THE RISKS FROM THE TRANSPORT OF DANGEROUS GOODS IN GREAT BRITAIN: AN UPDATE

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It is almost a decade now since the Health and Safety Commission (HSC) published a report by its Advisory Committee on Dangerous Substances (ACDS) on the 'Major hazard aspects of the transport of dangerous substances'. The report assessed the national risks from the transport of toxic and flammable substances by road and rail in Great Britain. Although none of the risks examined were intolerable, it was concluded that, in most cases, the risks should still be reduced to a level as low as is reasonably practicable. The report included a number of recommendations on risk reduction measures.

The transport data for the HSC report dated from the mid-late 1980's. Since then significant changes have taken place in the transport of dangerous goods in Great Britain (not least being the disappearance of chlorine and ammonia from the rail network). This paper examines the conclusions of the HSC report in the light of more recent data, from the mid 1990s, and seeks to determine whether national risks remain tolerable.

Keywords: risk, transport, carriage, dangerous substances/ goods

INTRODUCTION

In the mid-1980s, the European Seveso Directive[1] defined a major hazard installation in terms of threshold inventories of dangerous substances stored or processed at a site. Those thresholds were similar to, or exceeded by, the quantities transported in road and rail tankers in Great Britain. In order to assess the risks of carrying dangerous goods throughout the transport network, the Health and Safety Commission (HSC) initiated a study by its Advisory Committee on Dangerous Substances (ACDS). The report, [2] published in 1991, applied and developed quantitative risk assessment techniques to determine the national level of risk. The report set a benchmark in its conclusion that the bulk transport of four representative substances by road and rail did not present 'intolerable' individual or societal risks. Although the risks were assessed as 'tolerable,' very few of the risks were considered to be 'negligible'. Therefore, measures were needed to reduce them within the framework of control established in Great Britain. The criterion applied is that of 'reasonable practicability', that is to say, taking due account of costs, a measure to reduce risks should be implemented provided the costs are not in 'gross disproportion' to the benefit achieved. An implication of the requirement to reduce residual risks to a level as low as is reasonably practicable (ALARP) is an on-going need to monitor the level of risk to ensure that changes in the underlying situation are taken into account and any alterations in risk are reviewed.

It is now more than 10 years since some of the rail and road data were collected for the HSC report. Significant changes in the underlying situation have taken place. The rail industry has been privatised. Rail passengers and freight traffic have seen ups and downs during the decade. Now, after a period of uncertainty, an upward trend in rail passenger and freight traffic is emerging. On the roads, a moratorium on major road building was introduced. Overall road traffic volume, as measured by the average daily flow of vehicles, increased by 50% between 1981 and 1996 in Great Britain. This was due mainly due to the increase in private car ownership which, at 375 cars per thousand population (in 1994), is a slightly lower rate than the EU average [3]. Despite the increased traffic, the annual number of fatalities in road accidents fell to 3,421 in 1998, the lowest figures since records began 70 years ago and 39% lower than the 1981-85 baseline figure [4].

METHODOLOGY

RAIL TRAFFIC DATA

The HSC report selected chlorine, ammonia and liquefied petroleum gas (LPG) as potentially the most hazardous substances transported. Motor spirit was chosen as the dangerous substance carried in the greatest quantities. In order to compare the changes in the levels of risk in the decade since the traffic data for the HSC report were collected; the data for the same dangerous substances were resurveyed [5]. This task was not straightforward, as these data are not collected as part of the normal reporting procedures. On the rail network, the most significant changes were the cessation of both chlorine and ammonia transport. The changes in the transport of flammables by rail are summarised in Table1.

TABLE 1 Flammables Traffic by Rail

	LPG		Motor Spirit	
	1985	1994	1985	1994
Total Loaded wagon km	1,390,590	2,756,144	10,199,095	9,764,500
Total tonnes	113,140	245,736	2,910,196	2,643,600
Journeys per year	4,334	11,212	55,814	35,248
Tanker Capacity te				
2-axle	20	20	32	32-35
4-axle (bogie mounted)	40	40	75	75

Over the period surveyed, the transport of motor spirit by rail declined, although some of the reduction in traffic was attributable to the greater use of larger capacity tankers. Nevertheless, in 1998, one of the larger refineries announced plans to close its rail export terminal. The pattern of rail traffic in motor spirit also changed. Route lengths now tend to be longer and the major route i.e. the route carrying the most traffic, has altered. By 1994, the Humberside to Berkshire route had replaced the major route identified in the HSC report from Merseyside to Leeds and Humberside. Although a similar proportion of the national traffic, in terms of 'loaded tanker- kilometres' (~20%) was carried on the major route, the tonnage of motor spirit carried had fallen by 10% when the two surveys were compared.

In contrast, the tonnage of LPG transported by rail has more than doubled over the same period. Again, the major route has changed with a very high proportion of the national traffic travelling from Dorset to Avon now that the gas condensate field supplying the route has come fully on stream. Details of the representative routes are shown in Table 2.

