



#190 / General poster

TOPIC : Fires in energy systems and industrial installations (including electrical vehicles, hydrogen, photovoltaics, wind turbines, manufacturing and storage facilities)

Derivation of Fire Exposure Curve for Evaluating Fire Resistance of Underfloor Structure Based on LTO Battery Fire Tests for Railway Vehicles

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PURPOSE OF THE ABSTRACT

This study organizes hierarchical fire-test data for large-capacity Lithium Titanate Oxide (LTO) battery systems used in railway vehicles, such as trams, and proposes a procedure for deriving a fire-exposure curve to evaluate the structural fire resistance of the vehicle underfloor.

The tested battery system consists of cells (20 Ah), modules (2p12s), packs (27 series-connected modules), and sub-systems (3p pack configuration). To quantify thermal runaway and fire propagation characteristics, hierarchical fire tests were conducted from the cell level to the sub-pack level. In the cell-level tests using heaters, no flame propagation to adjacent cells was observed. However, in module and sub-pack tests employing an ethanol pool fire to simulate external fire scenarios, fire propagation occurred when the surface temperature exceeded approximately 400 °C. Notably, in the sub-pack test where ethanol combustion overlapped with battery thermal runaway, the maximum Heat Release Rate (HRR) reached approximately 1.8 MW, demonstrating significant thermal feedback to adjacent structures.

Based on these empirical data, this study derives a fire resistance performance curve that reflects the specific behavior of battery fires (rapid temperature rise followed by a long plateau and gradual decay), distinguishing it from standard curves such as ISO 834 or RABT. The derivation process involves correcting HRR data to account for the limitations of oxygen consumption calorimetry and converting the heat flux into an equivalent exposure temperature by considering radiative, convective, and conductive heat transfer between the battery pack and the vehicle underfloor structure. The resulting curve integrates the requirements of EN 45545-3 with performance-based design principles, providing a direct metric for securing the structural fire safety of railway vehicles.

Figure 1 shows the status of the fire test at the pack level.



FIGURE(S)

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Status of the fire test at the pack level

KEYWORDS

Railway Vehicles | Fire Exposure Curve | LTO Battery

BIBLIOGRAPHY

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