Informal Document No. ③
(125th WP.29, 6-9 November 2001,
agenda item 3.2.1.)

Notification to the ECE of a Public Request Made by the Government of Canada to all Interested Parties for Comments on Possible Measures to Prevent Motor Vehicle Exhaust Gas Poisoning

Transmitted by the Department of Transport, Government of Canada

The Department of Transport is about to publish a Notice in the *Canada Gazette* Part I requesting comments from interested parties on possible measures to prevent motor vehicle exhaust gas poisoning. This Notice is being issued in response to a submission made in January 2001 by an individual who requested that the Department of Transport undertake specified measures to prevent injury and death caused by carbon monoxide poisoning from motor vehicle exhaust gas. The request, which was also submitted to the U.S. Department of Transportation, was supported by five health- and environment-related organizations and a number of individuals. In March 2001, the Department also received a request from a vehicle operator who described his nearly fatal experience with accidental exhaust gas poisoning and who requested that carbon monoxide detectors with audible alarms be mandated for all large trucks.

This Notice presents an overview of the scientific mechanism of motor vehicle exhaust gas poisoning, an analysis of the incidence of death in Canada from exhaust gas poisoning, and an examination of the various courses of action open to the Department in attempting to prevent the injuries and deaths that occur each year due to exhaust gas poisoning.

Summary

Motor vehicle exhaust gas poisoning occurs as a result of exposure to carbon monoxide, which is a colourless, almost odourless gas. The symptoms of carbon monoxide poisoning include headache, nausea, dizziness, and general disorientation, which may progress to unconsciousness and even death if the concentration of the gas is sufficient or if exposure is prolonged. Canada began regulating the carbon monoxide content of exhaust gas at the tailpipe in 1971; the current limit, which was set in 1987, is 2.1 g/km. Recent studies indicate that the actual tailpipe carbon monoxide concentration of a newly manufactured vehicle is 1000 parts per million or less; however, the content is higher during cold starts, especially at low ambient temperatures, and during acceleration.

There are essentially two types of exhaust gas poisoning: unintentional, which usually occurs as a result of poor vehicle maintenance, and self-inflicted. The incidence of unintentional exhaust gas poisoning has decreased steadily since the imposition of emissions controls, declining to a low of 9 deaths in 1997, the most recent year for which statistics are available. Suicides, which represent about 90% of all exhaust gas poisonings in Canada, have fluctuated between a high of 385 and a low of 260 over the twenty-year period from 1978 to 1997. There were 268 self-inflicted poisonings in 1997, which accounted for 7.3% of all suicides in Canada.

The Department could adopt one of three approaches to the problem of preventing exhaust gas poisonings. It could maintain the status quo, adopt a non-regulatory approach, or introduce regulatory requirements. Given that the death rate from unintentional poisonings has declined significantly and is expected to continue to decrease, further action may not be necessary. The incidence of exhaust gas poisoning suicides remains essentially stable, and it may be possible to undertake effective measures to reduce these fatalities.

A non-regulatory approach could consist of conducting an information campaign that would warn the public of the hazards of exhaust gas poisoning and explain how to prevent it. A regulatory approach could consist of three possible initiatives. A vehicle interior air quality test could be mandated, such as that used by the Russian Federation; air quality monitors could be specified for all motor vehicles; or suicide-resistant tailpipes could be required for passenger vehicles.

The Mechanisms of Motor Vehicle Exhaust Gas Poisoning

Carbon Monoxide Poisoning

While several constituents of exhaust gas are harmful, carbon monoxide (CO) is the most potentially dangerous. It is a colourless, almost odourless gas produced by the incomplete combustion of carbonaceous material, which includes coal, wood, paper, oil, gasoline, gas, explosives, and cigarettes.[1] When inhaled, carbon monoxide is absorbed through the lungs into the blood where it combines with the hemoglobin in red blood cells to form carboxyhemoglobin, which is a very stable compound. The affinity of carbon monoxide to hemoglobin being much greater than that of oxygen, CO replaces the oxygen in the first site of the hemoglobin molecule and blocks the release of oxygen from the remaining three inner sites. The oxygen deprivation that ensues affects the muscles, heart, and brain most acutely, with the greatest burden being borne by the heart. Not only is it deprived of oxygen in its own right, the heart also attempts to compensate for the reduced supply to the rest of the body by increasing the blood flow.

The symptoms of carbon monoxide poisoning include headache, nausea, dizziness, and general disorientation, which may progress to unconsciousness and death. A low level of exposure decreases work or exercise capacity and causes angina attacks in people with chronic angina. Visual perception, manual dexterity, and performance in sensory motor tasks, such as driving, are also reduced. In serious cases, pulmonary edema, pneumonia, kidney failure, and permanent brain damage may result; however, even in mild poisonings, symptoms such as irritability, restlessness, prolonged delirium, depression, anxiety, and memory impairment may persist for many months after the incident.

The severity of the symptoms and the time before their onset depend on the concentration of carbon monoxide in the air, the duration of exposure, the degree of physical exertion of the victim, and individual susceptibility. People with heart and respiratory problems, those taking depressant medication, individuals who are under the influence of alcohol, pregnant women, fetuses, and newborns are most susceptible to the adverse effects of carbon monoxide. Table 1 outlines the principal signs and symptoms of carbon monoxide poisoning at increasing blood concentrations of carboxyhemoglobin.

