Motor vehicle emission regulations and fuel specifications - part 2 historic review (1996 - 2005)

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ABSTRACT

This report details the development of world-wide legislation and regulations governing motor vehicle emissions, fuel specifications and fuel consumption from 1996 to 2005. It describes outdated legislation on emissions limits and emissions testing, vehicle inspection and maintenance programmes and legislation aimed at controlling in-service emissions performance, fuel consumption and carbon dioxide emissions. Automotive fuel specifications (including reference or certification fuels) and fuel characteristics are also documented.

This comprehensive work of reference is a companion to CONCAWE Report 6/97 which provided similar details for the period 1970 to 1996. It should also be read in conjunction with Part 1 (and the Appendix to Part 1 – report no. 5/06), which have been issued as separate volumes. Part 1, and its Appendix, summarise the most important legislation, either in place or shortly to be enacted. Part 1 is updated annually, whereas this report - which reviews the history of automotive emissions legislation – will be revised at appropriate, longer term intervals.

KEYWORDS

Vehicle emissions, legislation, automotive fuels, specifications

CONTENTS

INTRODUCTION - HOW TO USE THIS REPORT

This report collects together in one place the most important worldwide laws and regulations relating to motor vehicle emissions and automotive fuel specifications. The amount of material to be covered has increased steadily over the years, and this led to a bulky report which was becoming difficult to use and time-consuming to update. As a consequence it was decided in 1996 to divide the report into two sections, as described below:

- **Part 1 described current and future automotive emissions legislation and fuel quality regulations.**
- **Part 2 provided additional details of current and future legislation, plus information of a more historic nature.**

This approach served CONCAWE well for ten years, but it became apparent that:

- The size of both Parts 1 and 2 was increasingly unmanageable.
- Part 2 was over-complicated as it included current and future background material, plus historical information.

In 2006 it was therefore decided that a more radical approach was required:

Part 1 Report A description of the most important current and future automotive emissions legislation and fuel quality regulations.

Part 1 Appendix Background information relating to current and future automotive emissions legislation and fuel quality regulations.

Part 2 Report Historical information, covering outdated legislation and fuel specifications for the period under review.

As a further innovation, the Part 1 Appendix and Part 2 Report have been published on CD-ROM and included inside the back cover of the Part 1 Report.

All countries from which information is available are included. To make the document easier to use, the amount of background information contained in Part 1 has been limited wherever possible. References to the more comprehensive information contained in the Appendix are included where appropriate. References to sections and tables in the Appendix will contain the prefix "A"; where there is no prefix, the reference will be found in Part 1.

Part 2 now contains historical data only.

Part 2 is a comprehensive reference document to be used in conjunction with Part 1. It is arranged in exactly the same format as the Part 1 Report and the Appendix, but each Section, Sub-section, Table and Figure Number is prefixed “B”, to signify that it is located in Part 2.

Two innovations were introduced in the last edition with the objective of improving its accessibility:

- Information is now presented on a regional or country-by-country basis

- Where possible, data tables have been grouped together so that readers can readily locate data without having to read the explanatory text.

The format is therefore as follows:

Regional/Country Format

Section	Region/Country
European Region	
1	European Union (including all national adaptations of EU legislation and local regulations)
2	Other European countries, Turkey and Russia
The Americas	
3	US (Federal States)
4	US (California)
5	Canada
6	Central & South America
Far East, Middle East & Africa	
7	Japan
8	Australasia
9	Rest of Asia
10	Middle East and Africa

One further section completes the report:

B.11 World-Wide Harmonization of Test Cycles.

Sub-Section Format

Sub-Section	Subject
1	Emissions Legislation
2	Fuel Specifications
3	Test Procedures
4	Reference Fuels
5	Fuel Consumption & CO_2
6	In-Service Emissions Legislation

Part 1 is kept up to date with regular revisions and the 2004/2005 version replaces Report Number 9/04. The title, "**2004/2005 Update**", reflects the actual period

under review, i.e. late 2004 to late 2005 inclusive. CONCAWE, as a European organization, has focused on providing detailed information for Europe. Much attention has also been paid to the United States and Japan as their legislation also influences worldwide trends. Every effort is made to document information from other countries - however, details for some countries are unavailable or the data obtained are often not as complete as that for Europe. Input from readers of this report is always welcomed.

Readers with information which they feel could usefully be incorporated in this report should contact the CONCAWE Secretariat:

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B.1. EUROPEAN UNION

B.1.1. VEHICLE EMISSIONS LIMITS

Background

Emissions regulations in Europe were formulated in the seventies and early eighties primarily by the United Nations Economic Commission for Europe (UN-ECE). The ECE is supported by most European nations (including many Eastern European countries), the US, Japan and China. Its role is to produce model standards which may be adopted by member nations, but it has no power to enforce compliance.

In its early years, the European Union generally adopted regulations which were technically identical with the ECE equivalents. This position has changed over time, with the European Community, now the European Union, gradually assuming a major role in formulating automotive emissions standards. UN-ECE is now unlikely to adopt any proposal which has not been agreed within the EU.

European Union regulations, published as Directives, have the force of law within EU Member States under the provisions of the Treaty of Rome. EU countries may not prohibit the marketing of vehicles which comply with the provisions of the Directives, but may prohibit vehicles which do not comply. With the introduction of the "Consolidated Emissions Directive" in June 1991, implementation became mandatory for all EU Member States and was no longer left to the discretion of individual national governments.

Present membership of the EU is: Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden and the United Kingdom. Of the current members of the EU, Austria, Denmark, Finland and Sweden, were signatories to the “Stockholm Agreement” of July 1985 in which these countries, together with Canada, Norway and Switzerland, agreed to adopt US 1983 standards. These countries also adopted heavy duty limits based on UN ECE.

Having joined the EU in 1994, Austria, Finland and Sweden were allowed a four-year transition period, ending on 1 January 1999, to harmonise legislation. Austria and Finland, together with Norway and Switzerland, have adopted most of the EU Directives. Sweden retained US limits based on Federal test procedures and also adopted stringent Low Emission Vehicle standards.

In March 1994, the EU Council of Ministers adopted EU Directive 94/12/EC, for light duty vehicles applying further more stringent emissions limits from 1996. Contrary to earlier standards, no conformity of production allowance was permitted over and above the type approval limits. With light commercial vehicles, the provisions of 96/69/EC progressively replaced the requirements of EU Directive 93/59/EEC over the period 1997-98. Heavy duty vehicles had to comply with the provisions of the "Clean Lorry Directive" 91/542/EEC.

