

## Abstract

**Subject:** Development and implementation into production of modern door systems intended for implementation in rail vehicles.

The work concerns the development and implementation of modern door systems for rail vehicles, with particular emphasis on testing the mechanical properties of aluminum alloys used in their construction. The basic materials used in the research were aluminum alloys 6060 (in T6 and T64 states) and 6063 (in T6 state), commonly used in door profiles and railway structures. The work included a detailed analysis of their microstructure, tensile tests, fatigue and impact tests. The results showed that heat treatment in the T6 state significantly increases fatigue strength and crack propagation resistance, while the T64 state improves plasticity at the expense of lower strength parameters. Cyclic bending and torsion tests confirmed that the durability of alloys is strongly dependent on the type of load and microstructure of the material, and that the fatigue process is gradual, which allows for diagnostics during operation.

The phenomena of cracking after impact loads and the facts of fractures were also analyzed, which made it possible to determine the mechanisms of material degradation under dynamic conditions. The test results provided the basis for developing recommendations for the selection of aluminum alloys and their heat treatment parameters for door structures.

In the application part, the work focused on three key types of systems: driver's cab doors, swing-sliding doors, and fire-resistant doors. Bench tests of pressure resistance, fire tests of innovative barriers and fire walls, and thermal insulation analyses were performed. The results showed that the use of optimized aluminum profiles and fire-resistant composites enables compliance with the requirements of PN-EN 45545 in terms of tightness and fire resistance, and also ensures high thermal insulation of the driver's cab door.

The conclusions indicate that the appropriate selection of aluminum alloys and processing technologies is key to increasing the service life of door systems. Innovative material solutions reduce the weight of the structure, improve fire safety, and reduce the life cycle costs of rail vehicles. The work proves that an interdisciplinary approach, combining material research, fatigue analysis, and operational testing, enables the effective implementation of new generations of door systems in rail transport.