Table 1: Principal Signs and Symptoms of Carbon Monoxide Poisoning at Different Concentrations of Carboxyhemoglobin*

Carboxyhemoglobin Concentration (%)	Principal Signs and Symptoms
0.3 – 0.7	Normal endogenous level.
2.5 – 5	No symptoms. Compensatory increase in blood flow to certain vital organs. Chest pain of angina pectoris patient is provoked by less exertion.
5 – 10	Mild sensitivity to light.
10 – 20	Tightness across the forehead. Slight headache. Marked sensitivity to light. Possibly slight breathlessness on exertion. May be lethal to fetus and for patients with severe heart disease.
20 – 30	Slight or moderate headache and throbbing in the temples. Flushing. Nausea. Fine manual dexterity abnormal.
30 – 40	Severe headache, vertigo, nausea, and vomiting. Weakness. Irritability and impaired judgement. Fainting on exertion.
40 – 50	Same as above, but more severe with greater possibility of collapse and loss of consciousness.
50 – 60	Possibly coma with intermittent convulsions and Cheyne-Stokes respiration.
60 – 70	Coma with intermittent convulsions. Depressed respiration and heart action. Possibly death.
70 – 80	Weak pulse and slow respiration. Depression of respiratory centre leading to death.

[1] The information contained in the first three paragraphs of this section and in Table 1 was taken from the *Encyclopaedia of Occupational Health and Safety*, Third (Revised) Edition, Volume 1, International Labour office, Geneva, Switzerland, 1989, pp. 395-9, and R. Grace, A. Guzman, M. Portnoff, and D. Purta, "Carbon Monoxide Monitor for Automobile Passenger Compartment," U.S. Department of Transportation, National Highway Traffic Safety Administration, Report No. DOT HS 807 761, July 1991, pp. 23-26.

* There is considerable individual variation in the occurrence of symptoms.

Table 2 describes the signs and symptoms associated with different concentrations of carbon monoxide.

Table 2: Main Physiological Effects at Increasing CO Concentrations [2]

Concentration of CO (ppm)*	Signs and Symptoms of Carbon Monoxide Poisoning
50	Permissible exposure level for 8 hours as set by the U.S. Occupational Safety and Health Administration (OSHA)
200	Mild frontal headache in 2 to 3 hours
400	Frontal headache and nausea after 1 to 2 hours. Occipital headache after 2.5 to 3.5 hours.
800	Headache, dizziness, and nausea in 45 minutes. Collapse and possible death in 2 hours.
1600	Headache, dizziness, and nausea in 20 minutes. Collapse and death in 1 hour.
3200	Headache and dizziness in 5 to 10 minutes. Unconsciousness and danger of death in 30 minutes.
6400	Headache and dizziness in 1 to 2 minutes. Unconsciousness and danger of death in 10 to 15 minutes.
12,800	Immediate unconsciousness. Danger of death in 1 to 3 minutes.

* ppm stands for parts per million.

The Carbon Monoxide Content of Exhaust Gas

In Canada, motor vehicle exhaust emissions have been regulated by law since 1971, at which time the permissible level for carbon monoxide was set at 24.1 g/km. In 1975, the limit was lowered to 15.4 g/km, and in 1987, the Department of Transport reduced the level again to 2.1 g/km where it remains today. As a result of the imposition, in the late 1990s, of more stringent limits on other pollutants, such as oxides of nitrogen, the CO concentration of exhaust gas has continued to decrease. Increasingly strict limits on these pollutants, which are being phased in and will come into full force in 2004, will reduce actual CO emissions even further. According to information provided by the Department of the Environment, as of 1998, almost 80% of the vehicle fleet conformed to the 2.1 g/km carbon monoxide emission limit.

Research conducted for the Department indicates that the average concentration of carbon monoxide in the exhaust gas of a late-model motor vehicle is 1000 ppm or less.[3] Table 2 indicates that a lower concentration of 800 ppm is likely to produce serious symptoms of CO poisoning; therefore, it is most important that exhaust gas not be allowed to enter the interior of the vehicle. If properly maintained, the exhaust system will prevent any such infiltration.

The importance of good vehicle maintenance is underscored by a study done by the Department of the Environment that measured the gaseous and particulate matter emissions of 75 in-use, light-duty passenger cars and trucks in the Vancouver area.[4] The sample, which was representative of the vehicle fleet in British Columbia, included 50 passenger cars, 10 of which had failed their AirCare inspection, and 20 light-duty trucks, 2 of which had failed. According to the results of the study, the CO emissions of these vehicles ranged from 0.39 g/mile (0.24 g/km), which is considerably lower than the permissible CO limit, to 71.2 g/mile (44.2 g/km). The higher emissions were generally found in older vehicles and in vehicles that had not passed their inspection.

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[2] The information in this table was taken from the Web site of Industrial Scientific Corporation, www.indsci.com/gas_co.html.

[3] M. Parkes and R.C. Burk, "A Review of the Potential Hazard of Carbon Monoxide Emissions in Gasoline Powered Vehicles and its Prevention," unpublished paper prepared by Carleton University for the Department of Transport, June 15, 2001.

[4] Lisa Graham, "Gaseous and Particulate Matter Emissions from In-Use Light Duty Gasoline Motor Vehicles," ERMD Report #99-67, unpublished paper of the Environmental Technology Advancement Directorate, Environment Canada.

The association between vehicle age and emissions levels is further corroborated by a two-week study conducted in the year 2000 in Denver, Colorado. Using remote sensing equipment to measure tailpipe carbon monoxide emissions, this study found that the mean CO concentration of the 23,000 vehicles measured was 4,300 ppm, but that vehicles manufactured in the early 1980s had average tailpipe CO concentrations of approximately 14,000 ppm, while those of year 2000 models were only about 1,000 ppm.[5]

Although the average emission of carbon monoxide from a newly manufactured vehicle is 1000 ppm, and often lower, emissions are higher during cold starts, when the vehicle is idling, and during acceleration. In a separate study, the Department of the Environment compared the emissions of a 1993 Buick Regal during both hot and cold starts and at different ambient temperatures.[6] The results showed that CO emissions were 32 times greater when the engine was cold, one reason being that the catalytic converter must be heated to its operating temperature by the exhaust gas passing through it in order to reach peak efficiency.