As required by EU Directive 94/12/EC, the EU Commission submitted proposals to the Council of Ministers for the further regulation of vehicle emissions to take effect during the period 2000/2005/2010. These were based on the Auto/Oil industry study and comprised the implementation of new emissions standards for passenger

cars for 2000 and 2005 and suggested reductions in emissions levels for light and heavy duty commercial vehicles. In addition, a revised test cycle was proposed for light duty vehicles and two new test cycles were suggested for heavy duty vehicles. The proposals also included the introduction of requirements for on-board diagnostic systems, more rigorous periodic inspections, a tightening of evaporative emissions limits and further constraints on fuel quality specifications. The Council adopted a common position, based upon the EU Commission proposals but the European Parliament demanded more stringent legislation. Following a conciliation phase, new emission limits and fuel specifications for both 2000 and 2005 were announced at the end of June 1998. The EU Commission also set up a separate *The Car of Tomorrow* Task Force and implemented an extension of the Auto/Oil Programme.

From 2000 the ECE 15 emissions test cycle was revised to eliminate the 40-second idle stabilisation period. The EU Commission proposal did not include a separate cold start procedure but this decision was overturned during negotiations between representatives of the Council and the Parliament. A GRPE sub-group proposed two new test cycle procedures for heavy duty vehicles to be introduced along with the new emissions limits. One is a steady-state test which will be applied to "conventional" diesel engines from 2000 and the other is a transient test. Both tests are applied to "advanced" diesel engines systems from 2000 (i.e. diesel engines fitted with advanced emission control systems and/or advanced after-treatment devices) and all vehicles will be tested by both cycles from 2005.

B.1.1.1. Light Duty Vehicles

In March 1994, the Council of Ministers adopted EU Directive 94/12/EC, which set out the emission limits to be applied from 1996 onwards. Unlike the earlier regulations, separate standards were given for gasoline and diesel-fuelled vehicles. Implementation dates were 1 January 1996 for new models and 1 January 1997 for existing models. Slightly less stringent limits applied to DI diesels initially, but they had to comply with the full standard by 1 October 1999. Contrary to the earlier standards, production vehicles had to comply with the Type Approval limits, i.e. no allowance was permitted for manufacturing tolerances (the so-called “Conformity of Production” limits allowed in earlier legislation). It should also be noted that the implementation of these limit values by EU Member States was mandatory and no longer (as in previous exhaust emissions directives) left for the decision of Member States. In addition, the requirements relating to evaporative emissions and durability of anti-pollution devices specified in EU Directive 91/441/EEC also apply.

From 8 October 1996 the limits were incorporated into EU Directive 96/69/EC, together with limits for light commercial vehicles (see **Table B.1.1**). Category M vehicles are essentially passenger cars, whereas Category N_1 refers to commercial vehicles with a maximum weight of 3.5 t.

Table B.1.1 EU Directive 96/69/EC exhaust emissions limits for passenger cars and light commercial vehicles [1]

Effective Date		Vehicle [1]		Limit Values (g/km)		
New Type Approvals	**New Registrations**	**Reference M/m (kg)**	**Type**	**CO**	**HC + NOx**	**PM**
01/01/96	01/01/97	Category M[3] passenger cars	Gasoline IDI Diesel DI Diesel[2]	2.2 1.0 1.0	0.5 0.7 0.9	- 0.08 0.10
01/01/97	01/10/97	Category N_1 Class I ≤1250	Gasoline IDI Diesel DI Diesel [2]	2.2 1.0 1.0	0.5 0.7 0.9	- 0.08 0.10
01/01/98	01/10/98	Category N_1 Class II 1251-1700	Gasoline IDI Diesel DI Diesel [2]	4.0 1.25 1.25	0.6 1.0 1.3	- 0.12 0.14
01/01/98	01/10/98	Category N_1 Class III >1700	Gasoline IDI Diesel DI Diesel [2]	5.0 1.5 1.5	0.7 1.2 1.6	- 0.17 0.20

(1) Also applies to vehicles designed to carry more than six persons including the driver and vehicles with max. mass exceeding 2500 kg.

(2) Until 30 September 1999, then IDI Diesel limits apply.

(3) Except vehicles designed to carry more than six occupants or with maximum mass >2.5t. These vehicles are covered by the appropriate N category.

Since 1 January 1996 vehicle manufacturers have been required to state CO_2 emissions and fuel consumption as obtained by the method given **Section B.1.3.2**. This EU Directive 93/116/EC was published on 17 December 1993 and applied to private passenger cars (M_1 vehicles) only.

EU Directive 94/12/EC required that proposals be submitted and decided upon before 30 June 1996 for implementation of further reductions in exhaust emissions by 1 June 2000. Proposed limits were developed as the outcome of the "European Auto/Oil Programme" (see **Section B.1.1.5**) but were subsequently amended in a conciliation process because the proposals from the European Parliament were irreconcilable with the "Common Position" of the Council of Ministers. The limit values applicable for the year 2000 are summarised in **Table B.1.2**, below. Note that the test procedure has been modified compared to that employed previously. Further details of the new test cycle will be found in **Section B.1.3.2**. It is also important to recognise that the diesel emission limits have been further tightened by the introduction of a separate NOx standard.

Table B.1.2 EU Emissions Limits for Passenger Cars and Light Commercial Vehicles - Year 2000 (EU Directive 98/69/EC)

Category		Class	Reference Mass "RW" (kg)	Fuel	Limit Values (g/km)				
					CO	HC	NOx	HC+NOx	PM (1)
Euro 3 A (2000) (2)	M (3)	-	All (3)	Gasoline	2.3	0.20	0.15	-	-
				Diesel	0.64	-	0.50	0.56	0.050
	N_1 (4)	I	RW ≤1305	Gasoline	2.3	0.20	0.15	-	-
				Diesel	0.64	-	0.50	0.56	0.050
		II	1305 <RW ≤1760	Gasoline	4.17	0.25	0.18	-	-
				Diesel	0.80	-	0.65	0.72	0.070
		III	RW >1760	Gasoline	5.22	0.29	0.21	-	-
				Diesel	0.95	-	0.78	0.86	0.100

(1) For compression ignition engines only.

(2) Dates for "Year 2000" implementation are as follows:

Category/Class	Date
M (3); N_1 Class I – New types	01/01/00
N_1 Classes II & III – New types	01/01/01
M (3); N_1 Class I – All models	01/01/01
N_1 Classes II & III – All models	01/01/02

(3) Category M vehicles in excess of 2500 kg are treated as Category N_1, Class 1 vehicles. Until 01/01/03, M_1 diesel vehicles weighing more than 2000 kg, designed to carry more than 6 occupants (including the driver) or classed as off-road vehicles will be considered as Category N_1 vehicles.