TABLE 2 Representative routes for rail transport

Representative Routes	LPG		Motor Spirit	
	1985	1994	1985	1994
Major Route	Hampshire-Midlands	Dorset -Avonı	Merseyside-Leeds-Humberside	Humberside-Berkshire
Route Length km	329	237	223	405
tankers/yr	1,323	10,137 x 20te	5,300 x 32te 3,900 x 75te	5,200 x 75 te
tanker- km/yr	435,267	2,402,469ı	2,051,600	2,106,300
% national traffic	31	87	20	22

ROAD TRAFFIC DATA

The transfer of chlorine traffic from rail to road inevitably increased road movements substantially. One main haulier now makes deliveries in higher capacity tankers and, on average, the journeys have become longer. Anhydrous ammonia traffic by road, on the other hand, has fallen despite the cessation of rail traffic. This is due to the reduction in usage of ammonia as ammonium nitrate imports led to the closure of manufacturing plants in Britain. Again, the size of cargoes has increased, so that overall, 25% fewer journeys are now made than before. The data for road transport of toxic products is summarised in Table 3.

TABLE 3 Toxics Traffic by Road

	Chlorine		Ammonia	
	1987	1994	1987	1994
Total Loaded tanker km	1,121,358	2,012,500	632,233	503,520
Total Deliveries tonnes	169,438	230,000	45,061	34,620
Journeys per year	9,871	11,500	2,974	2,098
Mean loaded Journey km	114	175	213	240
Tanker Capacity te	17	20	15	16.5

The total tonnage of LPG transported in bulk by road remained relatively unchanged on trunk routes, the larger tanker capacity effectively balancing the smaller number of journeys needed. However, the pattern of transport altered with the onward distribution of LPG from the terminals supplied by the trunk routes being undertaken in smaller tankers to the end consumer. This break bulk traffic, in small 6 to 7.5 tonne tankers, accounted for more than half the total tonnage delivered to consumers. Such tankers now complete in excess of 92,000 journeys per year. The traffic is summarised in Table 4.

The first impression of the transport of motor spirit by road is that the total tonnage has declined considerably since the HSC report. Given the growth in road traffic, consuming this fuel, this is unlikely to be the case. The explanation appears to be that the 1987 HSC figure (derived from 50% of all petroleum products transported) was an over-estimate. According to the UK Petroleum Industry Association (UKPIA) data for 1987 [5], only 22.2 million tonnes were transported by road. Therefore, it is more likely that the tonnage has remained reasonably constant, although tanker capacities have increased, as have the lengths of journeys.

TABLE 4 Flammables Traffic by Road

	LPG		Motor Spirit	
	1987	1994	1987	1994
Total Loaded tanker km	19.5×10^6	16.2×10^6	82×10^6	129×10^6
Total tonnes	955,000	1,446,000	32×10^6 (22.2)* $\times 10^6$	22.8×10^6
Journeys per year	63,667	76,106	1.3×10^6	1.4×10^6
Mean loaded Journey km	307	213	64	92
Tanker Capacity te	15	19	20-25	20-28

* UKPIA: total motor spirit delivered in 1987 (ACDS assumed a value of half of all petroleum products delivered in the same year)

RAIL RISK ASSESSMENT

The spreadsheets used to assess the risks for the HSC report were modified to remove inconsistencies and to improve the modelling. Further directional events were added. Population surveys were reassessed and updated. New surveys were undertaken where the major routes had changed. As noted above, the transport of liquefied chlorine and ammonia by rail had ceased.

SOCIETAL RISK FROM THE TRANSPORT OF LPG

Societal risk results have been calculated for the off rail, rail passenger and total population (i.e. both off rail plus passengers), on the Dorset to Avon and Hampshire to Midlands routes. Supplementary route information was supplied by the rail operator and the off rail population data was updated.

The total societal risk from the transport of LPG on both routes, scaled up to the national traffic in LPG is shown in Table 5. The national comparison between the previous study and the current traffic are shown in Figure 1 (for this and subsequent figures, the results are 'faired' to permit direct comparison). There is clearly an increase in overall risk due to the increase in traffic.

TABLE 5 Total National Societal Risk from the Transport of LPG by Rail
(Dorset to Avon and Hampshire to Midlands Routes)

Frequency of N or more fatalities (*10^6 per year)						
N	>= 1	>= 3	>= 10	>= 30	>= 100	>= 300
Off Rail	2,534	1,596	1,009	477	151	57
Passengers	944	942	936	880	51	0
Total	2,943	2,299	1,867	1,331	229	57

SOCIETAL RISK FROM THE TRANSPORT OF MOTOR SPIRIT

Sixteen significant trunk routes were identified, forming the majority of the national rail traffic in motor spirit. The national traffic was used to scale up the risk from the representative route and the results are listed in Table 6. The increase in risk, shown in Figure 1, appears to be due to the increase in the length of journeys and greater usage of larger capacity tankers on the bulk routes than formerly.

TABLE 6 Total National Societal Risk from the Transport of Motor Spirit by Rail

Frequency of N or more fatalities (*10^6 per year)				
N	>= 1	>= 3	>= 10	>= 30
Total	25,131	15,041	5,763	0

ROAD RISK ASSESSMENT

SOCIETAL RISK FROM THE TRANSPORT OF CHLORINE

Five major road routes were identified. The Runcorn to Amlwch route, which carried 60% of the national rail traffic in the HSC report, accounted for only 20% of the national road traffic in 1994. Societal risk results have been calculated for the off road, on road and total population on the Runcorn to Amlwch route, scaled up to the national traffic and average route length. The national societal risk is outlined in Table 7. A comparison of the levels of risk in the two studies is shown in Figure 2. This shows an increase in risk due to the increase in traffic.

