closing the gasoline system - control of gasoline emissions from the distribution system and vehicles

Prepared by the CONCAWE Secretariat

ABSTRACT

This report shows that a series of measures effectively closing up the gasoline system of distribution and use in motor vehicles is the preferred strategy to control gasoline emissions. These emissions contribute about 40% to the volatile organic compound (VOC) element of photochemical ozone, and control is being given priority in the EC.

The European Commission is proposing to control gasoline evaporative emissions from cars in the draft directive which sets stringent exhaust emission limits, requiring 3-way exhaust catalysts for all cars. A further draft directive is expected during 1990 to control emissions from distribution of gasoline from refineries and terminals to service stations.

The effectiveness of each of the main options to control gasoline emissions is examined. Carbon canisters are capable of 90% control of evaporative emissions from parked cars, but full effectiveness depends upon choice of test conditions which realistically represent road fuels and the more testing ambient conditions found.

This leads to the conclusion that the strategy being followed by the Commission should be followed through by taking the opportunity presented by the enlarged on-board carbon canister to control vehicle emissions, giving control of refuelling and evaporative emissions in one step, including running losses.

This strategy is more effective and energy efficient than the alternative of restricting the quality and composition of gasoline. The enlarged carbon canister is the most effective way of achieving the "closed gasoline system".

To underline this conclusion, the effectiveness of the closed system approach is assessed for the control of benzene emissions derived from gasoline. Limiting the benzene content of gasoline would be a much less effective approach.

CONTENTS Page

SUMMARY

This report identifies the preferred strategy to control gasoline emissions from the system of distribution and use of gasoline in motor vehicles.

These emissions contribute approximately 40% to the inventory of some 10 million tons of uncontrolled volatile organic compound emissions from man-made sources in Western Europe (OECD).

Gasoline emission control is being given priority within the EC as part of the overall strategy to reduce pollution by photochemical ozone in the lower atmosphere.

The European Commission is proposing to control gasoline evaporative emissions from cars by means of on-board carbon canisters containing activated charcoal. The proposal is part of the draft directive to implement the stringent exhaust emission limits already agreed in principle, which will require use of 3-way exhaust catalysts for all cars. A draft directive requiring vapour recovery equipment to control emissions from gasoline distribution is also expected during 1990.

Though the EC strategy is based on significant steps towards "closing the gasoline system", current proposals stop short of being fully effective. Refuelling emissions are not to be controlled in the initial stage and vehicle running losses are not addressed. In particular, choice of inadequate test conditions in the proposed directive is likely to result in a carbon canister which is too small and does not meet its potential of 90% control of evaporative emissions from parked cars.

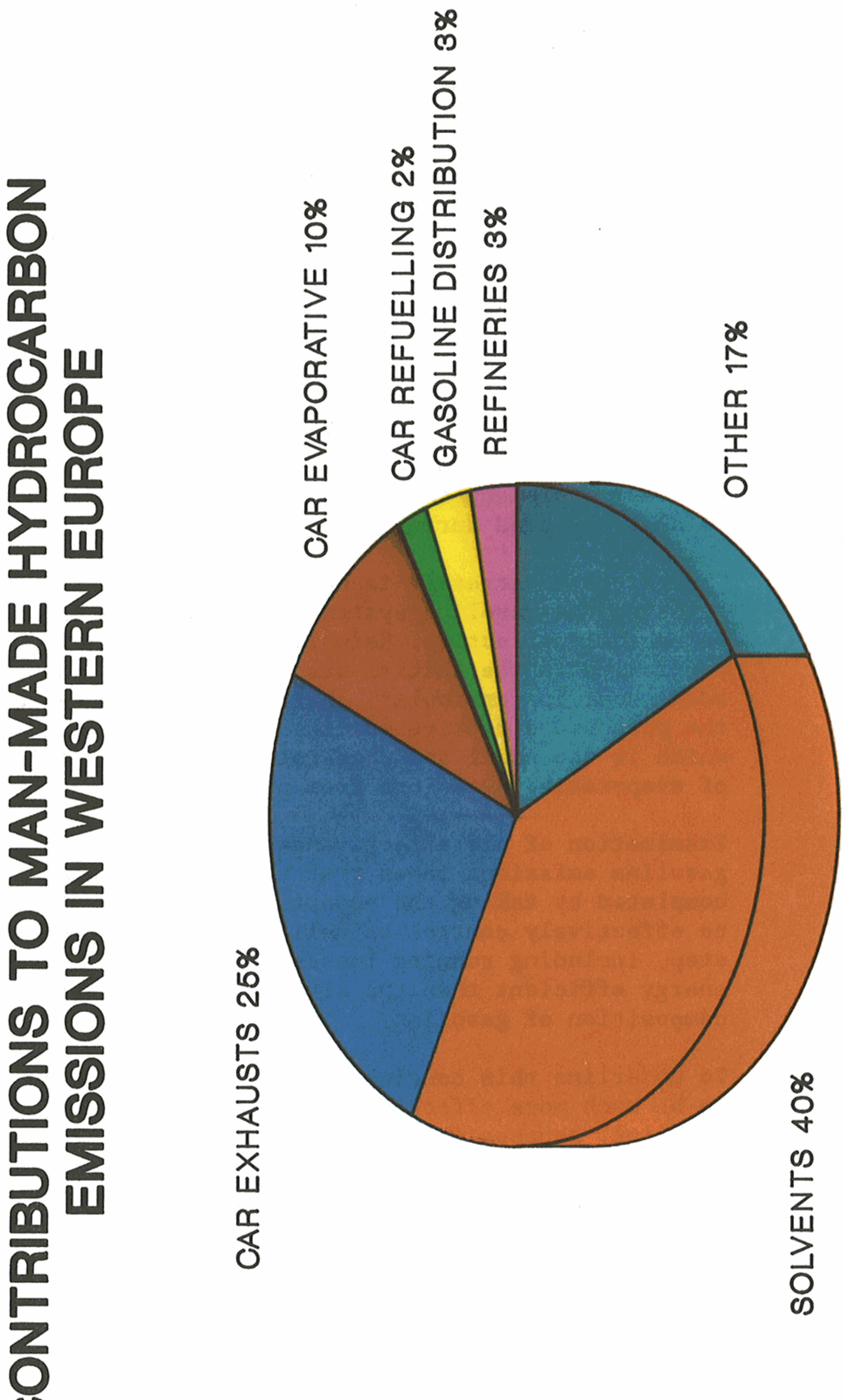
Examination of the effectiveness of the main options to control gasoline emissions shows that the Commission's strategy should be completed by taking the opportunity of the enlarged carbon canister to effectively control refuelling and evaporative emissions in one step, including running losses. This strategy is more effective and energy efficient than the alternative of restricting the composition of gasoline.