(4) Plus those Category M vehicles specified in Note (3), above.

It is important to note that these emission values are obtained over the revised urban + extra-urban cycle (Type I Test), or "New European Driving Cycle (NEDC). It has also been referred to as the "MVEG Cycle". This test is identical to the ECE 15+EUDC cycle, with one important exception. Emissions measurements now commence immediately from engine "key on" – in the earlier test the engine was started and idled for 40 seconds before commencing the cycle and emissions measurement. Omitting this "idle stabilisation" period increases the severity of the test as the engine and emissions control system are operating at the test temperature and not in a partially warmed-up condition. **Table B.1.3** compares the 1996 Class M_1 emission limits over the ECE 15+EUDC cycle, the same limits converted to the new cycle and the 2000 limit values:

Table B.1.3 Comparison of Emission Limits for Passenger Cars over the New and Old Test Cycles

Vehicle	Test Cycle	Limit Values (g/km)				
		CO	HC	NOx	HC+NOx	PM (1)
Gasoline 1996	ECE 15 + EUDC	2.20	-	-	0.50	-
Gasoline 1996	Projected NEDC (2)	3.30	0.34	0.25	0.59	-
Gasoline 2000	NEDC	2.30	0.20	0.15	0.35	-
Diesel 1996 (3)	ECE 15 + EUDC	1.00	-	-	0.70	0.08
Diesel 1996 (3)	Projected NEDC (2)	1.06	0.14	0.57	0.71	0.08
Diesel 2000	NEDC	0.64	0.06	0.50	0.56	0.05

(1) Diesel vehicles only.

(2) Adjusted for the change in test procedure, using conversion factors employed by the EU Commission.

(3) Limits for indirect injection engines – these applied to direct injection engines from 1 October 1999.

Evaporative Emissions

The evaporative emissions test (Type IV Test) has been increased in severity and details will be found in **Section B.1.3.6.** The limit value for evaporative emissions remains at 2.0 g of HC per test.

On-Board Diagnostics (OBD)

EU Directive 98/69/EC also requires the fitting of OBD systems, according to the schedule shown in the table below. Details of the threshold values for the operation of OBD malfunction indicators and the malfunctions to be detected will also be found in **Section B.1.6.4**.

Table B.1.4 EU Implementation Schedule for OBD

Category/Class of Vehicle	Date
Gasoline powered M_1 and N_1 - All classes	01/01/00
Diesel powered M_1 (1) - New types	01/01/03
Diesel powered M_1 (1) - All models	01/01/04
Diesel powered M_1 exempted by note (1)	01/01/05
Diesel powered N_1 Class I - New Types	01/01/05
Diesel powered N_1 Classes II & III - New Types	01/01/06

(1) Excludes vehicles designed to carry more than six occupants, including the driver and vehicles exceeding 2500 kg in mass.

Directive 2002/80/EC includes further guidance on the required infrastructure for OBD equipment

Cold Start (-7°C) Requirements

EU Directive 98/69/EC also stipulates that, from 1 January 2002, all new types of gasoline powered M_1 and N_1 Class I vehicles must meet the following emissions limits when tested at -7°C:

Table B.1.5 Cold Start (-7°C) Emission Limits

Emissions (g/km)	
CO	**HC**
15.0	1.8

The test (designated the Type VI test) is conducted over the four urban elements of the Type I test cycle and further details will be found in **Section B.1.3.2**.

Directive 2001/100/EC, published on 7 December 2001, extends the requirements to include category N_1 class II and III with positive-ignition engines. It also includes category M_1 with positive-ignition engines designed to carry more than six occupants and vehicles of category M_1 with positive-ignition engines whose maximum mass exceeds 2500 kg. These latter vehicles were also previously excluded. The limits are as follows and applied to all new types of vehicle from 1 January 2003:

Table B.1.6 Cold Start (-7°C) Emission Limits for Heavier Passenger Cars and Light Commercial Vehicles

Category	Class	Emissions (g/km)	
		CO	HC
M_1 (1)		15	1.8
N_1 (2)	II	24	2.7
	III	30	3.2

(1) Except vehicles designed to carry more than six occupants and vehicles the maximum mass of which exceeds 2500 kg.

(1) And those category M_1 vehicles which are specified in note 1.

Reference Fuels

The Directive also specifies the reference fuels to be employed for emissions testing. This was subsequently updated by Directive 2002/80/EC and full details will be found in **Section B.1.4**.

Conformity of Production and In-Service Conformity Checks

EU Directive 98/69/EC introduces two new statistical methods for checking conformity of production and revised criteria for in-service conformity checks. Details of the in-service checks are summarised in **Section B.1.6**.

Tax Incentives

Article 5 of the Directive allows Member States to make provision for tax incentives only in respect of motor vehicles in series production complying with EU Directive 70/220/EEC, as amended by 98/69/EC. Incentives can be applied as follows:

- M_1 and N_1 Class I vehicles meeting the "Euro 4" limit values of **Table B.1.2** with effect from 1 January 2000.
- N_1 Classes II and III meeting the "Euro 4" limit values of **Table B.1.2** with effect from 1 January 2001.

Incentives have to be terminated once the emission limits become mandatory.

Other Provisions

The EU Commission must submit proposals for:

- Improved roadworthiness testing.
- Examination of Type V testing (ageing testing to verify the durability of "anti-pollution" devices), including the possibility of abolishing the procedure.

Light Commercial Vehicles

These vehicles are classified into three categories according to their mass, to reflect the differences in their power train layouts and body sizes. Vehicles are tested over the ECE 15 + EUDC test cycle. For vehicles with a maximum engine power of no more than 30 kW and a maximum speed not exceeding 130 km/h, the maximum speed of the extra-urban cycle was limited to 90 km/h until 1 July 1994. After that

date, vehicles which cannot attain the acceleration and maximum speed values required by the cycle must be operated with the accelerator control fully depressed until they once again meet the required operating curve. Deviations from the operating cycle must be recorded in the test report. The requirements relating to evaporative emissions and durability of anti-pollution devices specified in EU Directive 91/441/EEC also apply.

EU Directive 96/69/EC was published in October 1996 but for all practical purposes the limits for Class M vehicles came into effect on 1 January 1996 (see **Table B.1.1**). These supersede the requirements of 93/59/EEC given in **Table A.1.6** of **Report No. 6/97**.