The study also established that the ambient temperature can greatly influence the level of emissions. During the course of five 300-second cold start tests conducted on different days, the CO emissions of the Buick Regal were found to be 73.4 g, 40.2 g, and 34.9 g at –10ºC, as compared to 14.6 g and 15.8 g at 24ºC. It took from 90 to 110 seconds, depending on the ambient temperature, for CO emissions to drop to idling levels, which as already mentioned are higher than when the vehicle is travelling. Acceleration of the vehicle produced CO emissions that were comparable to those of a cold start.

Exhaust Gas Poisoning by Asphyxiation

While exposure to carbon monoxide is a known mechanism of exhaust gas poisoning, another possible cause is asphyxiation. Exhaust gas contains little or no oxygen; consequently, if it is allowed to accumulate inside the vehicle in sufficient quantity, the air will be depleted of oxygen. Exhaust gas also contains carbon dioxide, which, under conditions of oxygen deprivation, stimulates the breathing reflex, thereby accelerating the asphyxiation process and increasing the body's uptake of carbon monoxide. The elevated temperature and water vapour content of exhaust gas further increase the rate of CO absorption.

The Department is not aware of any exhaust gas poisonings by asphyxiation, as accident investigators do not measure blood oxygen levels. Table 3 outlines the physiological effects of diminishing oxygen concentrations.

Table 3: Main Physiological Effects of Different Oxygen Concentrations[7]

Oxygen Concentration (% Volume)	Signs and Symptoms of Oxygen Deprivation
23.5	Maximum safe level established by the U.S. Occupational Safety and Health Administration (OSHA)
21	Oxygen concentration of air
19.5	Minimum safe level established by OSHA and the U.S. National Institute for Occupational Safety and Health (NIOSH)
17	Impairment of judgment
16	First signs of anoxia (oxygen deprivation) appear
16 to 12	Breathing and pulse rate increase, muscular co-ordination is slightly impaired
14 to 10	Emotional upset, abnormal fatigue upon exertion, disturbed respiration
10 to 6	Nausea and vomiting, inability to move freely; loss of consciousness may occur
6	Convulsive movements and gasping respiration occur; respiration stops, then heart action ceases.

[5] Cited by Parkes and Burk.
[6] Lisa Graham, Kevin O'Leary, and Lianne Noseworthy, "Characterization of the Tailpipe and Evaporative Emissions of the Test Vehicle for the Residential Garage Study," ERMD Report #99-26768-1, unpublished paper of the Environmental Technology Advancement Directorate, Environment Canada.
[7] The information in this table was taken from the Web site of Industrial Scientific Corporation, www.indsci.com/gas_co.html.

The Incidence of Motor Vehicle Exhaust Gas Poisoning in Canada

In order to gauge the incidence of exhaust gas poisoning in Canada and to understand the trends governing its occurrence, the Department analyzed statistical data compiled by Statistics Canada. Deaths due to exhaust gas poisoning are compris ed of suicides, unintentional poisonings, and exhaust gas poisonings for which it could not be determined whether the injury was inflicted accidentally or purposely. Table 4 shows the incidence of each type of poisoning and the total exhaust gas poisoning deaths that occurred over the twenty-year period from 1978 to 1997, the most recent year for which statistics were available.

Table 4: Incidence of Death by Motor Vehicle Exhaust Gas Poisoning in Canada for 1978 to 1997[8]*

Year	Number of Suicides	Number of Unintentional Deaths	Undetermined Whether Injury Accidentally or Purposely Inflicted	Total Number of Deaths by Motor Vehicle Gas Poisoning
1978	292	74	41	407
1979	328	73	45	446
1980	331	63	19	413
1981	307	67	28	402
1982	312	73	22	407
1983	362	81	6	449
1984	317	55	12	384
1985	329	41	10	380
1986	385	68	13	466
1987	NA*	NA	NA	NA
1988	340	40	14	394
1989	260	44	9	313
1990	278	37	6	321
1991	276	20	7	303
1992	330	46	12	388
1993	294	33	9	336
1994	322	36	10	368
1995	385	30	10	425
1996	310	24	17	351
1997	268	9	17	294

* The data for 1987 were unavailable.

As Table 4 shows, the total number of exhaust gas poisonings fluctuated between 294 and 466, with the low value occurring in 1997 and the high figure in 1986. Since exhaust gas poisonings are classified statistically within the larger category of external causes of death, which includes all accidental fatalities and excludes deaths due to disease, the incidence of death by exhaust gas poisoning may be compared to that due to external causes. Figure 1 demonstrates that, depending on the year, from 2.2% to 3.4% of the premature deaths that occurred in Canada from 1978 to 1997 were caused by exhaust gas poisoning, which is a very small percentage.