To underline this conclusion, the "closed system" approach is shown to be much more effective than limiting the benzene content of gasoline. Benzene is a natural constituent of gasoline. It is estimated that about 80% of man-made benzene emissions in Europe comes from gasoline cars, most of which is emitted from exhausts and will be controlled by catalysts.

There is no evidence that health problems are caused by current ambient air levels of benzene, which can be about 3 to 8 parts per billion in urban areas. Nevertheless, some authorities consider it prudent to reduce the levels of ambient benzene in urban areas.

An effectively "closed gasoline system" is capable of reducing benzene emissions from cars by approaching 90%.

Figure 1


CONTRIBUTIONS TO MAN-MADE HYDROCARBON EMISSIONS IN WESTERN EUROPE
CAR EXHAUSTS 25%
CAR EVAPORATIVE 10%
CAR REFUELLING 2%
GASOLINE DISTRIBUTION 3%
REFINERIES 3%
OTHER 17%
SOLVENTS 40%

1. INTRODUCTION

Motor vehicles are a major source of nitrogen oxides (NO_x) and hydrocarbon emissions which contribute to the formation of ozone pollution in a complex photochemical process in the lower atmosphere (troposphere).

Annual emissions of volatile organic compounds (VOCs), including hydrocarbons but excluding methane, in Western Europe have been estimated at some 10 million tons from man-made sources. There are also significant emissions from natural sources.

Gasoline fuelled vehicles are the second largest contributor, with exhaust emissions accounting for 25%, evaporation from the car 10% (including an estimate of running losses), and a further 2% from car refuelling. Gasoline distribution, i.e. transportation from refineries to marketing terminals and from there to service stations, accounts for about 3%, and oil refining (including crude oil receipt) for another 3% of the inventory (Figure 1).

Taken together, gasoline distribution and use of gasoline in vehicles is estimated to contribute about 40% of total man-made VOC emissions. Therefore control of these emissions is seen as a priority within the European Community as part of the overall strategy to reduce pollution by tropospheric ozone.

The European Commission proposals to control emissions from vehicles were published in the draft directive on automotive emissions, COM (89) 662 (final) (1). A directive to control emissions from gasoline distribution is expected to be proposed during 1990.

The EC draft directive on vehicle emissions sets emission limits which would require catalytic converters to control exhaust emissions, and has chosen on-board technology to control evaporative emissions from parked cars by means of the small canister containing activated carbon (charcoal).

This summary report examines the effectiveness of each of the main options to control gasoline emissions, and of combinations of options to effectively "close the gasoline system".

2. CONTROL STRATEGY - CLOSING THE GASOLINE SYSTEM

The effective approach to control emissions from the distribution and use of motor gasoline is the installation of equipment to prevent gasoline from being emitted to the atmosphere, i.e. "closing the gasoline system". Individual steps involved are:

- **Vapour recovery units at refinery and marketing terminal gasoline loading facilities** for tank trucks, rail cars and barges, and vapour return lines at service station tanks (referred to as **Stage** I controls).

  Emissions from gasoline distribution are mainly due to displacement of vapour from tanks and delivery vehicles when gasoline is transferred. There is already progressive installation of Stage I equipment in gasoline distribution systems in several EC countries. Stage I vapour recovery will be the subject of a Commission proposal during 1990.

- **Exhaust catalysts** installed on vehicle tailpipes.

  The current Commission proposal for a directive on measures against emissions from motor vehicles sets emission limits that will require 3-way "closed loop" catalyst technology on all cars. Such technology offers the potential for reducing gasoline emissions in the exhaust by 90% compared with uncontrolled cars.

- **Small carbon canisters** (SCC) to control evaporative emissions from the car by adsorbing gasoline vapour on to activated charcoal in a canister, then purging by air fed to the engine. Emissions are fuel tank breathing day and night, called diurnal losses, hot soak losses when a car is parked with a hot engine after use, and running losses when driving.

  Such technology will be required to meet the evaporative emission limit proposed in the draft EC vehicle emission directive and offers the potential for 90% reduction of some evaporative emissions, but without control of refuelling and running losses. **But, better are:**

- **Enlarged carbon canisters** (ECC) to give combined control of all evaporative and refuelling emissions from vehicles, operating in a parallel way to small canisters.

  With the canister enlarged from 1-1.5 litres to 4-5 litres capacity, the technology offers potential to reduce refuelling emissions by at least 95%. Furthermore, if preliminary US EPA findings can be applied to the European situation, the ECC technology should allow control of vehicle running losses. These are losses which can occur, for example, when warm fuel is recirculated from the engine to the fuel tank during driving.

The control of evaporative and refuelling emissions can also be achieved separately by small canisters together with:

- **Vapour recovery equipment (Stage II)** fitted to service station pumps.

  Stage II effectiveness has been measured at 50-60% for European cars, and full effectiveness depends on replacement of old cars to achieve compatibility between filler nozzles and car filler necks. Then Stage II offers at maximum 85% emission reduction potential, provided the equipment is regularly checked and well maintained.

Requiring fitting of canisters to cars needs EC agreement and legislation. Stage II controls can be introduced at local/national level without causing a barrier to trade.