TABLE 7 Total National Societal Risk from the Transport of Chlorine by Road

Frequency of N or more fatalities (*10^6 per year)							
N	>= 1	>= 3	>= 10	>= 30	>= 100	>= 300	>=1000
Off Road	126	75	65	30	12	7	2
On Road	168	114	98	85	28	13	0
Total	191	142	131	100	49	17	2

SOCIETAL RISK FROM THE TRANSPORT OF AMMONIA

Anhydrous ammonia was transported by road on three major routes in 1994. A route was selected as representative, based on up-to-date information from the operators. Adjusted to national traffic and the average route length, the national societal risk is summarised in Table 8 and compared with the results from the earlier study in Figure 3. The reduction in risk reflects the fall in traffic.

TABLE 8 Total National Societal Risk from the Transport of Ammonia by Road

Frequency of N or more fatalities (*10^6 per year)						
N	>= 1	>= 3	>= 10	>= 30	>= 100	>= 300
Off Road	35	27	13	5	1	0
On Road	161	122	122	34	8	0
Total	191	143	132	37	12	0

SOCIETAL RISK FROM THE TRANSPORT OF LPG

In the time available for this project, we were unable to examine the risks from the smaller 6 to 7.5 tonne tankers. The results in Table 9 are based on the conservative assumption that all the national traffic is carried in 19 tonne tankers. From Figure 4, it is clear that, despite this assumption, there has been little change in the level of national societal risk arising from the transport of LPG by road.

TABLE 9 Total National Societal Risk from the Transport of LPG by Road

Frequency of N or more fatalities (*10^6 per year)						
N	>= 1	>= 3	>= 10	>= 30	>= 100	>= 300
Off Road	2,631	1,242	540	182	84	25
On Road	6,505	6,485	5,320	4,082	1,601	174
Total	6,589	6,559	5,571	4,142	1,660	238

SOCIETAL RISK FROM THE TRANSPORT OF MOTOR SPIRIT

The population densities along two of the typical routes, assessed for the HSC study, were resurveyed in order to include a wide range of roadside population densities in the representative result shown in Table 10. The increase in the loaded tanker-km has produced an apparent increase in risk as shown in Figure 5.

TABLE 10 Total National Societal Risk from the Transport of Motor Spirit by Road

Frequency of N or more fatalities (*10^6 per year)				
N	>= 1	>= 3	>= 10	>= 30
Combined	130,940	14,606	5,486	0

DISCUSSION

When the previous HSC study was undertaken, working parties were set up to ensure rigorous examination and debate of the results. In the absence of such working parties for the present study, we had to make some important assumptions. The reported data for releases from tankers were not considered to be sufficiently reliable to update the release frequencies derived for the previous HSC report. Consequently, we continued to use the release frequencies from the previous report in the present update. This may tend to over-estimate the level of risk in some instances. For example, the effect of changes to tanker design and driver training, introduced specifically to reduce the major contributors to the overall risk as highlighted in the HSC report, was not taken into account. A project has been initiated to derive up-to-date release frequencies but the work was not completed in time for this paper.

It is of interest to examine the effect of the transfer of liquefied toxic gas traffic from rail to road. In the case of chlorine the result was an increase in road traffic with a commensurate increase in risk. However, the reverse was the case for ammonia, where the end of rail traffic also saw a decrease in road traffic and the associated risk. Thus the increase in the risk from the transport of chlorine by road is, to a large extent, balanced by a decrease in the risk from the transport of ammonia by road.

The contribution to the total overall national risk in Britain by the traffic in toxic gases is at the low frequency, high N part of the societal risk curve. Thus the absence of toxics rail traffic is reflected in the significant fall in the frequencies of high N events in the overall risk for rail traffic, as shown in Figure 6. The corresponding change in the overall risk for road transport due to the contribution from the additional chlorine traffic is shown in Figure 7 and is far less significant. This is in part due to the fall in the risk from the ammonia traffic by road and also the fact that the slightly increased risks from the transport of flammables by road dominate the high frequency low N and central part of the overall societal risk curve.

CONCLUSIONS

Significant changes have taken place in the transport of dangerous substances in Great Britain in the past decade, notably the cessation in rail transport of liquefied chlorine and ammonia and the partial transfer of this traffic to the road network. The representative substances considered in the HSC study have been re-assessed. Overall, the significant decrease in the total risk from dangerous substances on the rail network has not resulted in a corresponding increase in total risk from dangerous substances on the road, mainly due to the fall in the traffic in ammonia by road. Therefore the conclusion in the HSC report that the risks are tolerable continues to be valid.

However, the risks are not negligible and the need to reduce risks to a level as low as is reasonably practicable continues. Further work, to assess the effectiveness of the risk reduction measures introduced since the previous study and their impact on release frequencies, is in progress.

DISCLAIMER

The views expressed in this paper are those of the authors and not necessarily those of HSE.

ACKNOWLEDGEMENT

The authors wish to acknowledge the assistance of all the managers from the oil, chemical, and transport industries without whose willing co-operation this work would not have been completed.