Upon completion of the European Auto/Oil Programme a similar situation to that involving passenger cars applied to light commercial vehicles. Again, the test cycle was modified and a separate NOx limit for diesel powered vehicles was introduced. Note also that the reference masses of the different vehicle classes were adjusted (see **Table B.1.2**).

B.1.1.2. Heavy Duty Vehicles

Clean Lorry Directive (1991)

On 1 October 1991 the European Council of Ministers adopted the "*Clean Lorry Directive*", which reduced in two phases the limit values for gaseous and particulate (PM) emissions by diesel engines and other heavy utility vehicles using the ECE R49 procedure (see **Section B.1.3.3**). This set limits, which are compulsory throughout the EU, as shown in **Table B.1.7**. The Council subsequently relaxed the particulate limit for vehicles with engines $\leq$0.7 dm^3 cylinder capacity to 0.25 g/kWh for the transitional period from 1 October 1995 to 30 September 1997, but allowed Member States to give tax incentives for small diesel engines meeting the 0.15 g/kWh limit before this date.

Table B.1.7 Limits for the "Clean Lorry" Directive (91/542/EEC)
Heavy Duty Vehicles more than 3.5 t GVW

Effective Date	Type Approval (g/kWh)				Conformity of Production (g/kWh)			
	CO	HC	NOx	PM	CO	HC	NOx	PM
1/10/95 (new models) 1/10/96 (all production)	4.0	1.1	7.0	0.15 (1)	4.0	1.1	7.0	0.15 (1)

(1) For engines with a cylinder swept volume of $\leq$0.7 dm^3 and a rated power speed >3000 min^{-1} the limit is 0.25 g/kWh max. until 30/09/97 for new models and 30/09/98 for all production respectively.

EU Directive 1999/96/EC

These values were superseded by EU Directive 1999/96/EC. The limit values are shown in **Tables B.1.8** and **B.1.9**, below, employing new test cycles, which are described in greater detail later in the text:

Table B.1.8 HD Emission Limits - Diesel Engines over the ESC/ELR Test Cycles (Steady-state & Dynamic Load Response Smoke Tests)

Implementation Date [1]		Gaseous and PM Emissions (g/kWh)				Smoke (m^{-1}) [3]
		CO	HC	NOx [2]	PM	
A - 2000	(Euro 3)	2.1	0.66	5.0	0.10 [4]	0.80

(1) All implementation dates are 1 October in the designated year.

(2) The specific mass of the oxides of nitrogen measured at the random check points within the control area of the ESC test must not exceed by more than 10 % the values interpolated from the adjacent test modes.

(3) The smoke value on the random test speed of the ELR must not exceed the highest smoke value of the two adjacent test speeds by more than 20 %, or by more than 5% of the limit value, whichever is greater.

(4) A derogation to 0.13 g/kWh applies for small engines having a swept volume of less than 0.75 dm^3 per cylinder and a rated speed greater than 3000 min^{-1}. This derogation will be terminated in 2005.

Table B.1.9 HD Emission Limits - Diesel and Gas Engines over the ETC (Transient) Test Cycle [1]

Implementation Date [2]		Gaseous and PM Emissions (g/kWh)				
		CO	NMHC [3]	CH_4 [4]	NOx	PM [5]
A - 2000	(Euro 3)	5.45	0.78	1.6	5.0	0.16 [6]

(1) The conditions for verifying the acceptability of the ETC tests when measuring the emissions of gas fuelled engines against the limit values applicable in row A shall be re-examined and, where necessary, modified in accordance with the procedure laid down in Article 13 of EU Directive 70/156/EEC.

(2) All implementation dates are 1 October in the designated year.

(3) A manufacturer may choose to measure the mass of total hydrocarbons (THC) on the ETC test instead of measuring the mass of non-methane hydrocarbons. In this case, the limit for the mass of total hydrocarbons is the same as that shown above for the mass of non-methane hydrocarbons.

(4) Natural gas engines only.

(5) Not applicable to gas fuelled engines under Stages A, B1 and B2.

(6) A derogation to 0.21 g/kWh applies for small engines having a swept volume of less than 0.75 dm^3 per cylinder and a rated speed greater than 3000 min^{-1}. This derogation will be terminated in 2005.

Test cycles for type approval

For type approval to row A (Euro 3) of **Tables B.1.8** and B.**1.9**, the emissions are determined over the ESC and ELR tests with conventional diesel engines including those fitted with electronic fuel injection equipment, exhaust gas recirculation (EGR), and/or oxidation catalysts. The ESC cycle is a steady-state test, whilst the ELR cycle is essentially a free acceleration smoke test. Diesel engines fitted with advanced exhaust after-treatment systems including DeNOx catalysts and/or particulate traps, shall additionally be tested over a heavy duty transient cycle, referred to as the ETC.

The two cycles for use from 2000 are the ESC/ELR and ETC tests. These procedures and their development are fully described in **Section B.1.3.4**. The ESC and ELR cycles are also referred to as the “OICA” cycle, whilst the ETC test is sometimes described as the “FiGE” cycle.

For comparative purposes, the 1996 emission standards have been converted to the values that would be obtained over the new test cycles, employing conversion factors used by the EU Commission.

Table B.1.10 Comparison of HD Emission Limits – Diesel Engines over the ESC/ELR Test Cycles (Steady-state & Dynamic Load Response Smoke Tests)

Implementation Date	Gaseous and PM Emissions (g/kWh)				Smoke (m^{-1})
	CO	HC	NOx	PM	
1996	2.99	0.94	7.2	0.14	-
2000	2.1	0.66	5.0	0.10	0.80

Table B.1.11 Comparison of HD Emission Limits – Diesel and Gas Engines over the ETC (Transient) Test Cycle

Implementation Date	Gaseous and PM Emissions (g/kWh)				
	CO	NMHC	CH_4	NOx	PM
1996	7.91	1.19 (6)	-	7.33	0.23
2000	5.45	0.78	1.6	5.0	0.16

Defeat Devices

The use of a defeat device and/or irrational emissions control strategy is forbidden. If the type approval authority suspects that a vehicle type utilises defeat device(s) and/or any irrational emission control strategy the manufacturer can be requested to provide information on the operation and effect on emissions of the use of such devices and/or control strategy. These details shall include a description of all emission control components, fuel control system logic including timing strategies and switch points during all modes of operation. This information should remain strictly confidential.

Tax Incentives

Member States are allowed, by means of tax incentives, to speed the introduction of vehicles which satisfy the limit values. However, such incentives have to satisfy certain conditions to avoid distortions of the internal market.