A major advantage of the strategy of "closing the gasoline system" is that it deals with concerns there may be - now or in the future - about gasoline components, since it essentially prevents the gasoline system from causing environmental effects. Furthermore, some national concerns about public exposure to benzene emissions can most effectively be addressed by containing the gasoline in this way. In particular, this strategy allows gasoline composition to be optimized to meet performance requirements in current and future engines. Thus it allows energy-efficient use of gasoline.

3. BASIS OF ASSESSING EFFECTIVENESS OF CONTROL OPTIONS

CONCAWE has assessed the potential effectiveness of the different control strategies to year 2010 and beyond based upon combinations of the individual control options. This has involved considering effects of control options and efficiency of equipment performance and making judgements about possible timing of implementing the various steps, e.g. car population, new car registrations, installation rates for new equipment. The growth of car population was assumed to be 25% from 1985 to 2010.

The consequences of restricting gasoline composition, and the potential impact on refining options and economics have also been assessed.

Exhaust emissions are estimated assuming that a car meets (and continues to meet through its life) the legislated standard in effect at the time it was registered. Durability requirements are part of current EC proposals for control of automotive emissions. For the 3-way catalyst case, the currently proposed stringent standards have been assumed. The assumption for both 3-way catalysts and small carbon canisters is that they will be required on all cars registered after December 31st 1992.

Correlations to predict **evaporative losses** from passenger cars are based on recent CONCAWE work studying the effect of volatility and temperature on the evaporative emissions from both controlled and uncontrolled European cars (2).

Until more details are known about the intended EC Stage I directive, the assumption for **Stage I vapour recovery controls** on terminals and tank truck unloading at service stations is that in a first phase over a period of 3 years, commencing 1993, 80% of gasoline consumption will be subject to vapour recovery. This is estimated to be equivalent to all terminals with throughputs greater than 50 kt/year (and associated service stations) being fitted with vapour recovery systems. The efficiency of the actual vapour recovery equipment at the terminals is assumed to be 95%, implying single stage recovery.

By 2003 a second phase of control is assumed to result in an overall Stage I recovery of 80%.

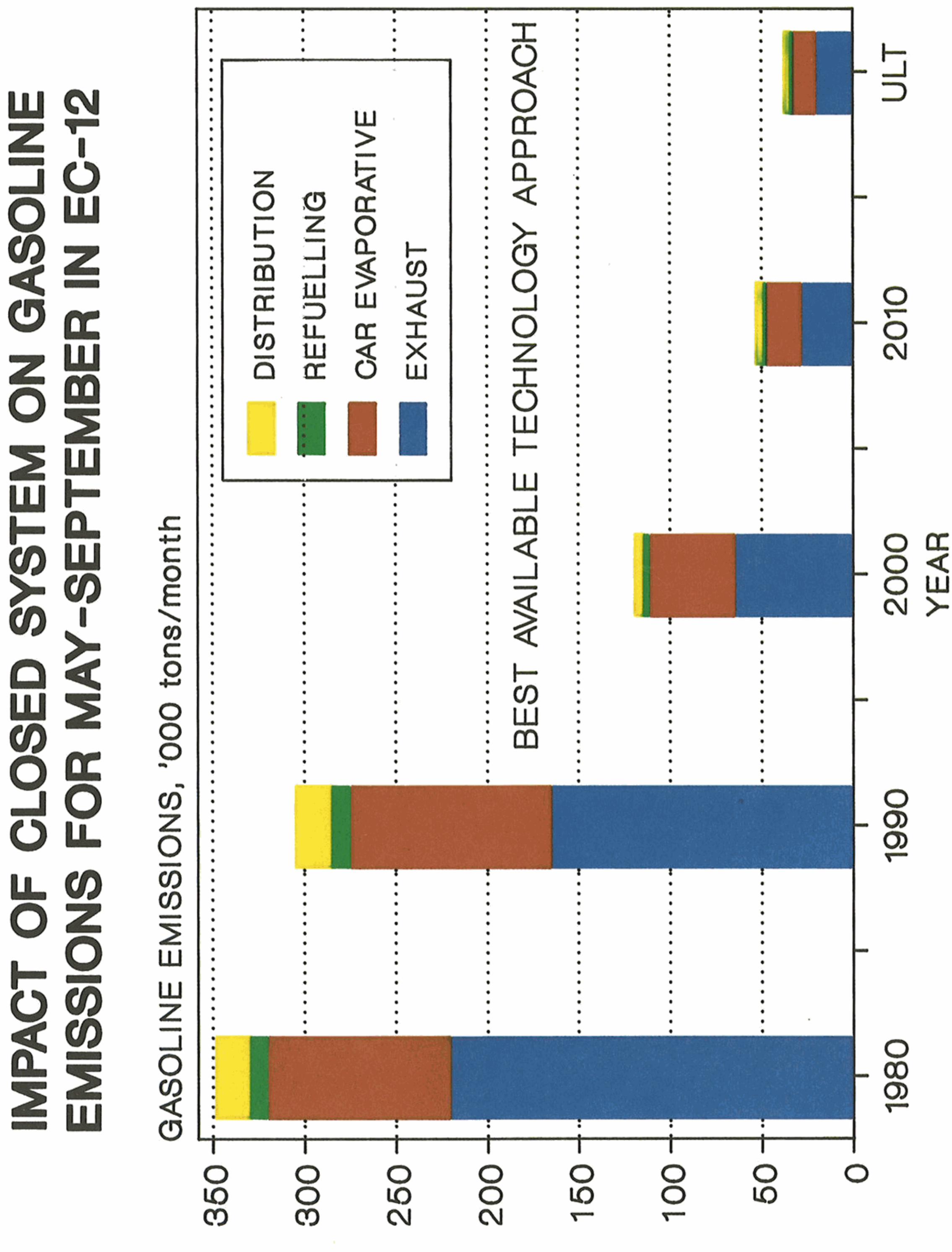
The installation rate and coverage for **Stage II refuelling vapour recovery** is assumed to be similar to that for Stage I, above. Efficiency of Stage II systems will change with time reflecting the initial incompatibility of filler nozzle and current car population filler necks. Tests on Stage II systems conducted as part of an overall CONCAWE project (5), indicate that average efficiencies of 55% can be expected with the current car population. With fully compatible car filler pipes and nozzles efficiencies up to 85% have been claimed. The assumption used in the model is that the efficiency of Stage II will initially be 55%, rising to 85%

eventually, with the main effect being achieved during the first 10 years, but 15-20 years required before old cars are completely replaced.