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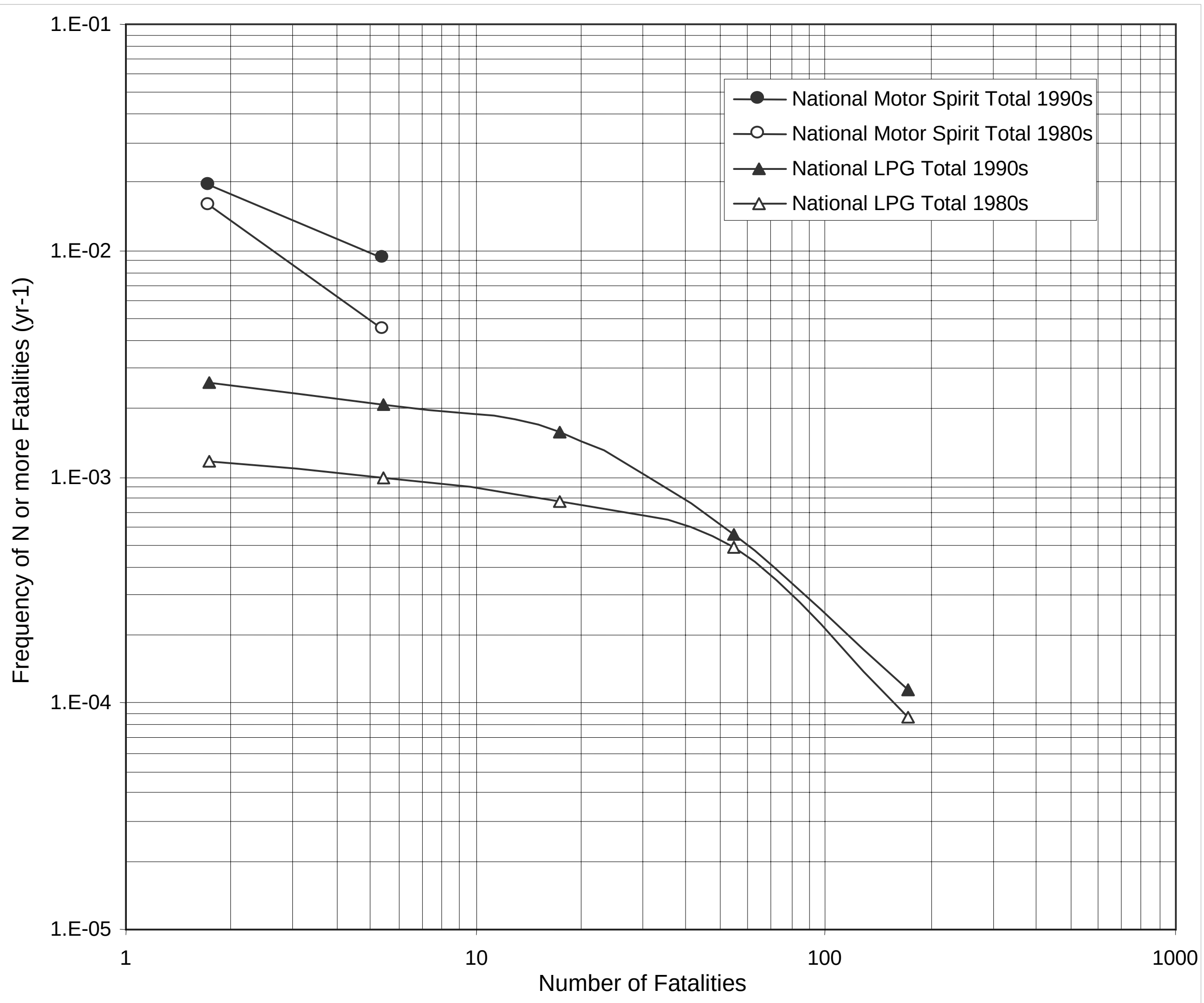

Figure 1 National Societal Risk En Route Transport of LPG and Motor Spirit by Rail

