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PROPOSAL FOR A NEW DRAFT REGULATION:
UNIFORM PROVISIONS CONCERNING CABIN AIR QUALITY TO REDUCE FATIGUE AND PREVENT ACCIDENTAL OR INTENTIONAL POISONING BY EXHAUST GASES

Transmitted by the representative of Australia

Proposal

Australia submitted an informal document (Doc No. 1) to the 122nd session seeking WP29's support for the development of a new regulation which would set a performance standard for a vehicle cabin air quality monitor. The monitor would incorporate oxygen and carbon monoxide sensors, and would be calibrated to detect poor air quality in normal driving conditions (which may contribute to driver fatigue) and to detect the particular gas composition of a suicide attempt.

WP29 agreed to consider the proposal for inclusion on its program of work subject to the provision of further information, including a cost benefit estimate.

Summary

Australia has undertaken this work and the key findings are outlined below. The analysis underlying these findings is contained in the attached paper.

Suicide Prevention

- Motor Vehicle Exhaust Gas Suicide (MVEGS) is responsible for a significant number of deaths every year in Australia, the United States of America, the United Kingdom, Sweden and other countries where there are high vehicle ownership rates.
- The available evidence indicates that restricting availability to particular methods of suicide does reduce overall suicide rates.
- Based on Australian data, fitting a cabin air quality monitor which would shut off the engine in a suicide attempt is cost effective (benefit:cost ratio of 7:1 over a 10 year period).

Fatigue

- Australian crash data suggests that driver fatigue and drowsiness is responsible for 20-30% of fatal road crashes every year, and a lesser proportion of non-fatal crashes.
- The vast majority of fatigue related crashes are in passenger vehicles.
- There are a range of contributing factors to fatigue, with sleep deprivation and disruption of circadian rhythms likely to be the key factors. Reduced oxygen levels can exacerbate drowsiness and may contribute to fatigue in road accidents, although this has not been quantified. The cost-effectiveness of the monitor in reducing fatigue related crashes is highly dependent on the estimate of the proportion of costs saved from improved air quality. At very low rates (less than 2% of crash costs) it is not likely to be cost effective.

Conclusion

The use of motor vehicles for committing suicide is a serious problem in many countries. The available evidence suggests that the development of an ECE Regulation for air quality cabin monitors for suicide prevention would be very cost effective in reducing suicide rates. The monitor is likely to also assist in fatigue management and improving driver safety, although the benefits of this are difficult to quantify. An internationally harmonised regulation would minimise the costs for the vehicle manufacturing industry.

Australia recommends that WP29 agree to put this proposal on the work program. If agreed, Australia will prepare and submit a more detailed proposal for consideration at the next meeting of the relevant Group.

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1. Outline of Proposal

It is proposed to develop a new ECE Regulation which would set a performance standard for a vehicle cabin air quality monitor. The monitor would incorporate oxygen and carbon monoxide sensors, and would be calibrated to detect poor air quality in normal driving conditions (which may contribute to driver fatigue) and to detect the particular gas composition of a suicide attempt.

The monitor would be calibrated to operate in two ways.

- To detect the "signature" gas concentrations which only occur when exhaust gas is being redirected into the vehicle cabin in a suicide attempt. Once the levels of carbon monoxide in the cabin become life threatening, the monitor would send a signal to the engine immobiliser to switch off the engine. This would occur only when the vehicle is stationary.
- To detect oxygen depletion so that when the oxygen concentration falls to levels likely to cause drowsiness in drivers, the device can trigger audible or visible warnings to the driver, or alternatively switch the ventilation system to a fresh air mode.

2. Scope of the Problem

2.1 Motor Vehicle Exhaust Gas Suicide (MVEGS)

<u>Methods of suicide</u>

Physical availability and socio-cultural acceptability are considered necessary preconditions for the choice of suicide methods. In countries with high per capita vehicle ownership, MVEGS is often chosen as it is relatively easy and painless. Methods chosen vary considerably in lethality. Lethality rates have been reported at 85% for firearms, 80% for hanging, 77% for exhaust poisoning, 75% for drowning and 23% for drug overdose.

The available data appears to suggest that nations with more cars per capita have significantly higher suicide death rates from motor vehicle exhaust gas poisoning. Conversely, in areas where car ownership is minimal, such as Hong Kong, the suicide rate by this method is low.