Reference fuels

The Directive describes diesel, natural gas and LPG reference fuels - these were subsequently modified by Directive 2001/27/EC of 10 April 2001. Full details will be found in **Sections B.1.4.5** and **1.4.7**.

Other Provisions

The EU Commission has to submit further proposals to the European Parliament and the Council. The proposals must take account of:

- The development of compression ignition engine and gas engine emission control technology including the after treatment technology, taking into account the interdependence of such technology with fuel quality,
- The need to improve the accuracy and repeatability of the current measurement and sampling procedures for very low levels of particulates from engines,

- The development of a worldwide harmonised test cycle for type approval testing.

B.1.1.3. Motorcycle and Moped Emission Standards (1997)

Until 1997 there were no formal EU emission limits for motorcycles and mopeds. However, the following ECE regulations were applied in Belgium, Finland, France, Germany, Italy, Luxembourg, the Netherlands and the United Kingdom:

ECE 40.01 2/3 wheeled vehicles with cylinder capacity above 50 cm^3
ECE 47 2/3 wheeled vehicles with cylinder capacity below 50 cm^3

Details of these regulations will be found in **Report No. 6/97**, **Section A.1.1.5**.

Current emission limits for motorcycles and mopeds are set out in the so-called multi-directive 97/24/EC of 17 June 1997. This legislation completed the implementation of previous separate directives with regards to motorcycles and mopeds. Since 17 June 1999 EU type approval for motorcycles and mopeds has been mandatory.

It is important to note that, according to the framework directive 92/61/EC on two- and three wheelers, existing national type approvals issued before 17 June 1999 remained valid for a maximum of 4 years, i.e. until 17 June 2003. Member States may wish to interpret "maximum" and reduce this period in their own country.

Emission limits (expressed in g/km), the applicable test cycle and application dates are shown in **Table B.1.12** below.

Table B.1.12 Multi-Directive EU Motorcycle and Moped Emission Limits

	Emissions (g/km)				Cycle	Application date
	CO	HC	NOx	HC+NOx		
mopeds						
Stage 1 (1)	6	-	-	3	UN-ECE 47	17/6/99 (new types)
Stage 2 (2)	1	-	-	1.2		17/6/02 (new types)
motorcycles						
2-stroke (3)	8	4	0.1	-	UN-ECE 40 (UDC-warm)	17/6/99 (new types)
4-stroke (3)	13	3	0.3	-		

(1) The limits for CO and HC+NOx are multiplied by a factor of 2 in the case of three wheeled mopeds and light quadricycles

(2) The limit for CO must be 3.5 in the case of three wheeled mopeds and light quadricycles

(3) For tricycles and quadricycles, the limit values must be multiplied by 1.5

For the moment, no specific dates are included in the directive to specify when "existing" types should comply with these new emission limits. Note, however, that existing national type approvals ceased to be valid from 17 June 2003.

B.1.1.4. Non-Road Mobile Machinery and Agricultural and Forestry Tractors (1998/2003, Stages 1 & 2)

EU Directive 97/68/EC sets out emission limits for internal combustion engines installed in non-road mobile machinery. The Directive also included a specification for the reference fuel to be employed for type approval testing and details will be found in **Section B.1.4.5**.

Table B.1.13 Emission Limits for Non-Road Mobile Machinery (EU Directive 97/68/EC)

Engine Category	Type Approval	Effective Date (1)	Net Power (P) kW	CO g/kWh	HC g/kWh	NOx g/kWh	PM g/kWh
A	Stage I (2) (3)	01/07/98	$130 \leq P \leq 560$	5.0	1.3	9.2	0.54
B		01/07/98	$75 \leq P < 130$	5.0	1.3	9.2	0.70
C		01/07/98	$37 \leq P < 75$	6.5	1.3	9.2	0.85
D	Stage 2 (2)	01/01/00	$18 \leq P < 37$	5.5	1.5	8.0	0.80
E		01/01/01	$130 \leq P \leq 560$	3.5	1.0	6.0	0.20
F		01/01/02	$75 \leq P < 130$	5.0	1.0	6.0	0.30
G		01/01/03	$37 \leq P < 75$	5.0	1.3	7.0	0.40

(1) Type approval for Stage I engines shall be terminated with effect from the mandatory implementation of Stage II.

(2) Member States may postpone implementation dates for 2 yr in respect of engines with a production date prior to the following schedule:

Category	Date
A	31/12/98
B	31/12/98
C	31/03/99
D	31/12/00
E	31/12/01
F	31/12/02
G	31/12/03

(3) Stage I emission limits are engine-out and must be achieved before any exhaust after treatment device.

- The test cycle is the 8-mode steady-state, C1 cycle from ISO 8178-4.

B.1.1.5. The European Auto/Oil and the Clean Air for Europe Programmes

The Auto/Oil 1 Programme

EU Directive 94/12/EC required that proposals be submitted and decided upon before 30 June 1996 for implementation of further reductions in exhaust emissions by 1 June 2000. Besides potential improvements in engine technology, the proposals were expected to include consideration of;

- improvements in test procedures, cold start, durability testing and evaporative emissions

- emissions control systems durability requirements
- new propulsion technologies, such as electric traction
- use of on-board diagnostic systems
- potential need for separate HC and NOx limits
- unregulated pollutants such as benzene and 1,3-butadiene
- improvements in fuel quality relating to emissions
- strengthening requirements for inspection and maintenance
- the use of fiscal incentives
- traffic management and enhanced urban transport systems

One of the major consequences of these guidelines was a EU Commission initiative, now generally referred to as the "European Auto/Oil Programme 1". This initiative was wide-reaching and involved legislators, the European Parliament, academia, consumer groups, the oil industry and automotive manufacturers. The Programme was very comprehensive and adopted a rational approach to future automotive emissions and air quality legislation for the period 2000/2010. The project was designed to identify the options available to achieve the air quality targets (**Table B.1.14**) and to offer the best cost-effective solutions by the following means:

- Assess vehicle/fuel technology interactions with emissions. Review what was already understood, then conduct a research programme to fill gaps in the knowledge base (the EPEFE programme – the European Programme on Emissions, Fuels and Engine Technologies)
- Develop a comprehensive emissions inventory
- Model air quality and compare with possible future standards.
- Build into that model the effects of both currently planned measures and possible future options for legislation
- Review the cost effectiveness of potential remedial actions

Table B.1.14 Air Quality Targets

Pollutant	Urban NO_2	Urban CO	Urban Benzene	Urban Particulates	Tropospheric Ozone
Air Quality Targets	200 $\mu g/m^3$ as a maximum hourly value	10 mg/m^3 as a maximum hourly value	10 $\mu g/m^3$ as an annual mean	50 $\mu g/m^3$ as an annual mean	180 $\mu g/m^3$ as a one-hour 99 percentile value

In accordance with the timetable laid down by EU Directive 94/12/EC, the EU Commission put forward on 18 June 1996 a number of measures and proposals arising from the Auto/Oil Programme. These were studied by the Council of the European Union and the European Parliament over an eighteen month period. A “conciliation” phase was then required because the Council could not agree with all the amendments proposed by Parliament. Following a series of informal discussions between the two parties, the “formal” Conciliation Committee was convened on 29 June 1998 and was able to resolve all the outstanding points within

one day. The agreement reached was the final stage of the legislative process emanating from the Auto/Oil 1 programme.