The assumption for the alternative means of controlling refuelling at the same time as evaporative losses, i.e. the enlarged carbon canister, is that the technology would be required on all new registrations after December 31st 1992. An efficiency of at least 95% has been demonstrated by CONCAWE (3) and confirmed by the German TÜV (4). The timing for the complete change of the car fleet is the same as used above for Stage II.

A description of the methodology and basic relationships assumed in the models is available.

Figure 2



IMPACT OF CLOSED SYSTEM ON GASOLINE
EMISSIONS FOR MAY-SEPTEMBER IN EC-12
GASOLINE EMISSIONS, '000 tons/month
DISTRIBUTION
REFUELLING
CAR EVAPORATIVE
EXHAUST
BEST AVAILABLE TECHNOLOGY APPROACH
350
300
250
200
150
100
50
0
1980
1990
2000
2010
ULT
YEAR

4. EFFECTIVENESS OF CONTROL OPTIONS

4.1 EC PROPOSAL TO REDUCE GASOLINE EMISSIONS

The EC draft directive on vehicle emissions sets emission limits which would require catalytic converters to control vehicle exhaust emissions and on-board canister technology has been chosen for controlling car evaporative emissions by means of the small carbon canister.

The Commission proposal on emission reduction from the gasoline distribution system (Stage I) is due later in 1990.

CONCAWE's strategy is consistent with the EC's chosen approach, but includes the additional benefits of a fully closed gasoline system with fully efficient enlarged on-board canisters.

Enlarged canister (ECC) technology is ultimately more effective than Stage II control. The efficiency of ECC technology for controlling refuelling emissions has been well documented (3 and 4) and offers at least a 95% reduction in emissions. This compares with 85% as the best achievable performance from well maintained Stage II systems once the filler nozzle is compatible with all cars (5).

Figure 2 shows the fully closed gasoline system case assuming the installation of enlarged carbon canisters to control both refuelling and evaporative losses from the car. This figure shows the changes in individual contributions with time. Since some 5% "uncontrolled cars" (i.e. pre-1993) remain in 2010, this figure also shows the "Ultimate" control that would be achieved eventually when all cars are fitted with 3-way catalysts and enlarged canisters (ECCs.)

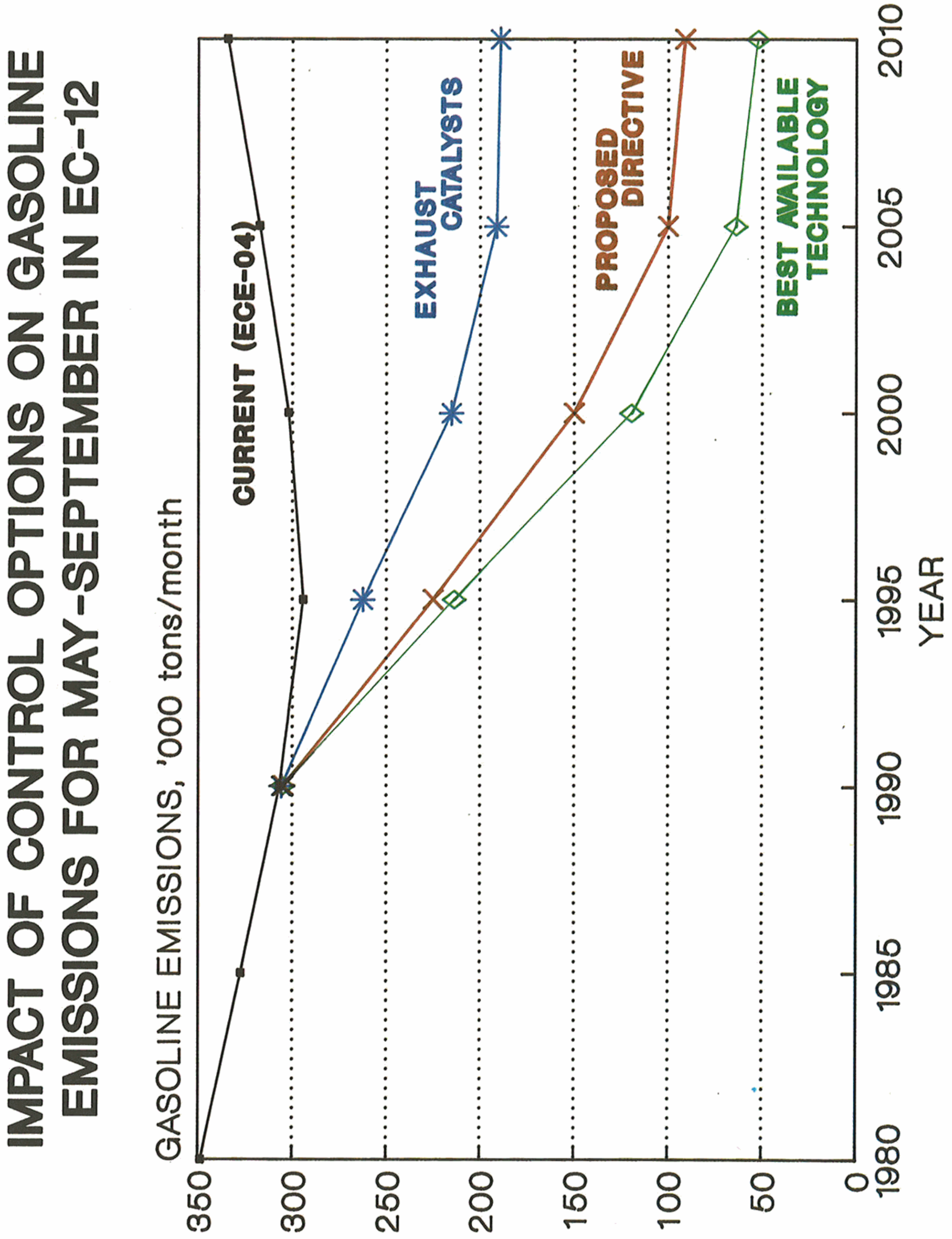
The effectiveness of each step in 'closing the gasoline system' is shown in Figure 3. The plots are based on average emissions predicted for the summer period. It is during the summer months, with higher ambient temperatures, that emission control is tested and "ozone episodes" generally occur.