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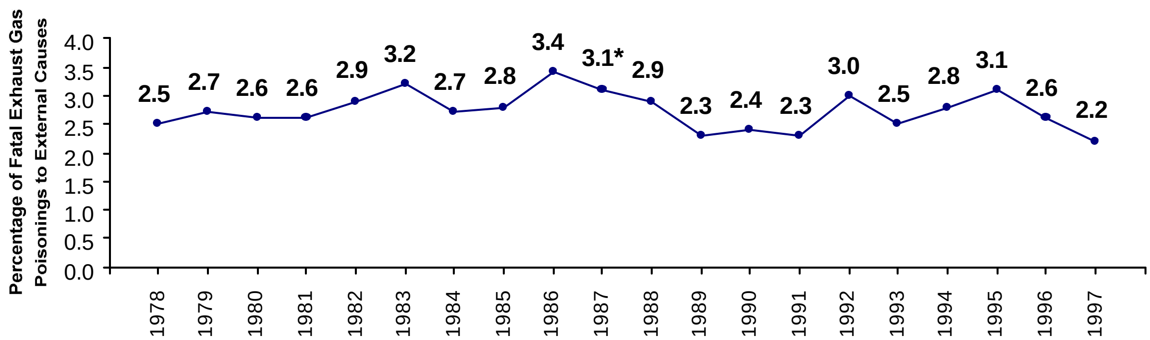
[8] The data in this table were taken from the Statistics Canada publication, *Causes of Death*, Catalogue Number 84FO208, 1987 to 1997, and Catalogue Number 84-203, 1978 to 1986. The International Classification of Diseases (ICD) categories used were: Suicide by motor vehicle exhaust gas (E952.0); Accidental poisoning by motor vehicle exhaust gas (E868.2); and Injury, undetermined accidentally or purposely inflicted, motor vehicle exhaust gas (E982.0).

Figure 1: Incidence of Death by Motor Vehicle Exhaust Gas Poisoning as a Percentage of Accidental Deaths in Canada[9]

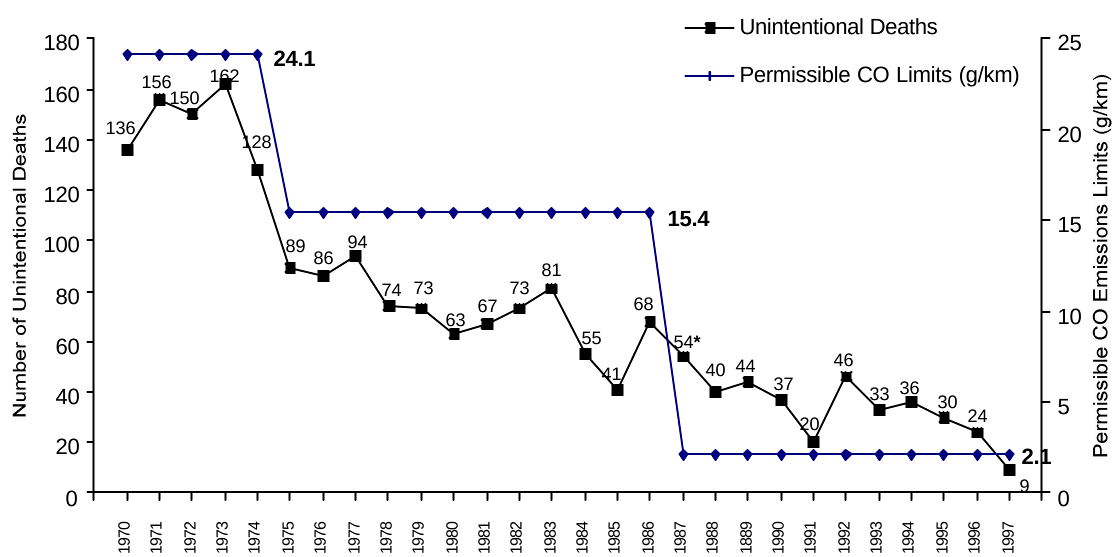


* This value is an extrapolation as statistical data for the year 1987 were not available.

Unintentional Deaths by Motor Vehicle Exhaust Gas Poisoning

Unintentional deaths account for only a small proportion of fatal exhaust gas poisonings—about 10% for the ten-year period from 1988 to 1997. In actual numbers, unintentional deaths ranged from a high of 81 in 1983 to a low of 9 in 1997, with a discernible decrease in incidence. For instance, the 10-year average for the period from 1978 to 1988 was 66 fatalities, while the average for 1989 to 1997 was 32, a decline of half. Increasingly stringent carbon monoxide emission limits may be credited with much of this reduction in deaths. Figure 2 correlates the number of unintentional deaths due to exhaust gas poisoning with the permissible carbon monoxide emission levels for the years from 1970 to 1997.

Figure 2: Number of Unintentional Deaths as a Function of Permissible Carbon Monoxide Vehicle Emissions Limits

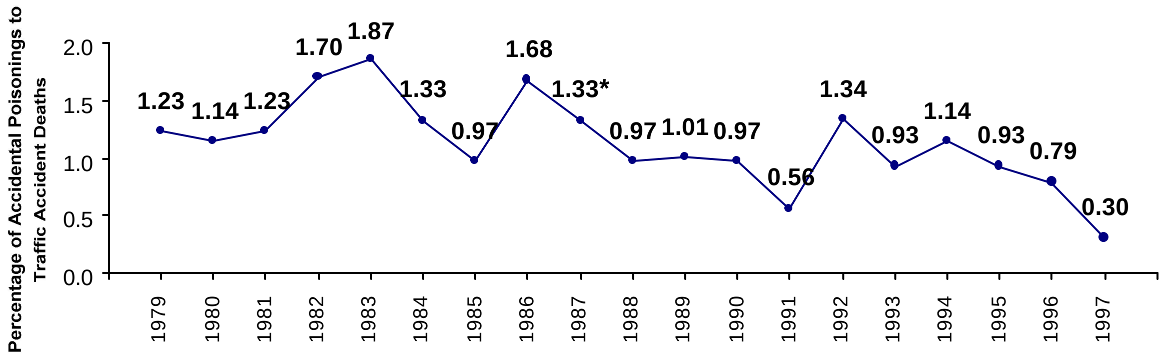


* This value is an extrapolation as statistical data for the year 1987 were not available.