The conciliation negotiations made significant changes to the common position agreed by the Council. An estimate of the effect of the Auto Oil package on road transport emissions is given in **Table B.1.15**, below.

Table B.1.15 Effect on road transport emissions of the Auto Oil measures

Pollutant	Emissions in 1990 (1000 t/yr)	Emissions as a percentage of 1990 emissions levels	
		In 2010 without Auto Oil	In 2010 with Auto Oil
Urban NOx	1937	37	23
Urban particulates (1)	125	79	37
Urban CO	25189	20	10
Total VOCs	4106	23	13
Total NOx	5864	36	23

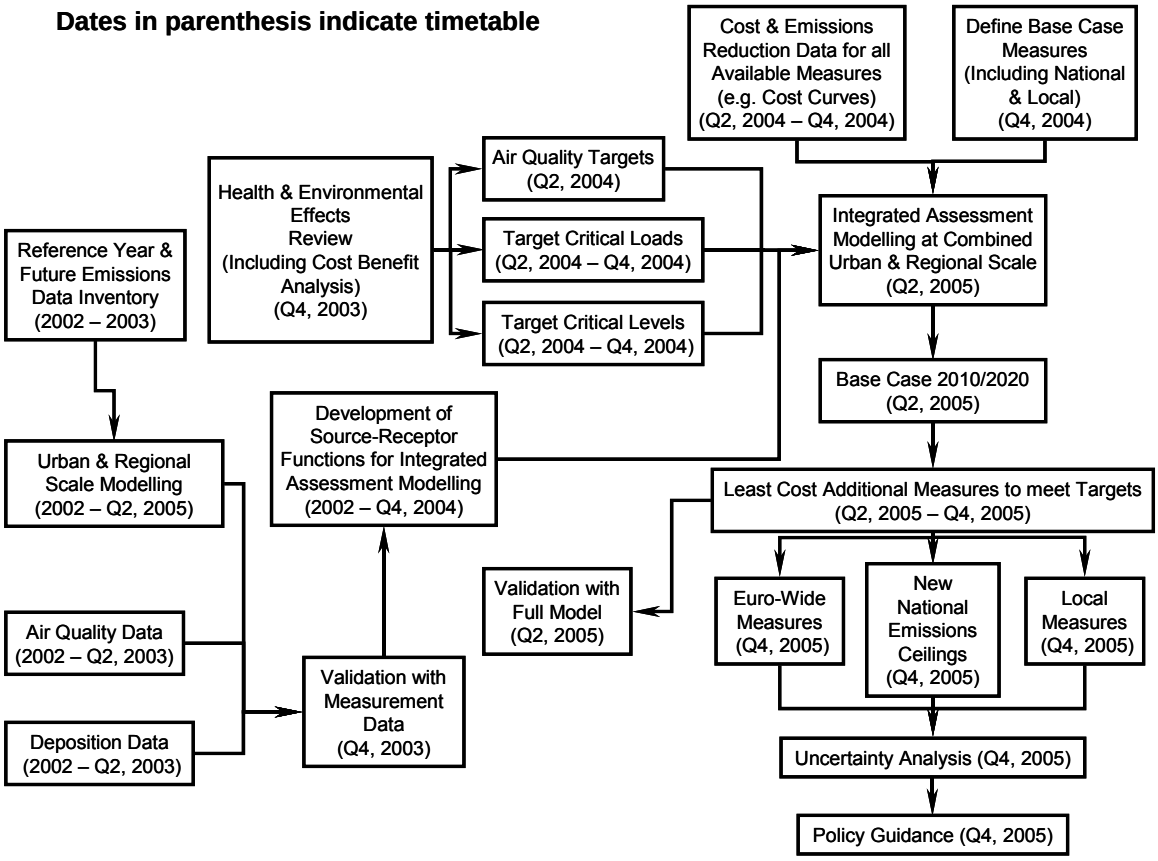
(1) Assumes that the current diesel share of new car sales remains constant at 24%.

The EU Commission also reviewed the ways in which other national and local initiatives, including excise duty and taxation, can influence consumer choice regarding car usage in favour of reduced emissions. The measures studied included road pricing, the expansion of public transportation systems and emissions-related vehicle taxes affecting the consumption of unleaded and low sulphur fuels, the maintenance levels of cars and scrappage schemes for old vehicles.

The Clean Air for Europe (CAFE) Programme

Air quality has been a major focus of EU legislators over the last 10-20 years. In 1996, the Air Quality Framework Directive established a framework for the improvement of air quality in Europe which has now been implemented through the Air Quality Daughter Directives and National Emissions Ceilings Directive.

The European Auto-Oil programmes used air quality as the basis for defining needed improvements and identifying cost-effective measures which could be taken in the road transport sector. The EPEFE programme provided a comprehensive data-base of vehicle/fuel effects on emissions for engine technologies up to the Euro-2 vintage. Currently, the Clean Air For Europe (CAFE) programme is extending this approach, considering all sources of emissions, in order to develop a “long-term, strategic and integrated policy to protect against the effects of air pollution on human health and the environment”. The following figure outlines the programme plan:



B.1.2. FUEL QUALITY REGULATIONS AND SPECIFICATIONS

B.1.2.1. Pre-2000 Regulations - Introduction

During the 1990's there were only modest changes in fuel specifications in Europe. The European Standards, promulgated in 1993, remained essentially unchanged although there some adjustments at a national level to both standard and "reformulated" grades. This section records the development of specifications during that period.

In 2000, however, significant changes were made to the specifications for both gasoline and diesel fuel and the reader is directed to the next section for details of the 2000 EU legislation and corresponding specifications. It is important to recognise that some of the details recorded in this section have been made redundant by the Year 2000 specifications. Year 2005 specifications will be found in **Part 1, Sections 1.2.2** and **1.2.3**.