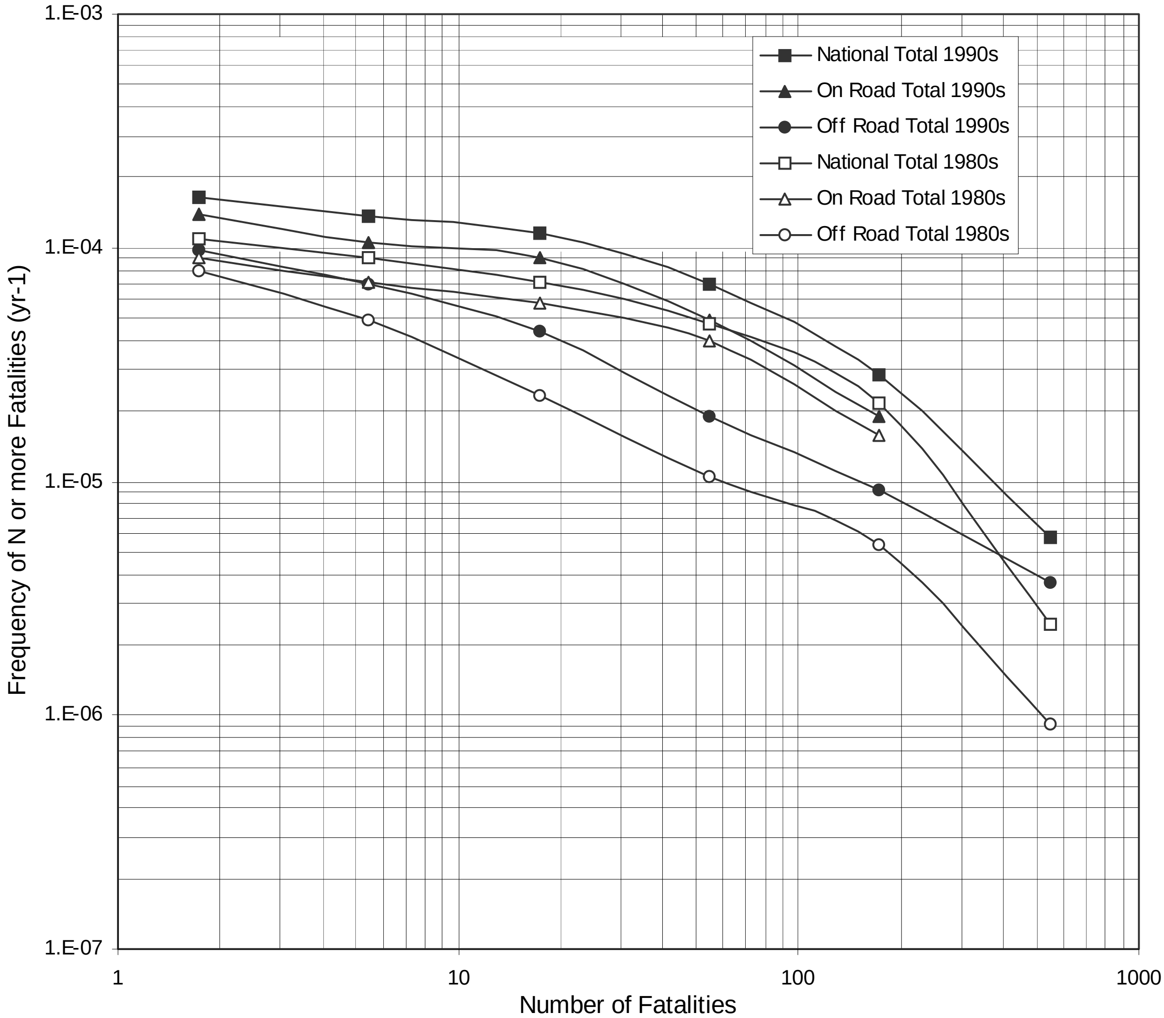

Figure 2 National Societal Risk
Transport of Chlorine by Road

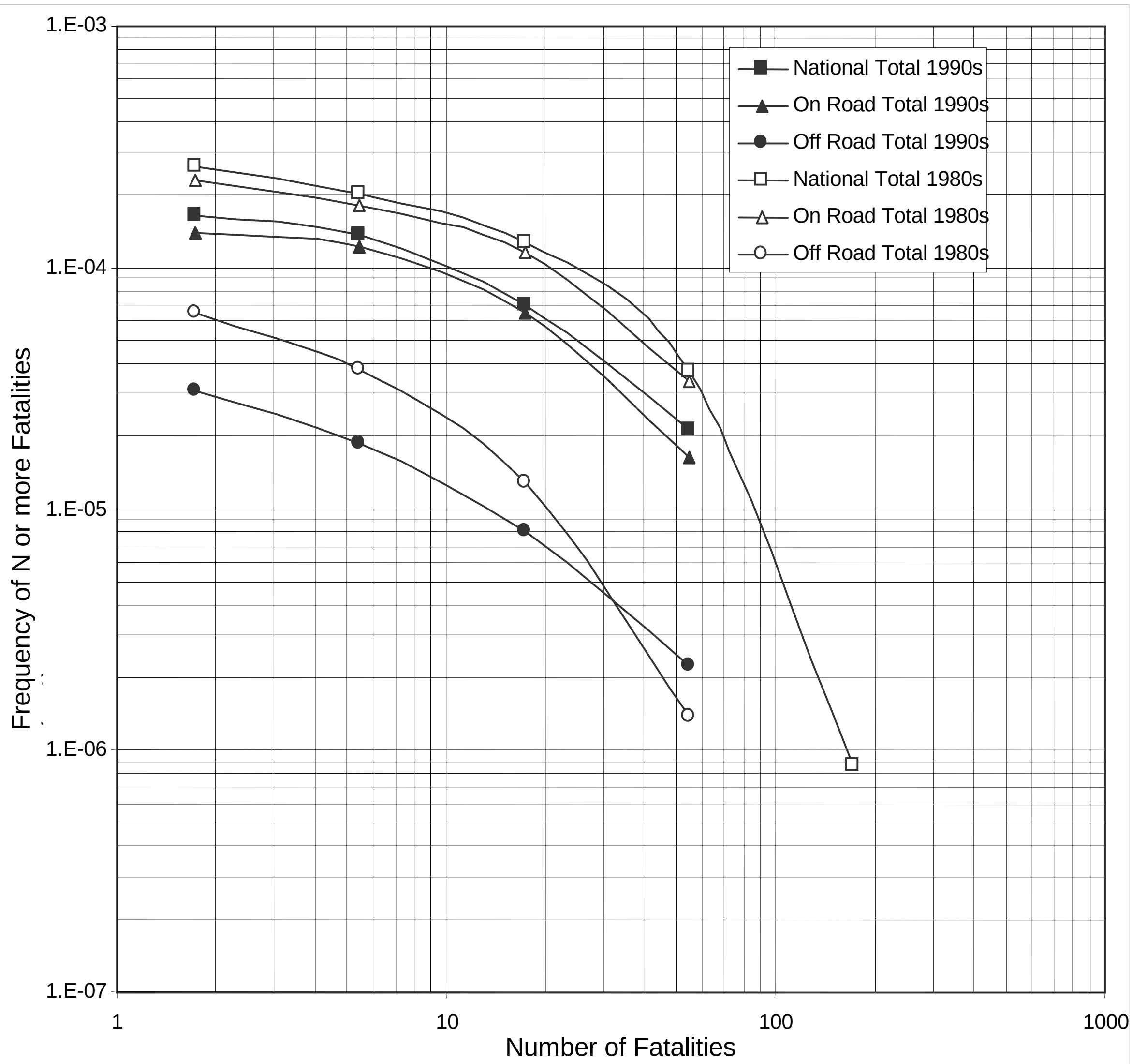

Figure 3 National Societal Risk