The main points to be noted from these two figures are:

- A properly designed on-board small carbon canister system (giving an efficiency of 90% (2) for reducing evaporative losses from the car) is capable of making almost as big a contribution to the reduction of gasoline emissions during the summer as exhaust catalysts. This emphasizes the need to ensure that a realistic test procedure is included in the final form of any legislation to achieve the full control potential of this technology.

  The test procedure proposed in the draft directive does not reflect maximum temperatures in Southern European countries nor fuel qualities marketed throughout the EC. Therefore,

Figure 3


IMPACT OF CONTROL OPTIONS ON GASOLINE
EMISSIONS FOR MAY-SEPTEMBER IN EC-12
GASOLINE EMISSIONS, '000 tons/month
350
300
250
200
150
100
50
0
1980
1985
1990
1995
2000
2005
2010
YEAR
CURRENT (ECE-04)
EXHAUST CATALYSTS
PROPOSED DIRECTIVE
BEST AVAILABLE TECHNOLOGY

canister systems designed and approved on this basis would fall short of meeting full potential emission recovery efficiency. This is discussed more fully in Section 5 of this report.

- Overall, complete "closure of the gasoline system" (including refuelling) ultimately offers almost a 90% reduction in evaporative gasoline emissions. This equates to about a 33% reduction in the total man-made VOC emissions from a 1980 base year, despite expected substantial increases in the European car population over the time period (estimated at about 25%).

  The oil industry has already made significant investments as part of closing the gasoline system with the introduction of unleaded gasoline (paving the way for exhaust catalyst technology), substantial refurbishment of gasoline storage tanks in refineries and marketing terminals with high efficiency seals to the ambient air, and the progressive installation of vapour recovery facilities for the loading/unloading of gasoline road trucks and rail cars in several countries.

The Commission is not proposing to control running losses, and considers control of refuelling losses of low priority. However, current developments at the national level, driven by concerns over public exposure to benzene, are resulting in national pressures to control refuelling losses now. Since a requirement for enlarged canister technology at national level would appear to represent a barrier to trade, this is resulting in local pressure for Stage II to be installed.

Early introduction of less than fully efficient small canister controls combined with Stage II would give some benefit in the short-term, but ultimately would be less effective than the enlarged canister. Studies in Europe and the USA have confirmed the much better cost-effectiveness of the enlarged canister option, since the enlarged canister has a low incremental cost compared with the small canister (6). It is logical, therefore, to propose to introduce the enlarged canister as soon as possible.

CONCAWE believes that advantage should be taken of the experience in the USA. Not doing so will result in a lost opportunity to install the more effective, more robust and more cost-effective enlarged canister control system, which represents best available technology.

4.2 VOLATILITY REDUCTION

CONCAWE has estimated the effect of the alternative approach of changing the composition of gasoline by limiting the volatility (RVP). We chose to assess the effect of 60 kPa in all EC-12 countries during the summer period May through September, and combined this with the assumption that 3-way catalysts will be required on all new cars from January 1993, but that closing of the gasoline system by means of carbon canisters/Stage I/Stage II is not required.

The reduction of gasoline volatility to 60 kPa RVP during the summer by itself would only reduce evaporative emissions from cars by about 10% (7). There would be an initial benefit from reduced volatility (assuming a requirement for 60 kPa RVP in the summer could already be met in 1990). This advantage is rapidly eroded with time, and ultimately the "closed system" offers a much more significant reduction. This illustrates that a control strategy which is based on measures to "close the gasoline system" has significant advantage over the alternative of reducing volatility, or of restricting composition in any other way.

- The "closed system" is ultimately a more effective strategy than reducing volatility. It enables the composition and quality of gasoline to be optimized to meet the performance requirements in current and future gasoline powered cars. This aspect could have significant implications in minimizing investment requirements for the motor industry with the associated cost burden to the European Community as a whole.

The "closed system" is a very robust strategy since it deals with any future concerns over any components in the gasoline. A strategy based on compositional control would clearly require specific legislation to address any new concerns.

Finally, this approach enables optimum use of energy and crude oil components in meeting the performance requirements of cars. The optimum use of energy is an important goal to minimize the cost of imports, and directly impacts on the emerging concerns over global warming and climate change. For example, a requirement to reduce the volatility of gasoline would require the removal of butane from gasoline. Such a step would not only require making up the lost gasoline tons but, since butane is an important octane component in gasoline, alternative and more energy demanding octane components would need to be produced and blended into the gasoline.

4.3 BENZENE IN GASOLINE

Benzene and other aromatic compounds are natural constituents of crude oil and become part of gasoline. Some processes used in refineries increase the aromatic content. Significant amounts of benzene are also formed during combustion in the engines of gasoline vehicles and emitted from car exhausts.

It is estimated (8) that some 80% of man-made emissions of benzene to the air in Europe comes from gasoline cars, most of which is emitted from the exhaust. A further 5% is due to evaporation during gasoline distribution, and about 1% comes from oil refining. The chemical industry accounts for some 5%. Remaining sources include solvent evaporation and various combustion processes including wood burning.

4.3.1 Health aspects

The health risks of exposure to non-occupational sources of benzene have been reviewed in a recent CONCAWE report (9).

Although occupational exposure to high levels of benzene has been associated with health effects, there are no data confirming benzene related health effects in the general public. Nevertheless some authorities, notably in California, Germany and the Netherlands, take the view that it is prudent to reduce the levels of ambient benzene in urban areas by measures to control gasoline emissions and/or the composition of gasoline.