Since accidental exhaust gas poisoning may be viewed as one of the risks associated with the use of motor vehicles, its incidence can be compared to that of motor vehicle accident deaths. According to Figure 3, which charts the deaths due to unintentional exhaust gas poisoning as a percentage of all motor vehicle traffic accident deaths for the years 1979 to 1997, unintentional deaths ranged from a high of 1.87% in 1983 to a low of 0.30% in 1997. In other words, the incidence of death due to unintentional exhaust gas poisoning is exceedingly low when compared to that of motor vehicle accidents as a whole.

[9] Tables showing the figures upon which figures 1 through 4 are based are available upon request.

Figure 3: Incidence of Unintentional Exhaust Gas Poisoning Deaths as a Percentage of Motor Vehicle Accident Deaths



* This value is an extrapolation as statistical data for the year 1987 were not available.

According to two recent statistical studies published by the U.S. Department of Transportation, factors that influence the risk of unintentional exhaust gas poisoning are the season of the year and whether the vehicle is moving or stationary. For the year 1993 and the years 1995 to 1997, these studies showed that 35% of accidental poisonings took place in the winter months of December, January, and February, with spring and fall having incidences of about 26% each and summer showing the lowest rate of about 14%.[10] It was also documented that the vehicle was stationary in approximately 75% of cases and moving in about 25%.

With more stringent limits on exhaust pollutants other than carbon monoxide already in place, which serve to decrease CO emissions, the risk of unintentional exhaust gas poisoning is expected to continue to decline.

Self-inflicted Motor Vehicle Exhaust Gas Poisoning

Suicide by exhaust gas poisoning is accomplished either by allowing the vehicle to idle with the windows open in an enclosed space or by redirecting the exhaust gas from the tailpipe into the interior of a sealed vehicle. The concentration of carbon monoxide in the exhaust gas of newly manufactured vehicles is sufficiently low that, when the exhaust gas is diluted by the ambient air in an enclosed space, the first method is largely ineffective. Anecdotal evidence indicates that, in numerous instances, even many hours spent in a closed garage with the engine running resulted in symptoms no more serious than general disorientation. By contrast, the second method can be lethal, as the exhaust gas enters the vehicle interior and replaces the ambient air with a gaseous mixture that may cause CO poisoning or asphyxiation. The lethality of this latter method is a function of vehicle age, engine maintenance, engine displacement, the interior volume of the vehicle, and its air exchange rate.

Table 4 above shows that the number of suicides by exhaust gas poisoning for the twenty years from 1978 to 1997 fluctuated between a high of 385 and a low of 260. Figure 4 below shows that, as a percentage of all suicides, self-inflicted exhaust gas poisonings varied between 10.5% and 7.3%, with a slight decline in incidence since 1989. In Canada, as elsewhere in the world, statistics indicate that men commit suicide more frequently than women, with an average of 3.5 men taking their own lives in Canada for every woman who does so. Self-inflicted exhaust gas poisoning is favoured by men, an average of 4.25 of whom use it for every women who does. As a method, exhaust gas poisoning ranks fourth in Canada after suicide by firearms, hanging and suffocation, and the ingestion of drugs or other harmful substances.[11]

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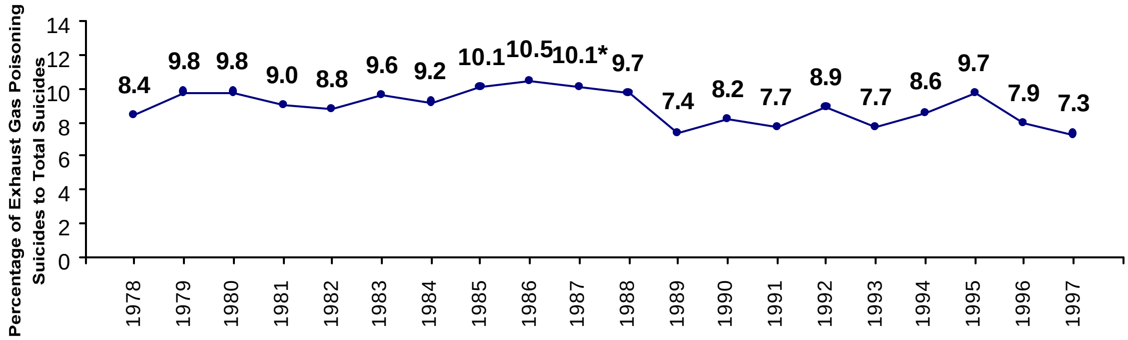
[10] "Fatalities Associated with Carbon Monoxide Poisoning from Motor Vehicles in 1993," and "Fatalities Associated with Carbon Monoxide Poisoning from Motor Vehicles, 1995-1997," U.S. Department of Transportation, National Highway Traffic Safety Administration, National Center for Statistics and Analysis, December 1996. Available on-line at: www.nhtsa.dot.gov/people/ncsa/pdf/CO_FINAL.pdf.

[11] Tables giving the incidence of suicide by gender and that compare the respective incidences and percentages of suicide by firearms, hanging and suffocation, the ingestion of drugs, and exhaust gas poisoning are also available upon request.

Figure 4: Incidence of Suicide by Motor Vehicle Exhaust Gas Poisoning in Canada



* This value is an extrapolation as statistical data for the year 1987 were not available.

