties of the conveyor belt depend on the carcass material; the type of textile fibres in the longitudinal (warp) and transverse (weft) directions of the textile carcass significantly influences these properties, as the carcass bears all tensile loads acting on the conveyor belt.

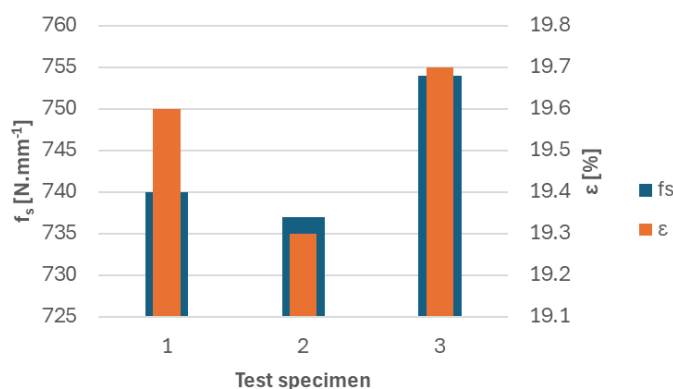


Fig. 6 Tensile properties of the conveyor belt

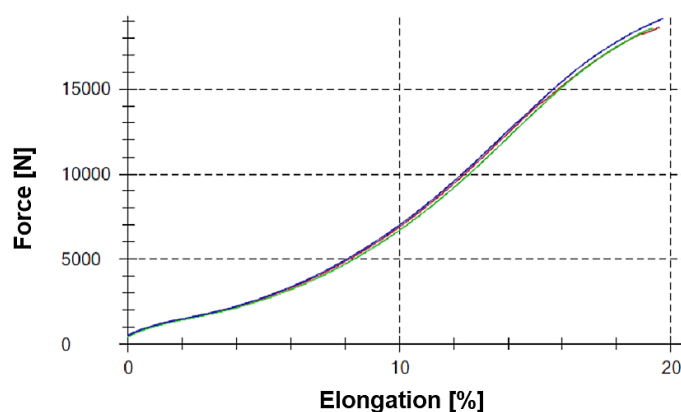


Fig. 7 Tensile curves for the three test specimens

The tensile strength and elongation values are the arithmetic means of the values obtained from the three test specimens. The tensile strength of the tested belt – 744 N.mm^{-1} – meets the required limit, exceeding the nominal strength by 18%. The elongation of 19.5% is consistent with the belt's carcass type, which consists of polyamide fibres in both the warp and weft directions.

The tested conveyor belt type did not meet the requirements for flame-resistant belts. The total after-flame time for all specimens following the removal of the burner was 180 seconds – exceeding the 45-second limit – with each individual specimen burning for a full 60 seconds, whereas the maximum permitted duration was 15 seconds. All three specimens exhibited continued burning during the 60-second airflow phase, with combustion persisting for approximately another 3 minutes after the airflow ceased. At the conclusion of the tests, the belt specimens showed significant damage (Fig. 8).



Fig. 8 Specimens at the end of the flammability test

The conveyor belt type under investigation complies with the requirements of the STN EN ISO 284 (2025) standard, which specifies a maximum electrical resistance limit of $3 \times 10^8 \Omega$ (i.e., 300 M Ω). A value of $49.94 \times 10^3 \Omega$ was measured for the tested specimen, indicating that the belt is sufficiently conductive to prevent the accumulation of static electric charge during operation.

4. Conclusions

Testing the physical properties of rubber-textile conveyor belts is a key tool for evaluating their quality, operational reliability, and service life. The materials constituting the

rubber composite – specifically the conveyor belt itself – ensure the physical properties required for transporting a given type of material. Tensile properties are crucial for specific operational applications. The tensioning force applied to the belt depends on its tensile strength. Belt component parameters, such as the number and type of textile carcass plies, the category of rubber cover layers, and the thickness of individual components, are designed to suit specific operating conditions. In the case of belts with textile carcasses, combinations of different fabrics are often used to achieve the required properties. This paper evaluates the tensile properties of the P630/3 4+2 conveyor belt and the flammability and electrical conductivity of the P2000/4 8+4 conveyor belt. Based on the results, the P2000/4 8+4 belt cannot be considered flame-resistant, but its electrical resistance meets the required limit.

The electrical conductivity of conveyor belts allows for the dissipation of static electric charges and prevents sparking, thereby reducing the risk of fires and explosions involving methane or coal dust in coal mines. It is one of the key safety parameters for mine conveyor equipment. The fire resistance of a conveyor belt enhances safety in coal mines by limiting the ignition and spread of fire, reducing the generation of smoke and toxic gases, protecting miners, and minimizing the risk of methane or coal dust explosions. Consequently, it is one of the most important characteristics of mine conveyor belts. Test results for rubber-textile conveyor belts are crucial for improving safety and fire prevention in coal mines, as they verify whether the belts meet the required safety parameters for operation in environments prone to explosions and fire.

Acknowledgement

This work was supported by the Scientific Grant Agency of the Ministry of Education, Research, Development and Youth of the Slovak Republic and the Slovak Academy of Sciences as part of the research projects VEGA 1/0114/25 and VEGA 1/0728/24, and by the Slovak Research and Development Agency under contracts No. APVV-18-0248 and APVV-23-0342.

References

- Ambriško, L., Čabaníková, L., 2026. Influence of belt construction on strain rate during tensile testing of rubber-textile conveyor belts. *Applied Sciences*, 16(8), 3983.
- Ambriško, L., Marasová, D., Grendel, P., 2016. Determination the effect of factors affecting the tensile strength of fabric conveyor belts. *Eksplatacja i Niezawodność - Maintenance and Reliability*, 18, pp. 110-116.
- Andrejiová, M., Grincová, A., Marasová, D., Kimaková, Z., 2025. Machine learning methods as a tool for analysis and prediction of impact resistance of rubber-textile conveyor belts. *Applied Sciences*, 15(15), 8511.
- Barros-Daza, M.J., Luxbacher, K.D., Lattimer, B.Y., Hodges, J.L., 2022. Mine conveyor belt fire classification. *Journal of Fire Sciences*, 40(1), pp. 44-69.
- Lemmi, T.S., Barbarski, M., Kabzinski, A., Frukacz, K., 2021. Effect of vulcanization process parameters on the tensile strength of carcass of textile-rubber reinforced conveyor belts. *Materials*, 14(24), 7552.
- Marasová, D., Taraba, V., Grujič, M., Fedorko, G., Bindzár, P., Mikušová, N., 2006. Belt transport (original in Slovak), FBERG TUKE, Košice.
- Ryba, T., Bzinkowski, D., Siemiątkowski, Z., Rucki, M., Stawarz, S., Caban, J., Samociuk,

- W., 2024. Monitoring of rubber belt material performance and damage. *Materials*, 17(3), 765.
- STN EN ISO 283, 2023. Textile conveyor belts - Full thickness tensile strength, elongation at break and elongation at the reference load - Test method (ISO 283:2023).
- STN EN ISO 284, 2025. Conveyor belts - Electrical conductivity - Specification and test method (ISO 284:2025).
- STN EN ISO 340, 2022. Conveyor belts - Laboratory scale flammability characteristics - Requirements and test method (ISO 340:2022).
- Wang, J., Li, S., Yang, L., Liu, B., Xie, S., Qi, R., Zhan, Y., Xia, H., 2024. Graphene-based hybrid fillers for rubber composites. *Molecules*, 29(5), 1009.