4. TUNNEL FIRES

4.1. BACKGROUND

Tunnel fires have long been a key focus in discussion of tunnel safety. In *chapter 4* a short characterisation of tunnel fires is presented, followed by a discussion of relevant influencing factors and a list of data that should be collected on tunnel fires. The main part of *chapter 4* is concerned with data on tunnel fires, in particular fire rates.

International data and statistics on tunnel fires have been collected and published by PIARC in 1999, (PIARC doc. 05.05.B – Fire and Smoke Control in Road Tunnels) [7]. The report has been a key reference document for estimating basic fire rates in tunnels and is now more than 15 years old. In the report data are given for selected tunnels in selected countries.

Since 1999, the range and quality of data on tunnel fires has increased. For 12 countries, comprehensive information on tunnel fires could be collected and evaluated during the development of this report. The aim is to present statistical data on fire incidents in tunnels from different countries and other information which may be useful to describe the characteristics of real tunnel fires so that parameters of fire risk can better be estimated and handled adequately for instance in risk analyses, in the tunnel design phase as well as in the tunnel operation phase. Feedback from experience with fires can also serve as basis for evaluation of tunnel operation, action of emergency services as well as user behaviour

In the following focus is given to updating fire rates rather than discussing the consequences of fires, because the consequences of a specific tunnel fire are very much dependent on the specific circumstances of an individual event. As tunnel fires are rare events, an entirely statistical approach to the assessment of consequences of tunnel fires is not likely to be sufficient.

4.2. CHARACTERISTICS OF TUNNEL FIRES

The discussion on tunnel fires is often dominated by the extreme events which occurred in the Mont Blanc tunnel, the Tauern tunnel and the Gotthard Tunnel. However, in reality the majority of tunnel fires are relatively small events in comparison, which nevertheless may have the potential to develop into more serious events, depending on various influencing parameters. The confined space of a tunnel provides an environment in which untenable conditions may develop rapidly in case of a fire. Series of real fire tests have been performed in the context of various national and international research programs in order to confirm assumptions on fire sizes and fire behaviour; in these tests the focus again was on large scale fires with high heat release rates. These trials are performed under certain conditions and the results need to be verified by data on real fires in terms of fire statistics.

The collection of data for these statistical purposes requires a more stringent definition of events which should be considered as fires. Today there is different practise in different countries on what event is recorded as a fire and what is not (for the definition of the term "*fire*" in the context of this report see *chapter 1.2*). There is also different practice on how fires are detected and if the cause of the fire is recorded or not. The fire size is often not estimated nor recorded, so the fire size in many cases has to be estimated based on indicators. The different practises in the data collection can be explained by different factors, such as different tunnel locations (urban or rural), traffic density, varying level of monitoring due to tunnel length, etc. For a further improved understanding the frequency and severity of tunnel fires, it may be necessary to analyse fire occurrences, fire load, heat release rate, fire duration and development and possibly also fire causes and their consequences.

Some relevant key factors for the characterisation of tunnel fires are the following:

Development of fire
- Development speed:
  - slow development with smoke
  - rapid development
  - explosive development

Fire size
- fire load
- fully developed fire
- not fully developed fire
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Fire causes:
- Collision
- Vehicle defect triggering a fire e.g. engine fire / overheated breaks etc.

The speed of fire development and the fire size are of significant importance with regard to tunnel safety. Both are influenced by the nature of the fire load, the technical conditions of the vehicles involved, the airflow conditions in the tunnel during fire development as well as the fire safety engineering design of the specific tunnel.

The maximum heat release rate of a fire depends on the quantity and type of material of the fire load as well as the boundary conditions of oxygen supply, tunnel characteristics and system response etc. Fires in personal vehicles rarely develop to high heat release rates, whereas fully developed fires in the cargo of heavy goods vehicles and pool fires potentially can develop into very high heat release rates.

The two types of tunnel fires (triggered by a collision or a vehicle defect) can be distinguished with regards to their characteristics: fires resulting from vehicle defect typically start in engine, exhaust system, wheels or brakes; seldom in the load. These fires in most cases are shielded fires which are likely to develop slowly in the first phase, with progressive development in later phase resulting in a fully developed fire. This type of fire development increases the opportunity to extinguish a fire (or delay its further development) either by the use of manual fire extinguishers, fixed fire-fighting systems and/or by responding fire fighters, before it is able to threaten the health and safety of people in the tunnel. Fires after collisions are often accelerated by (limited amounts) of fuel that has leaked as a result of the collision, hence the development is typically faster. Flammable liquid fires, i.e. pool fires with large amounts of flammable liquids, are extremely rare occurrences, which require a large amount of flammable liquid to be released (as a consequence of a collision or by other reasons).