According to the available data, the incidence of suicide by exhaust gas poisoning and its ranking as a method vary considerably between countries.[12] In Sweden, for instance, self-inflicted exhaust gas poisonings account for 15% of all suicides by men and 3% of all suicides by women, and like Canada, it is the fourth most frequently used method. In New Zealand, exhaust gas poisonings increased from about 10% of suicides in 1994 to nearly 30% in 1996. In Australia, this method was the second most frequently used in 1998 after hanging, and since 1990, it has consistently represented about 20% of all suicides. Australia's rate per 100,000 persons increased from 1.3 to 2.9 from 1979 to 1998; however, the numbers have stabilized, with 509 deaths in 1995 and 508 in 1998.

Based on statistics compiled by the Department, the rate of suicide by exhaust gas poisoning in the U.S. declined steadily from 1993 to 1997, from 5.4% in 1993 to 4.5% in 1997. The average rate of suicide by exhaust gas poisoning in Canada for the ten years from 1988 to 1997 was 8.3%, which is considerably less than that of Sweden, New Zealand, and Australia, but greater than that of the U.S.

Possible Approaches to Preventing Motor Vehicle Exhaust Gas Poisoning in Canada

There are three possible approaches to the problem of mitigating motor vehicle exhaust gas poisoning, each of which is outlined and discussed below. The present situation could be allowed to continue unchanged, a non-regulatory approach could be adopted, or the Department could mandate a performance test or the installation of one or more safety devices on specified classes of newly manufactured motor vehicles. A combination of a non-regulatory and a regulatory approach could also be adopted.

Maintaining the Status Quo

Statistics indicate that the incidence of unintentional exhaust gas poisoning has declined to a very low level since the introduction of motor vehicle emissions controls. Moreover, the anticipated decrease in carbon monoxide emissions that will result from more stringent limits on other pollutants is expected to reduce the number of unintentional deaths even further.

In contrast, the incidence of suicide by exhaust gas poisoning is much greater, and it has declined very little. According to research conducted in a number of countries, restricting the means available for committing self-destructive acts can reduce the overall suicide rate. Even when planned, many suicide attempts are impulsive, the act itself resulting from "psychological pain or despair coupled with the availability of the means by which to inflict self-injury."[13] If access to the means can be limited at such a moment, a suicide attempt may be averted, and a subsequent

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[12] The statistics presented in this paragraph are based on information provided in an informal document submitted by Australia to the United Nations Economic Commission for Europe's Working Party 29 titled, "Uniform Provisions Concerning Cabin Air Quality to Reduce Fatigue and Prevent Accidental or Intentional Poisoning by Exhaust Gases," (123rd WP 29, 6-9 March 2001, agenda item 2.2).

[13] *National Strategy for Suicide Prevention: Goals and Objectives for Action*, a collaborative effort of the Substance Abuse and Mental Health Services Administration (SAMHSA), the Centers for Disease Control and Prevention (CDC), the National Institutes of Health (NIH), and the Health Resources and Services Administration (HRSA), available on the internet at: www.mentalhealth.org/publications/allpubs/SMA01-3518/index.htm.

attempt may not necessarily take place. Alternatively, if a highly lethal method can be rendered less harmful, survival will be more likely, allowing the troubled person to be identified and given appropriate treatment. If properly treated, many of those who attempt suicide once will not do so again.

Reducing access to the means of self-injury is a cornerstone of the U.S. *National Strategy for Suicide Prevention*, which was recently published by the Center for Mental Health Services. The Strategy outlines 11 goals for the prevention of suicide, the fifth of which is to "promote efforts to reduce access to lethal means and methods of self-harm." Objective 5.5 of this goal is, by 2005, to "improve automobile design to impede carbon monoxide-mediated suicide." Australia also adopts the approach of reducing access to means in its proposal to the United Nations Economic Commission for Europe, World Forum on the Harmonization of Motor Vehicle Regulations, in which it requested that a global technical regulation be introduced to make air quality monitors mandatory on motor vehicles. The cost-benefit analysis of the proposal assumes that such a device would deter 40% of those who attempt to commit suicide by exhaust gas from making another attempt, whether through the use of a vehicle or by other means.[14]

Given that the incidence of unintentional exhaust gas poisoning has declined significantly since the 1970s, that carbon monoxide exhaust emissions are continuing to be reduced, and that many provinces are now instituting exhaust gas testing programs, it is expected that accidental poisonings will decrease further and may be eliminated altogether. The incidence of self-inflicted poisoning is much higher and remains essentially stable. However, it is hoped that future reductions in the emissions levels of newly manufactured vehicles will serve to lower the death rate of suicide by exhaust gas.

A Non-Regulatory Approach

This approach would consist of conducting an information campaign to warn the public of the hazards of motor vehicle exhaust gas poisoning, especially in older vehicles. A press release and an information leaflet would be issued describing the symptoms of carbon monoxide poisoning and outlining how to prevent it, with an emphasis on the importance of maintaining the vehicle exhaust system.[15] This information could also be published on the Road Safety Web site under "Safety Issues for Canadians," which already provides advice on air bags, anti-lock brake systems, bus safety, child safety, and several other subjects. A special effort would be made to reach people whose work requires them to spend long periods of time in a motor vehicle, such as transport truck operators.

The information leaflet would be an adjunct to the booklet called "Winter Driving: You, your car & winter storms" that is jointly published by the Canadian Automobile Association and Emergency Preparedness Canada. This booklet, which is also available on the Emergency Preparedness Canada Web site, provides specific information on how to avoid exhaust gas poisoning in emergency situations. Information on the dangers of exhaust gas poisoning is also currently provided in the owner's manuals of most motor vehicles, whether manufactured in North America or abroad.