B.1.2.2. Pre-2000 EN Standard Specifications for Gasoline and Diesel Fuel

In 1988 the EU mandated the European Standards Organization (CEN) to develop comprehensive specifications for unleaded gasolines (premium and regular grades), diesel fuel and automotive LPG. The standards were circulated to the national

bodies on 13 August 1992 for a formal vote before 13 October 1992. They were then officially ratified by CEN on 16 March 1993. Member States were required to adopt them as national standards by September 1993 and withdraw conflicting national standards by the same date. The standards were subsequently revised – later versions for gasoline and diesel fuel were published in 1999 and a new automotive LPG specification was issued in 2000. The specifications are given in full in **Tables B.1.16** to **B.1.24**.

Unleaded Gasoline - EN 228:1993

The 1988 EU mandate required the gasoline specifications to cover all major items and eliminate the three category classifications A, B and C in the 1987 CEN standard. In this specification the A category contained the mandatory limits, the B category included limits to be specified on a national level, and the optional C category defined other items which were allowed to be specified by national bodies.

Apart from the octane requirements of the regular grade, all relevant characteristics and test methods were specified in this European Standard. Provisions were included for national bodies to select seasonal grades from the eight volatility classes during a defined period of the year for a defined region of its country. These had to be specified in the national annex to the EN 228:1993 specification. Regular grade (if required) octane levels had also to be included in the national annex.

Table B.1.16 The CEN Unleaded Gasoline Specification (EN228:1993)

Property	Premium	Regular	Test Method
RON (min)	95.0	(1)	ISO 5164
MON (min)	85.0	(1)	ISO 5163
Lead g/l (max.)	0.013		EN 237
Benzene % v/v (max.)	5.0		EN 238
Sulphur % m/m (max.)	0.05		EN 24260
Gum mg/100 ml (max.)	5		EN 5
Copper Corrosion	1		ISO 2160
Appearance	Clear and Bright		Visual
Oxidation Stability : Mins (min)	360		ISO 7536
Density : kg/m^3	725-780		ISO 3675
Oxygenates	as per EU Directive 85/536/EEC		
Water Tolerance	no water segregation		

Volatility (Notes 2, 3)	Class 1	2	3	4	5	6	7	8
RVP hPa	350-700	350-700	450-800	450-800	550-900	550-900	600-950	650-1000
E70% v/v	15-45	15-45	15-45	15-45	15-47	15-47	15-47	20-50
VLI max. (RVP +7E70)	900	950	1000	1050	1100	1150	1200	1250
E100% v/v	40-65	40-65	40-65	40-65	43-70	43-70	43-70	43-70
E180% v/v min	85	85	85	85	85	85	85	85
FBP °C max.	215	215	215	215	215	215	215	215
Residue % v/v max.	2	2	2	2	2	2	2	2

(1) Must be specified in National standard.

(2) The test method, with the exception of RVP, is ISO 3405. RVP is tested according to EN 12, which is suitable for oxygenates contents meeting column A of EU Directive 85/536/EEC.

(3) See also Figure **B.1.1**.

(4) The use of dyes, markers and performance additives is allowed, but no phosphorous containing compounds.

Figure B.1.1 Relationship between RVP, E70 and VLI for the Eight Volatility Classes

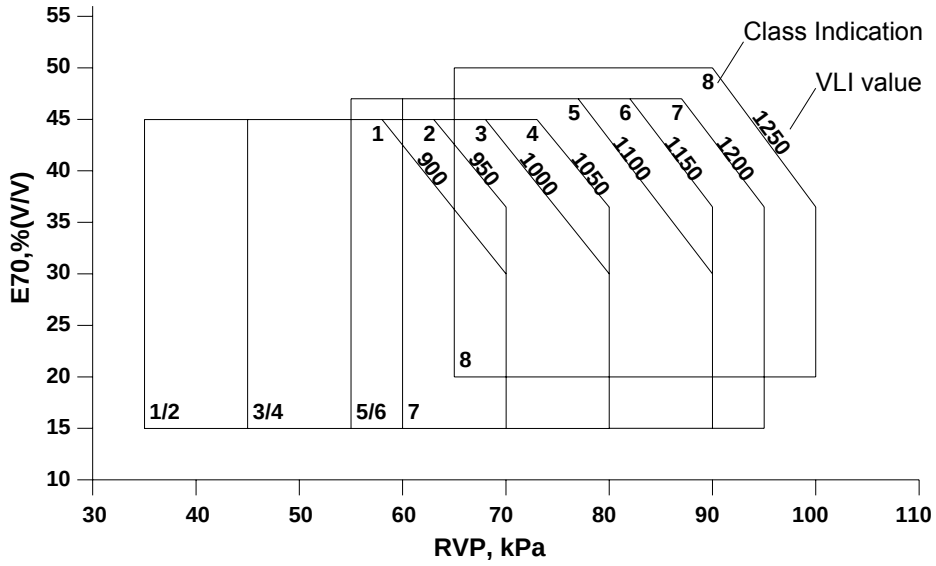


Table B.1.17 EN 228:1999 Premium Grade Unleaded Gasoline

Property	Units	Limits		Test Method (1)
		Min	Max	
RON		95.0	-	EN 25164:1993
MON		85.0	-	EN 25163:1993
Lead content	mg/l	-	5	EN 237:1996
Density @ 15°C (2)	kg/m^3	720	775	EN ISO 3675 EN ISO 12185 EN ISO 14596:1998
Sulphur content (2)	mg/kg	-	150	EN ISO 8754:1995 EN 24260:1994
Oxidation stability	mins	360	-	EN ISO 7536
Gum content (solvent washed)	mg/100 ml	-	5	EN ISO 6246
Copper strip corrosion (3 h @ 50°C)	rating	class 1		EN ISO 2160
Appearance		clear and bright		visual inspection
Hydrocarbon type content	% v/v			
- olefins (3, 4, 5)		-	18.0	ASTM D 1319:1995
- aromatics (3, 4, 5)		-	42.0	ASTM D 1319:1995
Benzene content (2)	% v/v	-	1.0	EN 12177:1998 EN 238:1996
Oxygen content (2)	% m/m	-	2.7	EN 1601:1997 prEN 13132:1998
Oxygenates content (2)	% v/v			
- methanol (6)		-	3	
- ethanol (7)		-	5	
- iso-propyl alcohol		-	10	
- iso-butyl alcohol		-	10	
- tertiary-butyl alcohol		-	7	EN 1601:1997 prEN 13132:1998
- ethers (5 or more C atoms)		-	15	
- other oxygenates (8)		-	8	

(1) All the test methods include a precision statement. In cases of dispute, the procedures described in EN ISO 4259:1995 shall be used.