In some countries suicide by exposure to motor vehicle exhaust gas has been reported to be especially high. In the United Kingdom, the most common means of death by suicide for men are car exhaust gas and hanging - overdose (self-poisoning) is by far the most common method chosen by women. In the UK the number of CO suicide deaths increased from around 350 per year in 1974 to over 1200 in 1991, this was followed by a reduction between 1992 to 1994. In Sweden, CO poisoning is the fourth leading method of suicide, accounting for 15% of all male and 3% of all female suicides (Olstrom et al., 1996).

In the United States, MVEGS increased progressively from 1981-87, peaking at around 2,700 deaths per year, then apparently rapidly declined over a 2 year period and then stabilised at around 1,900 per year in 1991, which represents about 5.6 % of all suicides in the US. The latest data from the US states that 5.6% of all suicides in 1998 (representing 1,726 people) were in the category "Gas Poisons", which was the fourth largest category. This group includes MVEGS, but the MVEGS proportion of this category was not available at the time this paper was prepared.

In New Zealand nearly 30% of suicides were from MVEGS in 1996, which has grown from around 10% in 1994.

In Australia, four methods accounted for 85% of suicides in 1998- hanging, motor vehicle exhaust gas, firearms and poisoning, with MVEGS now the second most common method. Since 1990, MVEGS has represented approximately 20% of all suicides. Between 1979 and 1998 suicide rates from CO poisoning increased from 1.3 to 2.9 per 100,000 persons (ABS, 2000). Actual numbers from motor vehicle exhaust gas poisonings have remained relatively constant over the past few years with 509 deaths in 1995 and 508 in 1998.

In Australia and other countries, MVEGS is favoured in middle age and principally by men. In the 30-50 year age group in Australia, MVEGS has been the leading means of suicide and around 80% of all MVEGS victims were male. Numbers were also substantial in the high risk 25-44 year age group. Studies in the 1990s in Denmark and Sweden also indicated that MVEGS was predominantly used by middle aged men (Thiedale et al, 1998, Ostrom et al 1996).

Impact of Catalytic Converters

Some studies in the 1980's concluded that the introduction of catalytic converters contributed to falls in MVEGS rates. However, increasing or stable levels in MVEGS in a number of countries during the period where catalysts were fitted to vehicles do not support this proposition. For example in the US, there was an upward trend in MVEGS in the 1980-87 in a period where an increasing proportion of passenger cars in the US would have been fitted with catalysts. Similarly in Australia, 36% of vehicles used in MVEGS in the State of Victoria in 1994-6 and 20% of vehicles used in the State of New South Wales in 1991-5, were catalyst equipped. In examining the coroner's records for the NSW MVEGS, Sugo (1996) concluded that the catalysts in use at the time (equivalent to US FTP 75 standards) were not effective in reducing suicide by CO inhalation. In examining the Victorian data, Routley and Ozanne-Smith (1998) reached similar conclusions. A report by McClure (1997) also concluded that the 60% reduction in MVEGS in the UK over the 1990-97 period could not be accounted for by the introduction of catalytic converters, which had only been installed in 36% of cars by 1997.

Even though the CO limits in emission standards have been tightened further since the period covered by these reports, lethal levels of CO emissions can still be reached in the confined space of a vehicle cabin when the exhaust gases are directed by hose or other means into the closed cabin. This is not surprising, given that the emission standards are, after all, designed for minimising broader scale air pollution. The rate at which such levels are reached are dependent on the CO concentration of the exhaust stream, the capacity of the engine, the size of the cabin and effectiveness of the cabin sealing.

In a cold start situation, Morgen (1998) estimated that death could occur within 15 minutes even in a car with a well functioning catalyst. If the catalyst was fully warmed up at the commencement of the MVEGS attempt, death from CO poisoning was unlikely, but unconsciousness and brain damage from oxygen depletion may result. Australian data also indicates that the average carboxyhaemoglobin level of victims using cars with and without catalytic converters was identical.

2.2 Fatigue

Driver fatigue is recognised as an important safety issue in all transport modes.

The symptoms or effects associated with fatigue include impaired performance (loss of attentiveness, slower reaction times, impaired judgement, poorer performance on skilled control tasks and increased probability of falling asleep) and subjective feelings of drowsiness or tiredness. Contributory factors to fatigue include long periods awake, inadequate amount or quality of sleep over an extended period, sustained mental or physical effort, disruption of circadian rhythms (the normal cycles of daytime activity and night sleep), inadequate rest breaks and environmental stresses (such as heat, noise and vibration).

