

Improving Firefighter Protection

Development of small-scale testing for the particle penetration of personal protective equipment (PPE) clothing using standardised combustion from cone calorimeter

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Toxic smoke particles can penetrate firefighter PPE ^{1,2}. This study presents a novel, small-scale method using cone calorimeter-generated smoke to assess textile resistance to particle and polycyclic aromatic hydrocarbons (PAH) penetration in a controlled, standardised setup.

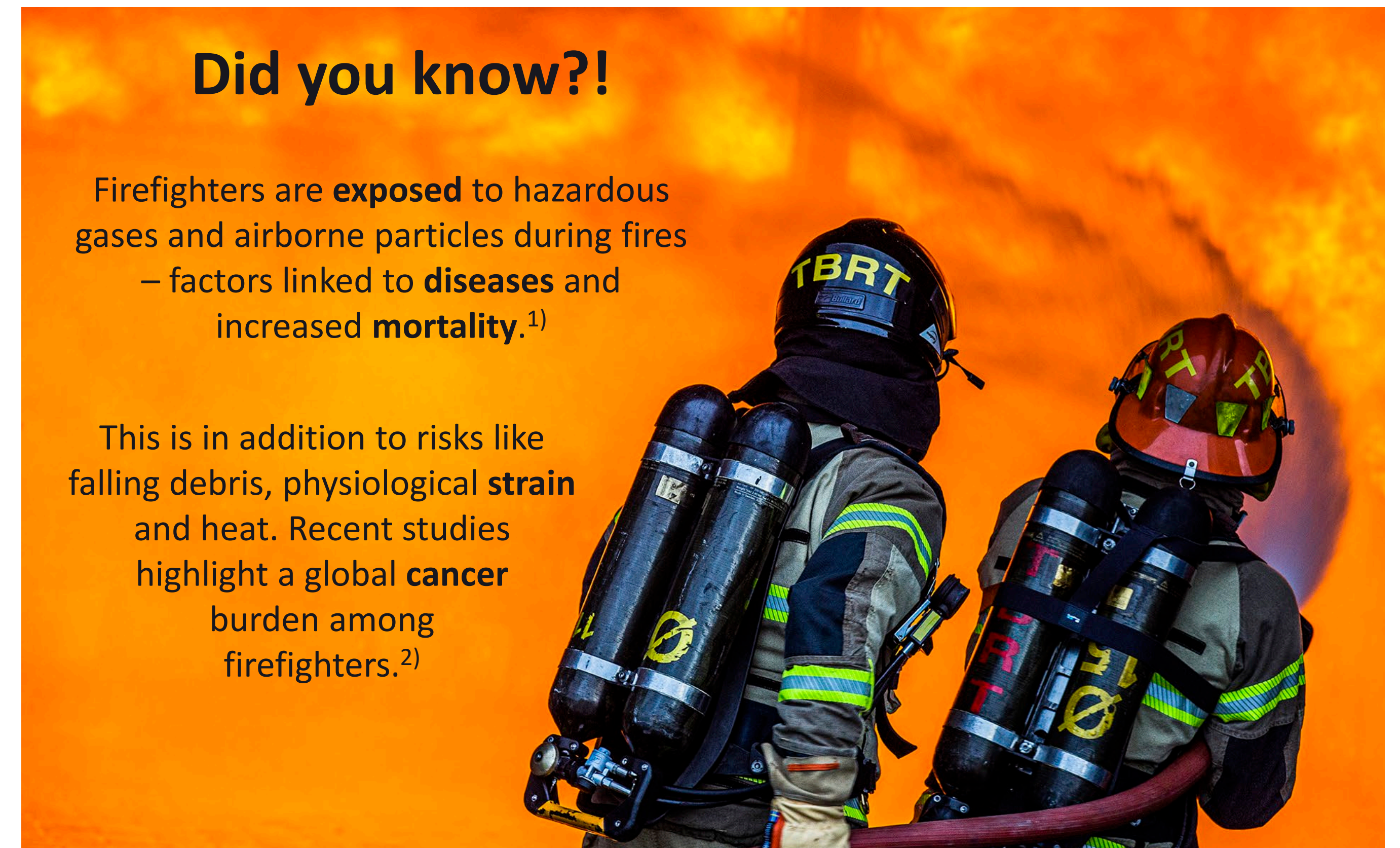


Generation of “standardised” smoke with the cone calorimeter according to ISO 5660 (right). Mixed cubic-shaped fuel consisting of wood, PVC plastic and foam mattress (left). Photo: RISE Fire Research

Smoke from burning wood, PVC plastic and foam mattress (see figure above) passes through an exposure box with the textile mounted inside (below). Particle levels and other parameters are measured on both sides to assess protective performance. Fire and smoke data (heat release, temperature, humidity, smoke production rate) are also monitored.



The exposure box where the textile specimen is positioned (left). The two different layers used in the experiment: PPE for firefighter (top) and wool undergarments (bottom). Photo: RISE Fire Research



Did you know?!

