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Gas temperatures in heavy goods vehicle fires in tunnels

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Abstract

Large-scale fire tests were carried out with heavy goods vehicle (HGV) cargos in the Runehamar tunnel in Norway. The tunnel is a decommissioned, two-way-asphalted road tunnel that is 1600 m long, 6 m high and 9 m wide, with a slope varying between 0.5% uphill and 1% downhill. In total four tests were performed with fire in an HGV set-up and a longitudinal ventilation flow of approximately 3 m/s. In three tests, mixtures of different cellulose and plastic materials were used; in the fourth test a commodity consisting of furniture and fixtures was used. In all tests the mass ratio was approximately 82% cellulose and 18% plastic. A polyester tarpaulin covered the cargo.

One purpose of the large-scale tests was to obtain new relevant gas temperature-time data from large-scale HGV fires in tunnels. There is presently a lack of such information for road tunnels. The maximum heat release rates produced by the four different fire loads varied between 66 and 202 MW resulting in maximum gas temperatures at the ceiling ranging between 1281 and 1365 °C. A comparison with literature values shows that the gas temperatures obtained here are uniformly higher than those obtained in other similar large-scale test series conducted using solid materials. A mathematical correlation of a temperature–time curve is given and this is the best representation of the measured temperature and a combination of frequently used temperature curves for tunnels (the HC curve and the RWS curve).

Keywords: Tunnel; Fire; Temperature; Vehicle; Semi-trailer; Large-scale Experiments

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Nomenclature

c_p	Heat capacity (J/kg K)
k	time width coefficient (1) (1/min)
N	number of terms in the summation in Eq. (1)
n	retard index (in Eq. (1)) (-)
r	amplitude coefficient (in Eq. (1)) (°C)
T	gas temperature (°C in Eq. (1), K in Eq. (2))
t	time (min)

Abbreviations

HC	hydrocarbon (as in the hydrocarbon curve)
HGV	heavy goods vehicle
HRR	heat release rate
PE	polyethene
PS	polystyrene
PUR	polyurethane
RABT	richtlinien für die Ausstattung und den Betrieb von Straßentunneln
RWS	rijkswaterstaat
UPTUN	cost-effective, sustainable and innovative upgrading methods for fire safety in existing tunnels
ZTV	zusätzliche Technische Vertragsbedingungen und Richtlinien für den Bau von Straßentunneln

1. Introduction

In recent years, a number of road tunnel fires have occurred throughout Europe with catastrophic outcome, including those in the Mont Blanc tunnel between France and Italy with 39 deaths (1999), the Tauern tunnel in Austria with 12 deaths (1999) and the St. Gotthard tunnel in Switzerland with 11 deaths (2001). In these fires the cargo in heavy goods vehicle (HGV) trailers played a major role in the outcome. The main reason being that the trailers contain a very high fire load and the fire could easily spread with the assistance of the ventilation. The rescue services also had great difficulty reaching the fire due to the enormous heat and smoke and the fast development of the fire, which also makes it difficult for people inside the tunnel to escape from the fire and from the smoke. The gas temperatures are not known in these fires but from the damage on the tunnel linings it can be concluded that they must have been high. Our knowledge of the gas temperature elevations in tunnel fires involving HGVs is also fairly limited as there has been only one large-scale test series using fully loaded HGV trailer performed previously [1].

Road tunnels are often covered with some type of lining, but the purpose of this lining can vary from one tunnel application to another. In some cases it is only a thin