In commercial terms, the consequences of fatigue can include increased operating costs, but effects of fatigue on safety are the primary area of public concern, and the primary focus of government regulatory and policy effort on fatigue.

The contribution of fatigue to transport accidents cannot be quantified with any certainty. This is not just because the conceptual definition of fatigue is imprecise: there are also major practical difficulties in determining whether a person was impaired by fatigue immediately before an accident or incident occurred. Quantitative estimates usually rely on indirect evidence or inference applied through subjective judgements, or more objective (but essentially arbitrary) criteria relating to the circumstances of the occurrence.

In Australia, estimates of the proportion of serious road crashes involving driver fatigue range from about 5 – 50%. Most experts believe that a figure of the order of 20-30% is plausible for fatal road crashes, with lower figures for less severe crashes.

Some estimates suggest an even higher fatigue contribution. An analysis of the cost of sleep-related accidents in the USA estimated that fatigue was a factor in 42-54% of motor vehicle accidents (Leger, 1994).

There is no strong evidence establishing a link between cabin air quality and fatigue leading to road crashes. Nevertheless the link between reductions in oxygen levels and functional impairment is well recognised in air quality standards for occupational health and safety. Thus while sleep deprivation and other factors are likely to remain the key contributors to fatigue leading to road crashes, reduced oxygen levels may exacerbate the effect of these factors.

3. Cost Effectiveness of the Monitor

3.1 Unit Cost Estimates

As indicated in the informal document presented at the 122nd session, an electronic monitor is being developed in Australia by the Royal Melbourne Institute of Technology (RMIT) University. The RMIT has estimated the unit cost of an integrated unit suitable for installation in new vehicle production at $16 (Australian).

Component Description	Aftermarket Product Unit Purchase Price (10,000 Units Production)	Integrated Device Unit Purchase Price (10,000 Units Production)
Sensors	$15	$10
Electronic Components	$12	$3
Packaging	$10	$3
Total Cost Per Unit	**$37**	**$16**

The sensor costs indicated in the table above will vary depending on the array of sensors. The $10 estimate is the typical cost of a two-element (CO & O_2) sensor, which is all that is required to address both the fatigue and suicide prevention measures. The integrated device will make use of the microprocessor used on the on-board engine and body management system, for decision and control purposes. The total cost does not include fitting costs, so some allowance is made for this in the following analyses.

3.2 Cost Effectiveness in Dealing with Motor Vehicle Exhaust Gas Suicide

The cost benefit analysis undertaken by Australia indicates that, using best estimates of costs and benefits, installing a monitor is a very cost effective measure, with a benefit:cost ratio of 7:1 over a 10 year period. The detail of this analysis is outlined in Appendix A.

One of the key factors in assessing the impact of the monitor is its “deterrence rate” – that is, the proportion of people who will be deterred from another attempt using a vehicle or other means, after their attempt at MVEGS has been prevented by the monitor shutting off the engine. There is no hard data on this factor, but based on the suggestion by an expert in the field in Australia (Baume, 1998), the deterrence rate used in the cost benefit analysis was 40%.

However, while the actual rate is not known, the effect of “limiting access to means” has been examined by a number of researchers. Cantor et al (1996) concluded that restricting the availability of a particular method of suicide often, but not invariably, reduces overall suicide rates. Psychological autopsy studies of suicide victims, and those who have narrowly survived an attempt, show that even in those who make long term plans and preparations to attempt suicide, the eventual action often occurs impulsively and in the presence of the means.

Reducing the availability[1] of the chosen means at that critical point, will influence the potential lethality of the act and is likely to lead to a reduction in the suicide rate (Hawton and van Heeringen, 2000). Kreitman also argued (in Hawton and van Heeringen, 2000) against the suggestion that means substitution will discount the benefits of reducing access to a particular means, and cites the reduction of suicide rates that followed the substitution of North Sea gas for coal gas in the UK. Marzuk et al (1992) also concluded that overall suicide rate can be lowered by restricting the availability or lethality of individual methods. Gunnel and Frankel (1994) also reported that restrictions on the prescribing of barbiturates in Australia in the 1960's resulted in a reduction in both barbiturate and overall suicides.