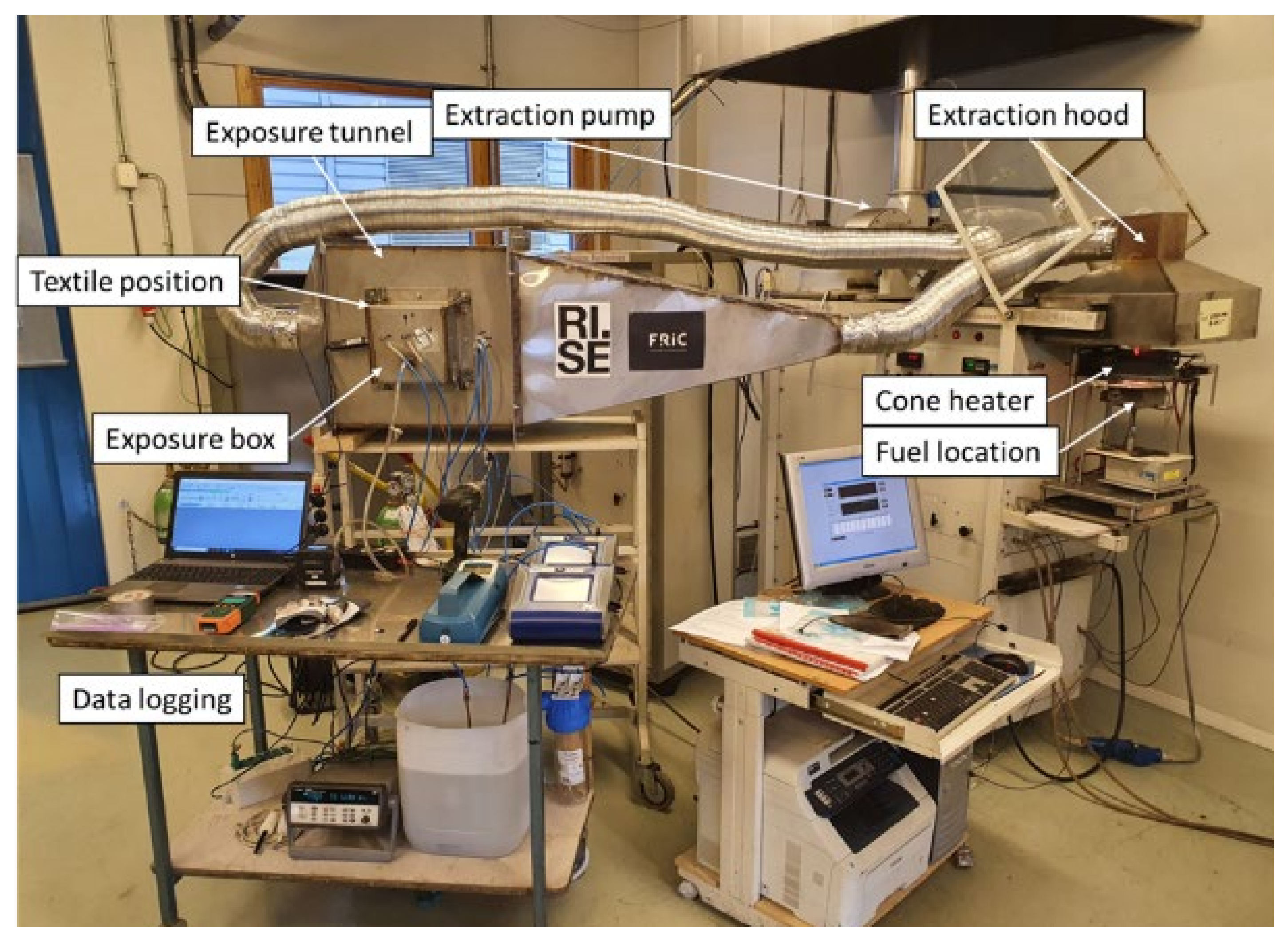
Firefighters are exposed to hazardous gases and airborne particles during fires – factors linked to diseases and increased mortality.¹⁾

This is in addition to risks like falling debris, physiological strain and heat. Recent studies highlight a global cancer burden among firefighters.²⁾

Photo: TBRT

Key conclusions:

- **Relevant** for the purpose: The Method generates standardised smoke and measures particle penetration.
- **Promising** for PPE screening, but **challenges** with repeatability and cost remain.
- Further improvements needed for practical, low-cost application (**discussed** in the full paper³⁾).



The experimental setup: Smoke is generated and transported into a smoke exposure tunnel, and into an exhaust duct. The textile position is inside an exposure box. Data on the generated fire and smoke, data on the conditions in the exposure tunnel, as well as on the textile's protective performance are collected. Photo: RISE Fire Research

1) Laroche, E. and S. L'Espérance (2021). 'Cancer Incidence and Mortality among Firefighters: An Overview of Epidemiologic Systematic Reviews'. Int. J. of Env. Research and Public Health 18 (5): 2519.

2) Jahnke, Sara A, Nattinee Jitnarin, Christopher K Haddock, Christopher Kaipust, Walker S Carlos Poston, Brittany S Hollerbach, Carolyn Crisp, and Brittni Naylor Metoyer. 2024. 'Meta-Analysis of Incidence and Mortality of Firefighter Cancer: An Update on Emerging Science'. Asian Pacific Journal of Cancer Prevention: APJCP 25 (3): 801.

3) E. Aamodt, T. Li, and R. F. Mikalsen, 'Development of small-scale testing for the particle penetration of personal protective equipment using a standardised combustion from a cone calorimeter, in Proceedings of the 35th European Safety and Reliability Conference (ESREL 2025), Stavanger, Norway, 2025