Transport of Ammonia by Road

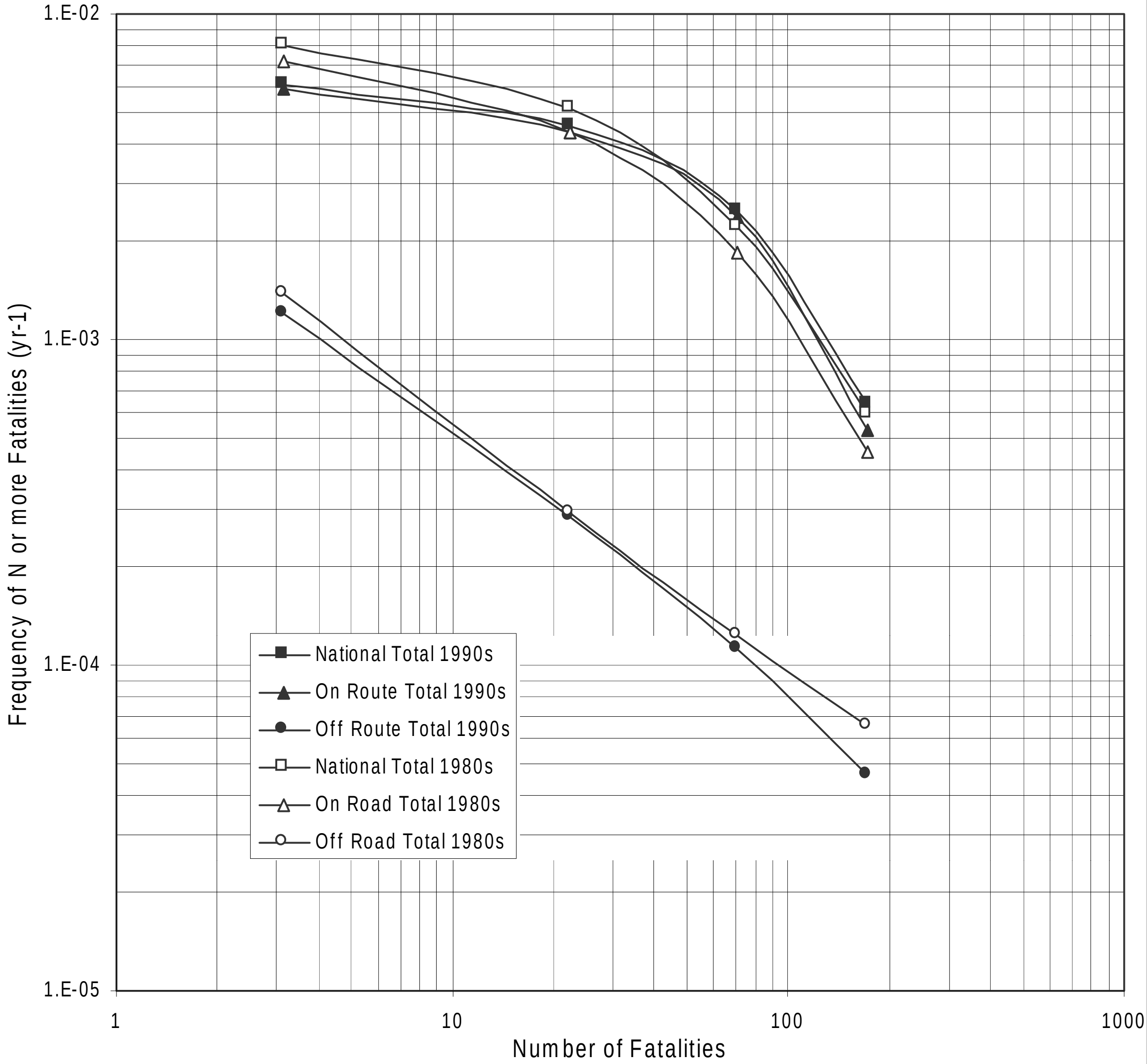

Figure 4 National Societal Risk Transport of LPG by Road