Given the uncertainty over the deterrence rate and to allow for changes in the cost of the monitor, a sensitivity analysis was also undertaken to model the effect of changes in these two factors. The results of that analysis are outlined in the matrix below and indicate that, except in the extreme case of high monitor costs and very low deterrence rates, there is a positive cost benefit.

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1 in this case the <u>effectiveness</u> of the means (the vehicle).

Benefit : Cost of Monitor over 2001-10[2]

Deterrence Rate	Monitor Cost per Vehicle		
	$20	*$30*	*$50*
10%	1.8	1.2	0.7
20%	3.5	2.4	1.4
40%	**7.1**	4.7	2.8

In addition, only about 50% of the fleet would be equipped with monitors at the end of the modelled 10 year period (see Appendix A). Given the costs per year of fitting the device grow only slightly, while the number of lives saved increases steadily, the benefit : cost ratio would improve if the analysis was extended over a 20 year period.

3.3 Cost Effectiveness in Dealing with Fatigue

As indicated in the discussion in 2.2, it is estimated that 20-30% of fatal car crashes, and a lesser proportion of non-fatal crashes, are fatigue related. In Australia, these crashes are estimated to cost around $1.9 billion per year (see Attachment C). While the impact of vehicle cabin air quality on fatigue related crashes is not known, the analysis has conservatively assumed that the fitting of a monitor would reduce fatigue crash costs by 2%. This represents a break even point over the 10 year period. The details of this analysis is outlined in Appendix B.

Given the uncertainty over the impact of cabin air quality on fatigue related crashes, and to allow for changes in the cost of the monitor, a sensitivity analysis was also undertaken to model the effect of changes in these factors. The results of that analysis are outlined in the matrix below and indicate that if the improved cabin air quality delivered by a monitor saves 5% or more of fatigue related costs, then it is likely to be cost effective. However, if it is 2% or less, then it is unlikely to be cost effective.

Benefit : Cost of Monitor over 2001-10

Proportion of Crash Costs Saved by Monitor	Monitor Cost per Vehicle		
	$20	*$30*	*$50*
1%	0.5	0.3	0.2
2%	**0.9**	0.6	0.4
5%	2.3	1.5	0.9

As with the MVEGS analysis, the benefit : cost ratio would improve over a longer period, as the proportion of vehicles in the fleet equipped with a monitor increases beyond the 50% level in 2010.

3.4 Summary of Benefit : Cost Analysis

The analysis suggests that the monitor is very cost-effective from a suicide prevention perspective, even when the deterrence rate is relatively low. The evidence for fatigue is less convincing, although there is not a lot known about the relative importance of oxygen depletion in fatigue based crashes. Thus, on the available evidence, the principal benefits from the monitor would be in preventing loss of life from suicide, with reduced fatigue a secondary benefit.

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[2] Although it is recognised that the possible adoption of a monitor would not occur for some years, the 2001-10 period was chosen to minimise uncertainty from longer term projections in the structure of the vehicle fleet.

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APPENDIX A

Air Quality Cabin Monitor for Prevention of Motor Vehicle Exhaust Gas Suicide (MVEGS)

Cost Benefit Analysis based on 2001-2010 Period

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
No of MVEGS Deaths	500	500	500	500	500	500	500	500	500	500
No of Cars in Fleet	10045000	10203000	10351000	10482000	10610000	10735000	10856000	10973000	11088000	11200000
New Car Registrations	612000	592000	591000	583000	589000	593000	598000	603000	608000	614000
No of New Cars less scrappage	552000	544000	552000	552000	564000	574000	585000	594000	604000	614000
% of monitor equipped vehicles	5.5	10.8	16.2	21.4	26.7	32.1	37.5	42.9	48.3	53.8
No of Suicides Prevented	11	22	32	43	53	64	75	86	97	108
Cost of Equipping Vehicles with monitors ($million)	12.2	11.8	11.8	11.7	11.8	11.9	12.0	12.1	12.2	12.3
Benefit in avoided costs of deaths prevented ($million)	16.5	32.5	48.5	64.3	80.2	96.3	112.4	128.7	145.0	161.5

2001-2010 Summary	
Deaths Prevented:	**591**
Present value of benefits ($million)	**722.2**
Present value of costs ($million)	**102.0**
Net present value ($million)	**620.2**
Benefit/cost ratio	**7.1**

Assumptions:

