In general there is a significant uncertainty associated with the recording of the fires and the resulting fire rates. As explained in section 4.7 some fires may not have been registered ('dark' numbers), this phenomenon causes the estimated fire rates to be a lower bound value. Other differences in fire rates may be results of differences in tunnel design, driving culture, vehicles etc. in the different countries/tunnels.

4.6. TYPE AND SEVERITY OF FIRE EVENTS

In addition to the estimate of fire frequency rates for all vehicles and for HGVs, it is of interest to estimate the type and severity of fires. Estimates, registrations and expert judgements in this respect are reported in the *appendix 4.1*, particularly from Austria, South Korea, and to some extent from Norway and the Netherlands.

The causes of fires in Austria were recorded, and it was shown that a large majority of the fires (60 of 68) were caused by vehicle defects. 6 fires were a result of collisions (5 with passenger vehicles, 1 with an HGV) and for 2 fires the cause was unknown. This means that 90% of all fires were caused by self-ignition and 10% were caused by collisions.

The self-ignition was measured in relation to breakdowns. Whereas passenger cars have 1.5 self-ignitions per 1000 breakdowns, HGVs have 9.9 self-ignitions per 1000 break-downs. The rate of self-ignition for HGVs is influenced by the gradients of the route leading towards the tunnel. The rate of fires caused by self-ignition is thereby 3 – 6 times higher for HGVs than for passenger vehicles (based on the Austrian and French data). The data from Norway revealed only 1.5 – 2 times higher fire rates for HGVs compared to passenger cars.

As examples of the distributions, the recordings from Austria, South Korea and Italy are shown in *table 7, table 8, table 9*.

TABLE 7: DISTRIBUTION OF FIRE SEVERITIES FROM THE AUSTRIAN STATISTICS

Fire severity	nonHGV	HGV
Outside*	6 %	25 %
0-1 MW	58 %	37 %
5MW	36 %	23 %
30MW		14 %
100MW		1 %
	100 %	100%

** In the Austrian statistics tunnel fires are registered even though the vehicle on fire has come to standstill outside the tunnel just before entering or just after exiting.*

TABLE 8: DISTRIBUTION OF FIRE SEVERITIES BASED ON DATA COLLECTED FROM THE TUNNELS ON THE SOUTH KOREAN EXPRESSWAYS

Fire severity	nonHGV	HGV
1 MW	77%	17%
5MW	23%	42%
25MW		33%
50 MW		8%
100MW		
200MW		
	100%	100%

TABLE 9: DISTRIBUTION OF FIRE SEVERITIES ACCORDING TO ITALIAN ANAS GUIDELINES [48]

Fire severity	nonHGV	HGV
0-1 MW	40%	85%
5 MW	59%	
8 MW	1%	
15 MW		12%
30 MW		2%
50MW		1%
	100%	100%

It should be mentioned that there is a much higher degree of uncertainty in the numbers describing fire size than in the fire rates, because the information on fire size often is scarce and imprecise in the fire data recordings.

It shall be pointed out, that this information is in particular relevant for risk assessment, because it influences the results for fire risk modelling significantly. The data reflects the situation which can be expected in a road tunnel, without specific measures influencing fire development (like early fire-fighting or active fire-fighting systems). A clear distinction has to be made to the design fire size, which is a deterministic value defined in prescriptive regulations, which serves as a basis for design requirements (e.g. the layout of a tunnel ventilation system).

4.7. DARK NUMBERS / MONITORING

It is a possibility that some tunnels have had fires even though the fires do not appear in the statistics. These missing data may be described as ‘dark numbers’.

The registered fire rate is strongly dependent on the monitoring, see *illustration 9* (taken from the Norwegian data, where tunnels with and without monitoring are distinguished). The difference between the fire rate in tunnels with and without monitoring can give an idea about the dark numbers. On the assumption that the event rate for all tunnels would be the same as in the tunnels with monitoring, the dark numbers appear to be more than twice the actual recorded numbers.