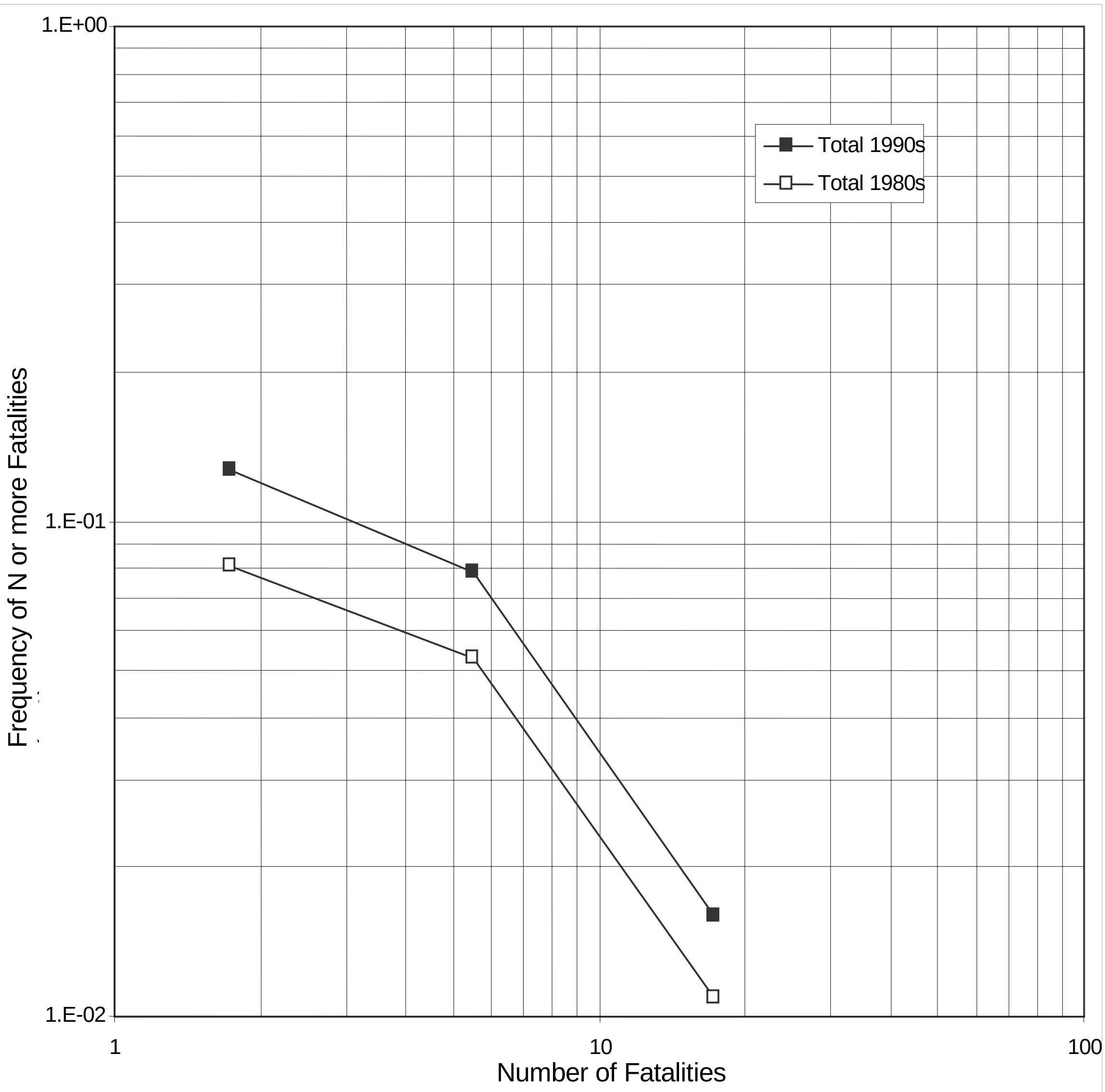

Figure 5 National Societal Risk Transport of Motor Spirit by Road

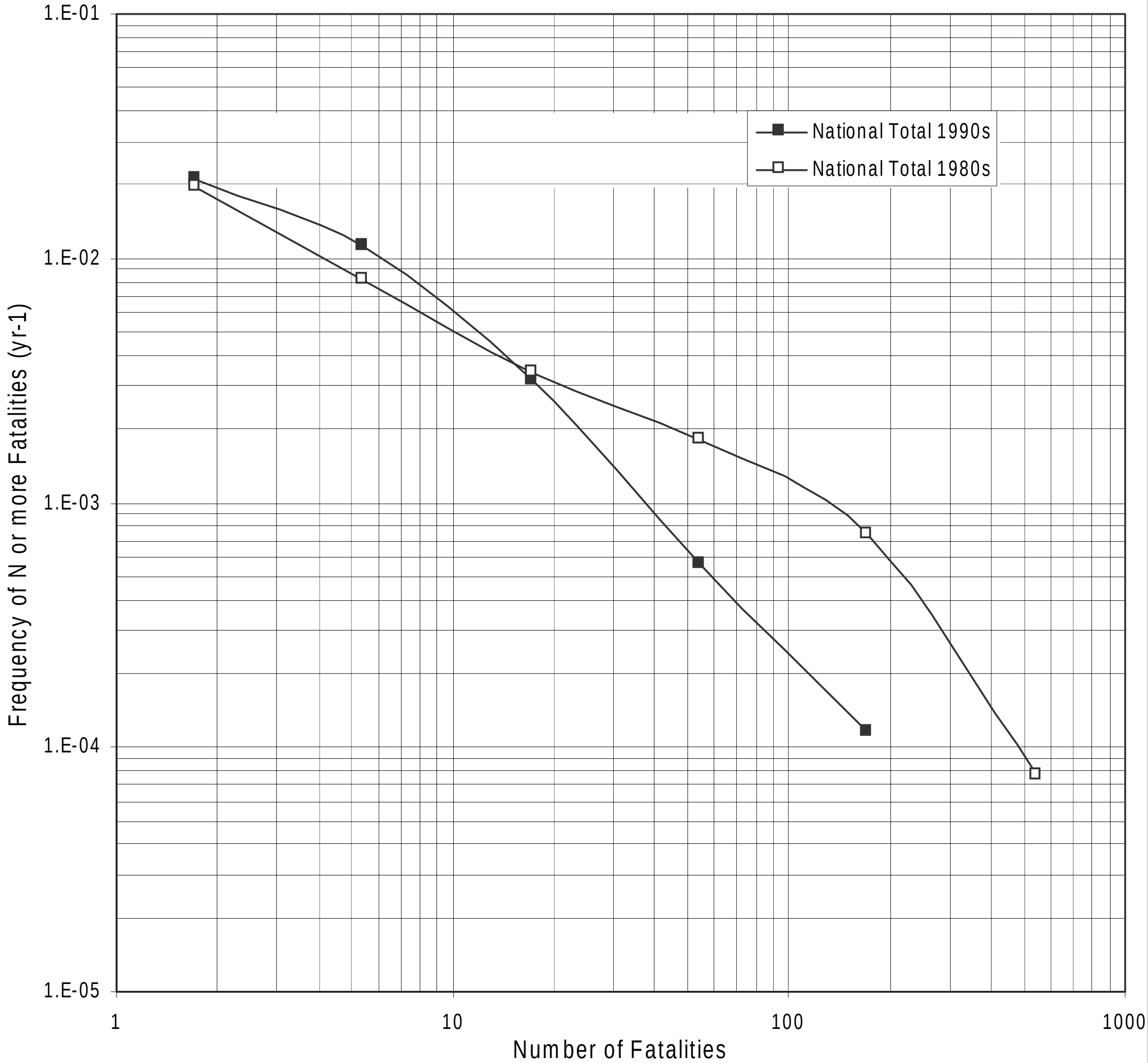

Figure 6 Total National Societal