The advantage of conducting an information campaign is that, in the Department's experience, public education is an effective tool for disseminating safety information. However, an information campaign would target unintentional deaths only, and it could remind those contemplating suicide of the effectiveness of exhaust gas poisoning as a method. Furthermore, this approach would do nothing to reduce the accessibility or lethality of this form of suicide.

An important non-regulatory initiative undertaken voluntarily by the Canadian Standards Association (CSA) is the adoption of the requirement for recreational vehicles to be equipped with carbon monoxide detectors. The CSA provides certification services for manufacturers who wish to use registered CSA Marks, which, when affixed to a vehicle, indicate that the vehicle was built in accordance with the applicable CSA standards. In July 1999, the Canadian Standards Association revised the standard governing recreational vehicles and, among other changes, added a requirement that carbon monoxide detectors be installed in all recreational vehicles equipped with, or designed for the future installation of, an internal combustion engine, as well as in all slide-in campers.[16] Many consumers are aware of the safety benefits of CSA certification and seek to purchase products that bear CSA Marks.

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[14] Informal document submitted by Australia to the United Nations Economic Commission for Europe, page 4.
[15] The U.S. Department of Transportation issued an advisory on the danger of carbon monoxide poisoning associated with motor vehicles in December 1996 at the time it released the results of the first statistical analysis of carbon monoxide poisoning in motor vehicles.
[16] CSA International, Z240 RV Series-99, "Recreational Vehicles," p. 6.

A Regulatory Approach

This approach would consist of several possible initiatives. An air quality test of the vehicle interior, such as that used by the Russian Federation could be introduced; an air quality monitor could be required for all newly manufactured motor vehicles; or suicide-resistant tailpipes could be mandated on passenger vehicles and light trucks.

Vehicle Interior Air Quality Test

Since 1976, the Russian Federation has required that all newly manufactured motor vehicles, except motorcycles, pass an interior air quality test at the time of manufacture. The test, which sets a limit of 20 mg/m^3 (17.2 ppm) on the concentration of carbon monoxide, is conducted under two conditions: with the vehicle travelling at a constant speed of 50 km/h and with the vehicle stationary while its engine idles. According to the information presented by the Russian Federation in an Informal Document submitted to the ECE, no more than 2.5% of the vehicles evaluated fail this test. The main causes of failure are design faults of the exhaust system, the fuel tanks or other fuel system components, and sealants.[17]

The advantage of an interior air quality test is that it ensures that exhaust gas and fuel vapours are not present in harmful concentrations inside the vehicle at the time of manufacture; however, such a test cannot provide a warning with regard to changes in air quality that may take place due to deterioration of the exhaust system, which is the most frequent cause of unintentional exhaust gas poisoning. Furthermore, an interior air quality test does not address the problem of self-inflicted exhaust gas poisonings.

Mandatory Air Quality Monitors

At its simplest, an air quality monitor would be capable of detecting the oxygen and carbon monoxide concentrations inside a motor vehicle and sounding an alarm when an unsafe level of either gas was reached. Additional features could include the monitoring of other gases or pollutants, such as carbon dioxide, benzene, and oxides of nitrogen; a visual display of the level of the gases being monitored; engine shutdown if a critical concentration of gases accumulated in a stationary vehicle; or automatic lowering of power windows, if the vehicle was so equipped, when a predetermined threshold was reached.

This approach would require that alarm thresholds be specified in a safety standard, for which the workplace oxygen and carbon monoxide concentration limits set by a number of health and safety organizations could serve as a basis. Table 5 presents the limits set by the World Health Organization (WHO), the U.S. Occupational Safety and Health Administration (OSHA), the U.S. National Institute for Occupational Safety and Health (NIOSH), and the American Conference of Governmental Industrial Hygienists, Inc. (ACGIH).

Table 5: Oxygen and Carbon Monoxide Safety Limits Set by Several Health and Safety Organizations[18]

Gas	WHO	OSHA	NIOSH	ACGIH
O_2	--	19.5%	19.5%	--
CO	9 ppm	50 ppm	35 ppm	25 ppm

In their study, Parkes and Burk suggested a carbon monoxide threshold of 70 ppm because this level would ensure that the carboxyhemoglobin concentration remained below 10%, a level that produces only very mild symptoms (see Table 1)[19]. J. Moller, in his work modelling the different signatures of oxygen and carbon monoxide, suggested the thresholds that are set out in Table 6.[20]

[17] Informal document submitted by the Russian Federation to the United Nations Economic Commission for Europe's Working Party 29 titled, "Harmful Substance Concentration in the Air of Vehicle Cab/Compartment due to Access of Exhaust Gases and Fuel Vapors," (124th WP 29, 26-29 June 2001, agenda item 2.2.1).
[18] The WHO, OSHA, and NIOSH data contained in this table were taken from K. Galatsis, W. Wlodarski, B. Wells, and S. McDonald, "Vehicle Cabin Air Quality Monitor for Fatigue and Suicide Prevention," SAE Technical Paper 2000-01-0084, p. 2.
[19] M. Parkes and R.C. Burk, "A Review of the Potential Hazard of Carbon Monoxide Emissions in Gasoline Powered Vehicles and its Prevention," p. 6.
[20] J. Moller, "Modelling the Different Signatures of Accidental and Intentional in Car Motor Vehicle Gas Poisoning," unpublished paper prepared for the Australian Department of Health and Family Services Mental Health Branch,

Table 6: Hazard Warning Levels Recommended by J. Moller

Warning Level	Oxygen	Carbon Monoxide
Low	19.5%	35 ppm
Moderate	17.0%	100 ppm
Critical	16.0%	200 ppm