The risk estimates being used to justify the need to reduce exposures to benzene are derived from studies on workers occupationally exposed to high levels of benzene during the 1940s and 50s.

Risk estimates aside, the only definite conclusions which can be drawn from workplace exposure studies are:

- no case of benzene-induced leukaemia has been confirmed following regular and repeated exposure at work to benzene concentrations in air below 100 parts per million (ppm);

- no adverse blood effect in humans has been confirmed following regular and repeated exposure at work to benzene concentrations in air below 25 ppm;

- benzene can cause chromosome aberrations, but there is no evidence to link these with the occurrence of leukaemia;

- there are no health data from which a reliable estimate can be made of the onset of health effects at specific concentrations of benzene in air.

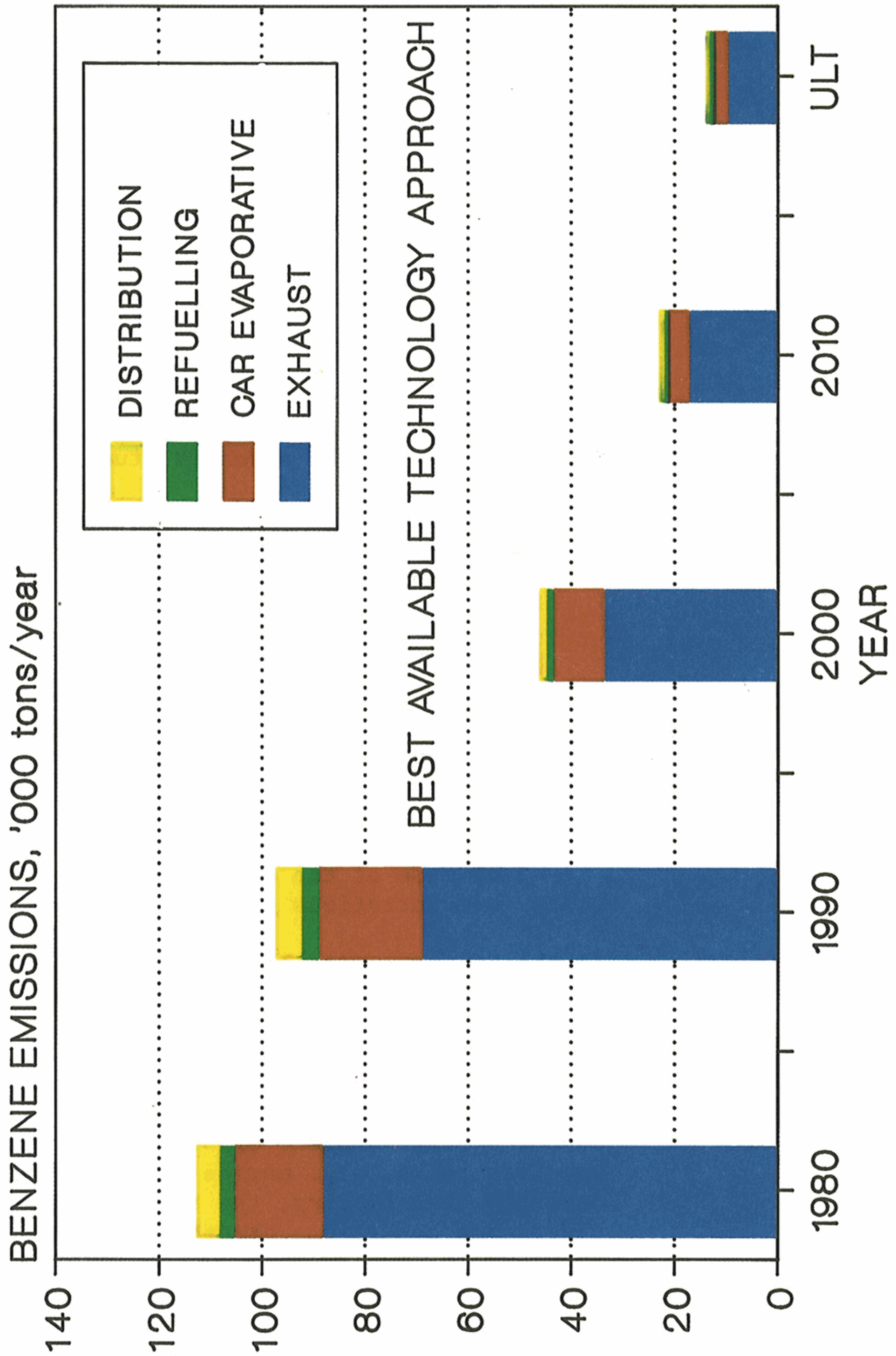
In the EC, an action level of 1.5 ppm was proposed, as a time weighted average workplace exposure, above which health monitoring would be required.

In comparison, review of exposures to oil industry employees had shown that good working practices and control measures ensure that 8-hour average benzene exposures are normally below 1ppm. For specific tasks, e.g. marine loading, top loading of road and rail cars and drum filling, the 8-hour average benzene exposures can under some conditions exceed 1 ppm (10), and special measures should be taken.

Despite these conclusions derived from occupational exposures, it is not possible to demonstrate a threshold level below which humans are safe from exposure to even weak carcinogens. This has led to a view that large numbers of people in urban areas exposed to low ambient levels of benzene could result in a significant number of

Figure 4

IMPACT OF CLOSED SYSTEM ON BENZENE EMISSIONS IN EC-12



deaths from leukaemia. The quantification of increased risk to the general population to low level exposure to benzene has been the subject of much debate. The issues surrounding this debate are fully discussed in a recent CONCAWE report (9).

CONCAWE believes that there is no scientific evidence to suggest that current ambient air levels of benzene, which can be in the order of 3 to 8 parts per billion (ppb) in urban areas, can be related to any increased risk of leukaemia in the general public (8). In fact, an analysis of the incidence of leukaemia in some European countries have shown no correlation with the increasing gasoline consumption over the last decades (11). However, application of the "closed gasoline system" approach as CONCAWE proposes, would reduce current benzene emission by nearly 90%.