Risk En Route Transport of Substances by Rail

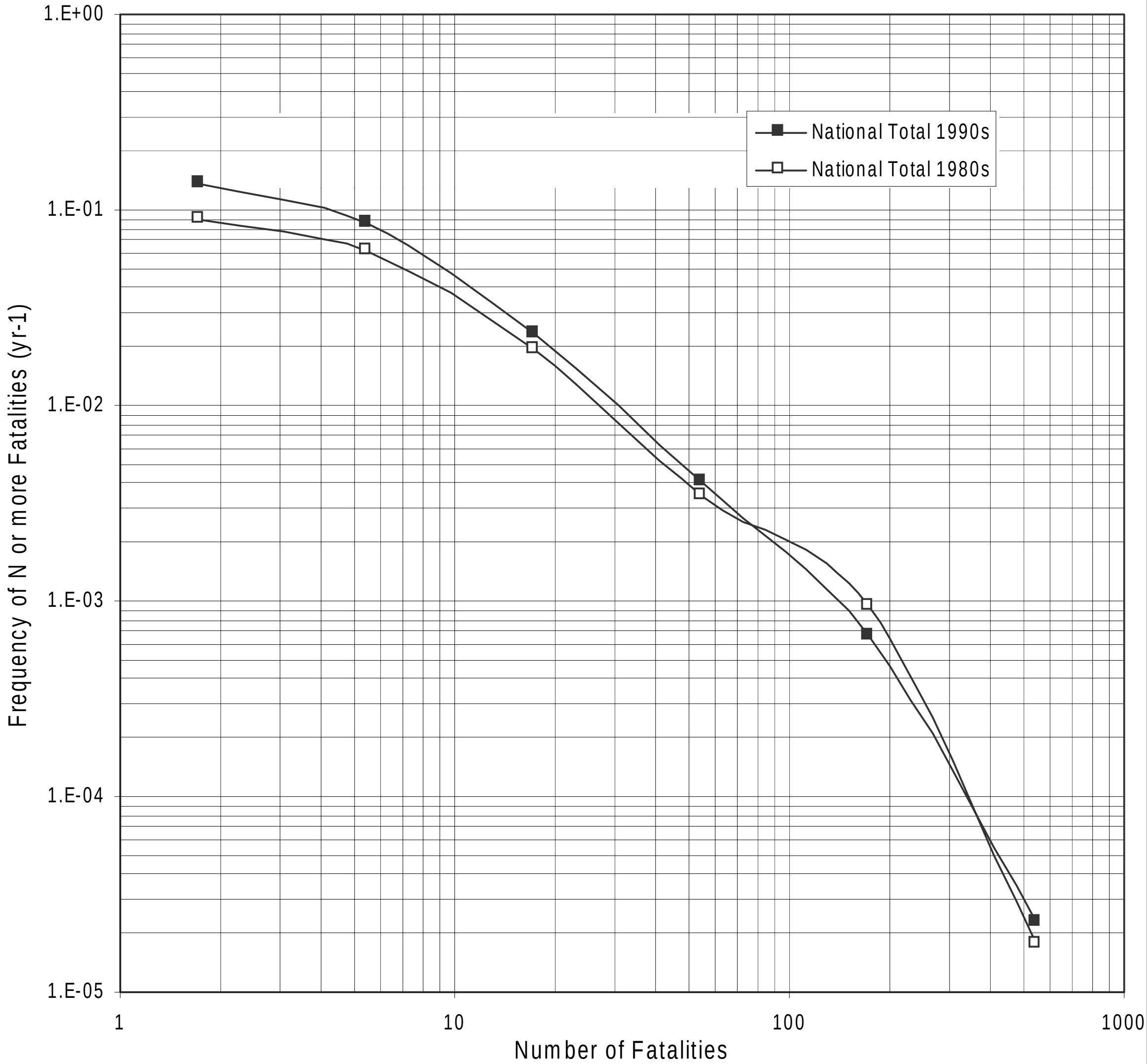

Figure 7 Total National Societal Risk En Route Transport of Substances by Road