Setting appropriate warning thresholds is important, not only for safety reasons, but in order to prevent false alarms. Research indicates that carbon monoxide levels well above the limits shown in Table 5 may be reached inside vehicles for short periods of time in slow-moving traffic, in underground parking lots, and while driving through tunnels.[21] For instance, carbon monoxide levels in the Fort Pitt Tunnel in Pittsburgh, Pennsylvania, are known to increase to 125 ppm when traffic has slowed to a crawl and to rise as high as 250 ppm when traffic has stopped entirely due to a collision. The carbon monoxide level inside an underground parking garage has been estimated at 100 to 200 ppm for periods of 10 to 20 minutes when a large number of cars, all running cold and therefore producing high concentrations of CO, are waiting to exit. Mandating air quality monitors would also probably lead to increased public awareness of air pollution levels while driving.[22]

With regard to the probable cost of factory-installed air quality monitors, three estimates were found in the literature. The earliest, taken from a research paper published in 1991 by the U.S. Department of Transportation, estimates a cost below $25.00 USD ($38.00 CAD)[23] per unit in quantities of 250,000 for a monitor equipped with a metal oxide semiconductor gas sensor.[24] The second estimate, published in the *Federal Register* of September 19, 1997, was based on a quote obtained by a petitioner from the Quantum Group, a manufacturer of detectors. The cost of $16.00 USD did not include installation, which the National Highway Traffic Safety Administration estimated would add 50 percent to the price, for a total of $32.00 USD ($48.50 CAD). The most recent estimate of $16.00 AUD (about $13.00 CAD) for the monitor alone was provided by Australia in its proposal to the United Nations Economic Commission for Europe (ECE).

The latter two estimates did not specify the type of sensor, which is an important consideration. Electrochemical sensors are inexpensive, but have a maximum life of 6 to 8 years, with declining sensitivity and accuracy over time; whereas non-dispersive infrared sensors are more costly, but do not need replacement. The requirement to change the sensors, even once, would seriously reduce the potential effectiveness of air quality monitors as a safety measure. In order for air quality monitors to be as effective as possible in reducing the risk of exhaust gas poisoning, it would be necessary for them to be maintenance free.

It is possible that mandating air quality monitors for all newly manufactured vehicles would reduce the overall suicide rate; however, given the cost of air quality monitors, they may not prove to be cost effective. In addition, due to the time normally required to a prepare and publish a regulatory amendment, it would be several years before the requirement for air quality monitors in motor vehicles would come into effect and approximately ten years before a significant proportion of the fleet would be equipped with them. In this interim period, it is expected that the likelihood of suffering fatal carbon monoxide poisoning from exhaust gas, whether intentional or unintentional, will be greatly reduced.

Mandatory Suicide-Resistant Tailpipes

A suicide-resistant tailpipe is designed so as to prevent the attachment of a hose to the end of the tailpipe. Screening near the tip prevents the insertion of a hose into the tailpipe, and hidden venting allows the exhaust gas to escape under the vehicle should a hose or bag be taped to the outside lip. Draft specifications developed by Australia require that the tip have an outside maximum diameter greater than 50 mm and an internal diameter no less than 15 mm. The hidden vent must have a low resistance, and it must be positioned so that the airflow over the

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[21] Grace et al., pp. 14-17.

[22] P. Jefferiss, A. Rowell, M. Fergusson, "The Exposure of Car Drivers and Passengers to Vehicle Emissions: Comparative pollutant levels inside and outside vehicles," Greenpeace U.K., September 1992.

[23] The exchange rates used for the estimates given in this paragraph were those in effect on June 7, 2001.

[24] Grace et al, p. 52.

exhaust system when the vehicle is travelling ensures that the exhaust gas will be discharged beyond the rear of the vehicle. The Australian design has been tested to ensure that it does not alter engine performance.[25]

According to the results of a study to assess the feasibility of installing after-market suicide-resistant tailpipe tips at the time the exhaust system of a vehicle is repaired, such tips would cost $4.00 CAD each.[26] It is expected that the cost of suicide-resistant tailpipes as original equipment on newly manufactured vehicles would consist mainly of a one-time redesign and retooling expense. Ford and Nissan have already developed effective and aesthetic prototype designs.

Since, according to Australian data, a hose is used to redirect the exhaust gas to the interior of the vehicle in 96% of suicides by exhaust gas poisoning, requiring the fitment of suicide-resistant tailpipes could substantially reduce the number of deaths due to self-inflicted exhaust gas poisoning. Any initiatives to make suicide-resistant tailpipes mandatory, either as original or replacement equipment, would have to be undertaken with discretion so as not to call attention to the lethality of motor vehicle exhaust gas poisoning as a method of suicide.

Request for Comments on Possible Measures to Prevent Motor Vehicle Exhaust Gas Poisoning

The Minister of Transport requested that automotive manufacturers, importers, public safety organizations, and other interested parties respond to the following questions in particular:

- Given the current carbon monoxide emission levels of newly manufactured motor vehicles and bearing in mind expected future reductions, is there a need for any action on the part of the Department?
- Would an information campaign be effective in lowering the incidence of unintentional motor vehicle exhaust gas poisoning?
- Should automotive manufacturers be required to provide air quality monitors as standard equipment on motor vehicles?
- Should automotive manufacturers be required to provide suicide-resistant tailpipes on motor vehicles?
- Should carbon monoxide detectors be required in motor homes, or is it sufficient that the Canadian Standards Association specify them as standard equipment?

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[25] J. Moller, C. Hutchings, J. Evans, and B. Price, “Motor Vehicle Exhaust Gas Suicide Resistant Tailpipe: Design feasibility assessment,” April 1998, unpublished paper.
[26] Ibid.