1	MVEGS death rates remain at 1998 Level
2	Vehicle fleet projections taken from BTE "Carmod" (2000 version), assuming all new cars are introduced and all old cars are scrapped on 1 Jan. It would be more realistic to average start-of-year and end-of-year %-of-fleet-with-sensors figures, equivalent to assuming constant rates of new vehicle introduction and scrappage. However, this refinement would not significantly alter the results over the 2001-10 period.
3	The likelihood of a old or new vehicle being used is related to its frequency in the vehicle fleet. That is, there is no deliberate selection of older vehicles in making a suicide attempt - people will use the vehicle that is available to them.
4	40% of those attempting suicide by MVEGS are dissuaded from further attempts by this or other means (Routley, 1998, p49)
5	The cost of a fatality is taken as $1,500,000 (BTE, 2000, p81)
6	The fitted cost of an air quality monitor is taken as $20

Factors Used in Calculations

Deterrence rate:	0.4
Cost of Fatality ($):	1,500,000
Fitted monitor cost($):	20
Discount rate	3.0%

APPENDIX B

Air Quality Cabin Monitor for Prevention of Driver Fatigue

Cost Benefit Analysis based on 2001-2010 Period

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
No of Cars in Fleet	10045000	10203000	10351000	10482000	10610000	10735000	10856000	10973000	11088000	11200000
New Car Registrations	612000	592000	591000	583000	589000	593000	598000	603000	608000	614000
No of New Cars less scrappage	552000	544000	552000	552000	564000	574000	585000	594000	604000	614000
% of monitor equipped vehicles	5.5	10.8	16.2	21.4	26.7	32.1	37.5	42.9	48.3	53.8
Cost of Equipping Vehicles with monitors ($million)	12.2	11.8	11.8	11.7	11.8	11.9	12.0	12.1	12.2	12.3
Benefit in avoided costs of deaths prevented ($million)	2.1	4.1	6.2	8.2	10.2	12.2	14.3	16.4	18.4	20.5

2001-2010 Summary	
Present value of benefits ($million)	**91.8**
Present value of costs ($million)	**102.0**
Net present value ($million)	**-10.2**
Benefit/cost ratio	**0.9**

Assumptions:

1	Vehicle fleet projections taken from BTE "Carmod" (2000 version), assuming all new cars are introduced and all old cars are scrapped on 1 Jan. It would be more realistic to average start-of-year and end-of-year %-of-fleet-with-sensors figures, equivalent to assuming constant rates of new vehicle introduction and scrappage. However, this refinement would not significantly alter the results over the 2001-10 period.
2	Fatigue crash costs as per (BTE, 2000, p81) and remain constant over 2001-10 period (see next sheet)
3	The fitted cost of an air quality monitor is taken as $20

Factors Used in Calculations

Cost of Fatigue Crashes ($)		1.9E+09
% crash costs saved by monitor		2%
Fitted monitor cost($):	20	
Discount rate	3.0%	

APPENDIX C

Table 1 Road Crash Cost data

Crash Type		Average cost (1)	Crash costs	Number of crashes	
Fatality		1652994	$2,920,000,000	1766	
Serious injury		407990	$7,150,000,000	17525	
Injury		13776	$2,470,000,000	179297	
PDO (property damage only)		5808	$2,440,000,000	420110	
Total			$14,980,000,000	618698	
		(1) Based on BTE (2000) estimates for 1996			

Table 2 Estimated economic costs of fatigue-related road crashes

Crash type	No. of crashes	Fatigue-related %(1)	Annual fatigue-related costs(2)		
Fatality	1766	20	$584,000,000		
Serious injury	17525	15	$1,072,500,000		
Injury	179297	10	$247,000,000		
PDO	420110	10	$244,000,000		
Total (all vehicles)	618698		**$2,147,500,000**	percent of total cost:	14%
Total Cost of Fatigue Related Crashes (less trucks)			**$1,907,026,000**	percent of total cost:	13%
		(1) Estimated figures partly based on past reviews.			
		(2) Based on BTE (2000) estimates for 1996			

Table 3 Truck driver fatigue

	HVD fatigue as % of truck-involved crashes	Truck crashes as % of total crashes	"severity multiplier"	overall %	cost
Fatality	15%	**14%**	$2	3%	$91,980,000.00
Serious injury	10%	10%	$2	2%	$107,250,000.00
Injury	7%	8%	$2	1%	$20,748,000.00
PDO	7%	8%	$2	1%	$20,496,000.00
Total					**$240,474,000.00**