4.3.2 Effect of closing the gasoline system on benzene emissions

Figure 4 shows the effects on benzene emissions over time of closing the gasoline system with control of refuelling losses via ECC technology. The results were generated with correlations relating benzene emissions to the changes in benzene and aromatic content of gasoline over time as predicted in a recently published CONCAWE planning study (12).

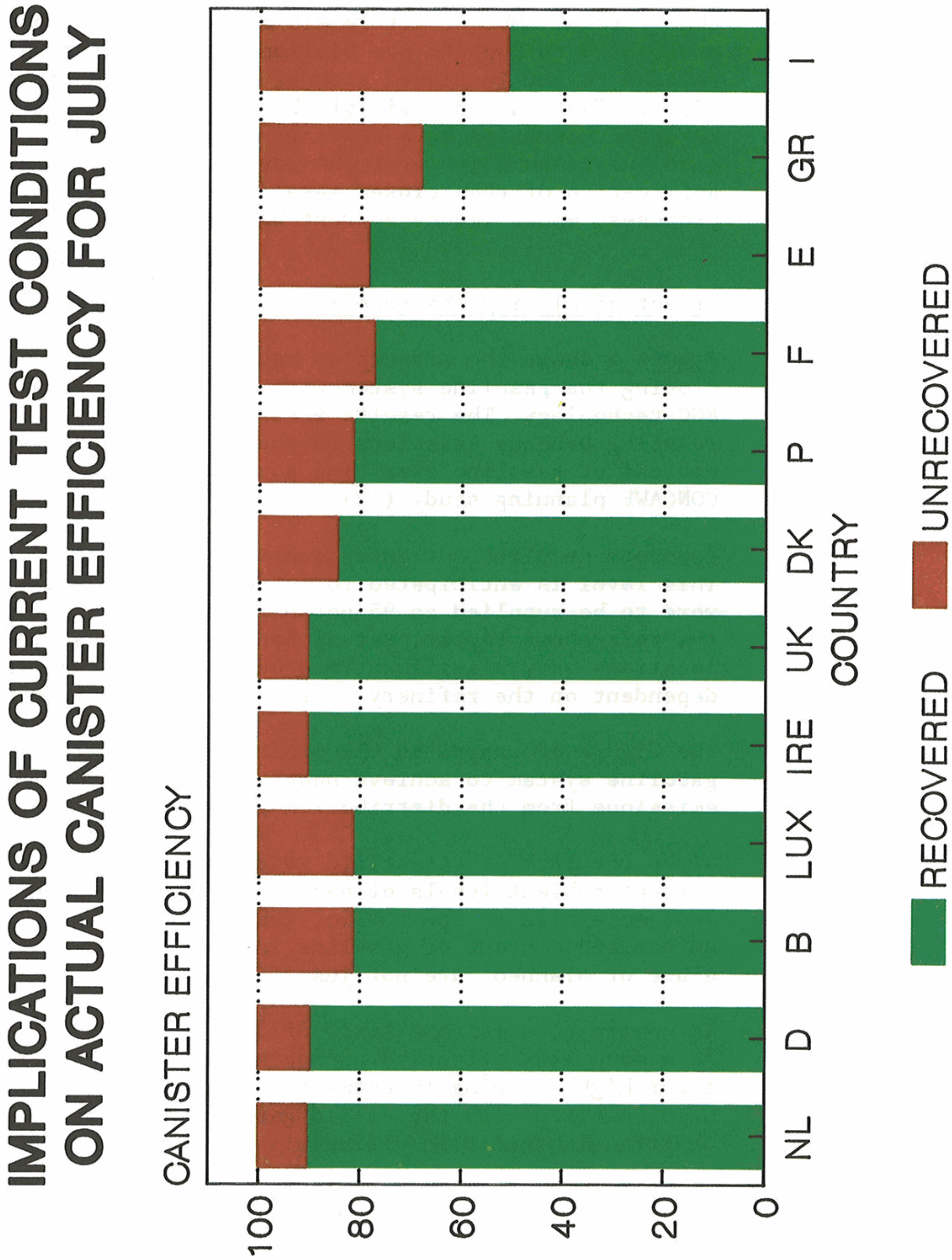
European gasoline currently contains on average 2.6 vol % benzene. This level is anticipated to increase to 3.2 vol %, if all gasoline were to be supplied as 95 octane unleaded grade. As discussed in the referenced report, actual benzene levels at individual locations vary significantly around this average and are highly dependent on the refinery configuration and crude oils processed.

The figure demonstrates the ultimate potential of closing the gasoline system to achieve nearly 90% reduction in benzene emissions from the distribution and consumption of gasoline.

Given the lack of scientific evidence to support the view that current ambient levels of benzene in air represent increased leukaemia risk to the public, CONCAWE believes further limitations on benzene content of gasoline in addition to those already in place or planned, are not justified.

In contrast, a maximum limit of 3 or 1% benzene in gasoline would be a much less effective approach. In addition, this option would incur high refining investment, operating and energy costs (12). When combined with the closed gasoline system, it offers little additional benefit in ultimately reducing benzene emissions.

Figure 5


IMPLICATIONS OF CURRENT TEST CONDITIONS
ON ACTUAL CANISTER EFFICIENCY FOR JULY
CANISTER EFFICIENCY
100
80
60
40
20
0
NL
D
B
LUX
IRE
UK
DK
P
F
E
GR
I
COUNTRY
RECOVERED
UNRECOVERED

5. EVAPORATIVE EMISSIONS TEST PROCEDURE

As discussed in Section 2 above, carbon canister technology offers the potential for at least a 90% potential reduction in evaporative emissions from cars. However, to achieve this the system must be designed properly. For example, the canister size must be adequate to store all the emissions generated during diurnal temperature changes (tank day and night breathing) and during heating up of the engine compartment on parking a car after use. In addition, the canister purge system must be adequate to avoid overloading of the canister so ensuring recovery of the adsorbed gasoline vapours and use of these gases by the engine.

Any test procedure must address these concerns if it is to fulfil its purpose of assuring that the technology performs in service. This means the test conditions (temperature-time relationships and driving cycles), together with the volatility of the test fuel, should represent realistically the more severe conditions found in some European countries.

To assess the performance of canisters over a range of ambient temperatures and gasoline volatilities a computer model was constructed based on test results derived from the recent CONCAWE evaporative emission project (2) assuming that the car industry will design the canister system to "just pass the test". The model indicates that the performance of a system designed to meet the requirements of the EC procedure under summer conditions in Europe would range between 52 and 80% control effectiveness in Southern Europe, and between 80 and 90% in Northern European countries.

The actual results for the currently proposed test conditions in the draft automotive emissions directive of 23°C minimum for the hot soak test and a test fuel of 60 kPa volatility, are given in Figure 5. This figure demonstrates the potentially poor control effectiveness of the carbon canister system designed from an unrealistic combination of test temperature and test fuel volatility. Using the model with test temperature and fuel volatility corresponding to the most demanding conditions in Europe, (86 kPa/28°C based on current specification maxima) would result in a canister system that provides 90% effectiveness for all the summer months throughout the EC-12.

To express the consequences of a more realistic test procedure on the physical requirements of the canister in perspective, the model indicates that the canister size would need to increase from about 1 litre (required to pass the currently proposed test) to 1.5 litres to provide a fully effective canister throughout Europe. The required increase in purge rate is also very important increasing from 1.2 grams of hydrocarbons/km driven to 2g/km. Such canister sizes and purge rates are well within the recent experience of commercial systems installed in cars sold in the US.

6. CONCLUSIONS

Gasoline emissions from vehicles

- Gasoline emissions from vehicles represent a major source (nearly 40%) of man-made volatile organic compounds, and are a prime target for emission control.

- The proposed EC automotive emissions directive will make a major contribution to control by specifying stringent exhaust emission limits (about 90% effective).

- The proposed control of evaporative emissions from cars stops short of being effective because:-

  - the carbon canister is inadequately designed for summer use in Southern Europe;
  - refuelling and running losses are not controlled.

- A well-designed carbon canister is capable of 90% control of evaporative emissions, including running losses, and the test procedure proposed in the draft directive needs to be revised to ensure that this potential is realised on the road.

- An enlarged carbon canister is the preferred way to control refuelling and evaporative emissions, including running losses, and is capable of over 95% control of gasoline vapours displaced from the car tank during filling.

- Together, 3-way exhaust catalysts and the enlarged carbon canister form an effective way of closing the gasoline system for vehicles.

- A combination of the small canister with Stage II control of refuelling emissions at retail pumps is less effective and much more expensive than the enlarged canister.

Gasoline distribution

- There is already progressive installation of vapour recovery (Stage I) equipment in gasoline distribution systems in several EC countries; Stage I vapour recovery will be the subject of a Commission proposal during 1990.

- Single stage vapour recovery equipment is capable of 95% effective control of an installation and an overall target of 80% recovery from gasoline distribution can be projected from a phased approach.

- Vapour recovery at service station pumps requires frequent maintenance and car filler necks need to be adapted to be compatible before its potential effectiveness of 85% could be achieved. 15-20 years would be required to replace the older cars, so that retail vapour recovery also needs time to become effective.

"Closing the gasoline system"

- Both the car and oil industries are already making major investments to control gasoline emissions, and these investments represent significant steps towards closing the gasoline system from distribution to use in vehicles.
- By completing closing of the gasoline system, including taking the opportunity presented by the enlarged canister, effective control of gasoline emissions can be achieved.
- Current steps being taking to close the gasoline system will reduce emissions of benzene from gasoline distribution and usage by approaching 90% from current levels.
- Therefore, further limiting the benzene content of gasoline is not justified, and is a much less effective approach and much more expensive than closing the gasoline system.
- Similarly, the approach of closing the gasoline system is more efficient than restricting gasoline volatility, since it enables gasoline composition to be optimized to meet engine design needs, and also meets a Community environmental objective of rational use of energy.

7. REFERENCES

1. EC (1989) Proposal for a Council Directive amending Directive 70/220/EEC on the approximation of the laws of the Member States relating to measures to be taken against air pollution by emissions from motor vehicles. COM(89) 662 final-SYN 240 (Official Journal of the EC, 90/C 81/01)

2. CONCAWE (1990) The effects of temperature and fuel volatility on vehicle evaporative emissions. Report No. 90/51. Brussels: CONCAWE

3. CONCAWE (1988) The control of vehicle evaporative and refuelling emissions - the on-board system. Report No. 88/62. Brussels: CONCAWE

4. TÜV (1989) Vergleichende Untersuchung von Tankstellen und fahrzeugseitigen Techniken zur Verminderung der Emissionen bei der Betankung von Fahrzeugen mit Ottokraftstoff. Preliminary report following the 2nd November 1989 Berlin refuelling workshop. (Zwischenbericht) Köln: Technischer Überwachungs-Verein Rheinland

5. CONCAWE (1990) VOC emissions from gasoline distribution and service stations in Western Europe - control technology and cost-effectiveness. Report No. 90/52. Brussels: CONCAWE

6. CONCAWE (1989) A US perspective on hydrocarbon controls at service stations. Report No. 11/89. Brussels: CONCAWE

7. CONCAWE (1987) Volatile organic compound emissions in Western Europe: control options and their cost-effectiveness for gasoline vehicles, distribution and refining. Report No. 6/87. Brussels: CONCAWE

8. CONCAWE (1983) Benzene emissions from passenger cars. Report No. 12/83. Brussels: CONCAWE

9. CONCAWE (1989) Health risk of exposure to non-occupational sources of benzene. Report No. 8/89. Brussels: CONCAWE

10. CONCAWE (1986) Review of European oil industry benzene exposure data. Report No. 3/86. Brussels: CONCAWE

11. Raalte, H.G.S. van (1982) A critical look at hazards from benzene in workplace and community air. Regulatory Toxicology and Pharmacology 2, 67-76

12. CONCAWE (1989) Economic consequences of limiting benzene/aromatics in gasoline. Report No. 89/57. Brussels: CONCAWE