(2) In cases of dispute concerning density, sulphur, benzene, oxygen and oxygenates the following procedures shall be used:

Property	Procedure
density	EN ISO 3675
sulphur content	EN ISO 14596:1998
benzene content	EN ISO 12177:1998
oxygen and oxygenates content	EN 1601:1997

(3) The content of oxygenate compounds shall be determined in order to make the corrections according to clause 13.2 of ASTM D 1319:1995.

(4) When ETBE is present, the aromatic zone shall be determined from the pink brown ring downstream of the red ring normally used in the absence of ETBE. The presence or absence of ETBE can be concluded from the analysis described in note (3).

(5) For the purpose of this standard ASTM D 1319:1995 shall be applied without the optional depentanisation step. Therefore clauses 6.1, 10.1 and 14.1.1 shall not be applied.

(6) Stabilising agents shall be added.

(7) Stabilising agents may be necessary.

(8) Other mono-alcohols and ethers with a final boiling point no higher than prescribed in **Table B.1.19**.

- **Water Tolerance:** Suppliers shall ensure that no water segregation occurs under the range of climatic conditions experienced. When there is a risk of water separation, anti-corrosion additives shall be incorporated.

Table B.1.18 EN 228:1999 Regular Grade Unleaded Gasoline

Property	Units	Limits		Test Method [1]
		Min	Max	
RON		*	-	EN 25164:1993
MON		*	-	EN 25163:1993
Lead content	mg/l	-	5	EN 237:1996
Density @ 15°C [2]	kg/m^3	720	775	EN ISO 3675 EN ISO 12185 EN ISO 14596:1998
Sulphur content [2]	mg/kg	-	150	EN ISO 8754:1995 EN 24260:1994
Oxidation stability	mins	360	-	EN ISO 7536
Gum content (solvent washed)	mg/100 ml	-	5	EN ISO 6246
Copper strip corrosion (3 h @ 50°C)	rating	class 1		EN ISO 2160
Appearance		clear and bright		visual inspection
Hydrocarbon type content	% v/v			
- olefins [3, 4, 5]		-	21.0	ASTM D 1319:1995
- aromatics [3, 4, 5]		-	42.0	ASTM D 1319:1995
Benzene content [2]	% v/v	-	1.0	EN 12177:1998 EN 238:1996
Oxygen content [2]	% m/m	-	2.7	EN 1601:1997 prEN 13132:1998
Oxygenates content [2]	% v/v			
- methanol [6]		-	3	
- ethanol [7]		-	5	
- iso-propyl alcohol		-	10	
- iso-butyl alcohol		-	10	
- tertiary-butyl alcohol		-	7	EN 1601:1997 prEN 13132:1998
- ethers (5 or more C atoms)		-	15	
- other oxygenates [8]		-	8	

* RON and MON shall be specified in a national annex to this European Standard.

(1) All the test methods include a precision statement. In cases of dispute, the procedures described in EN ISO 4259:1995 shall be used.

(2) In cases of dispute concerning density, sulphur, benzene, oxygen and oxygenates the following procedures shall be used:

Property	Procedure
density	EN ISO 3675
sulphur content	EN ISO 14596:1998
benzene content	EN ISO 12177:1998
oxygen and oxygenates content	EN 1601:1997

(3) The content of oxygenate compounds shall be determined in order to make the corrections according to clause 13.2 of ASTM D 1319:1995.

(4) When ETBE is present, the aromatic zone shall be determined from the pink brown ring downstream of the red ring normally used in the absence of ETBE. The presence or absence of ETBE can be concluded from the analysis described in note (3).

(5) For the purpose of this standard ASTM D 1319:1995 shall be applied without the optional depentanisation step. Therefore clauses 6.1, 10.1 and 14.1.1 shall not be applied.

(6) Stabilising agents shall be added.

(7) Stabilising agents may be necessary.

(8) Other mono-alcohols and ethers with a final boiling point no higher than prescribed in **Table B.1.19**.

- **Water Tolerance:** Suppliers shall ensure that no water segregation occurs under the range of climatic conditions experienced. When there is a risk of water separation, anti-corrosion additives shall be incorporated.

Table B.1.19 EN 228:1999 Unleaded Gasoline Volatility Classes

Property	Units		Limits						Test Method (1)
			Class A (2)	**Class B (3)**	**Class C/C1 (4)**	**Class D/D1 (4)**	**Class E/E1 (4)**	**Class F/F1 (4)**	
Vapour Pressure	kPa	min	45.0	45.0	50.0	60.0	65.0	70.0	prEN 13016-1:1997 (DVPE)
		max	60.0	70.0	80.0	90.0	95.0	100.0	
% evaporated @ 70°C, E70	% v/v	min	20.0	20.0	22.0	22.0	22.0	22.0	prEN ISO 3405:1998
		max	48.0	48.0	50.0	50.0	50.0	50.0	
% evaporated @ 100°C. E100	% v/v	min	46.0	46.0	46.0	46.0	46.0	46.0	
		max	71.0	71.0	71.0	71.0	71.0	71.0	
% evaporated @ 150°C, E150	% v/v	min	75.0	75.0	75.0	75.0	75.0	75.0	
Final Boiling Point, FBP	°C	max	210	210	210	210	210	210	
Distillation residue	% v/v	max	2	2	2	2	2	2	
VLI (10 VP + 7E70)	index	max	-	-	**C** -	**D** -	**E** -	**F** -	
		max	-	-	**C1** 1050	**D1** 1150	**E1** 1200	**F1** 1250	

(1) All the test methods include a precision statement. In cases of dispute, the procedures described in EN ISO 4259:1995 shall be used.

(2) Class A shall apply during summer, starting not later than 1 May and ending not before 30 September (see also Note 3).

(3) In countries with arctic conditions, class B shall apply during the summer, starting not later than 1 June and ending not before 31 August.

(4) Each country shall apply one or more volatility classes with VLI (class C1, D1, E1 or F1) for the transition periods on either side of summer. Each transition period shall be a minimum of 4 weeks. When transition periods are deemed critical, they shall be a minimum of 8 weeks. During the remaining period one or more winter classes shall apply with or without VLI (class C, C1, D, D1, E, E1, F or F1).

Figure B.1.2 EN 228:1999 – Relationship between Vapour Pressure, E70 and VLI for the Ten Volatility Classes

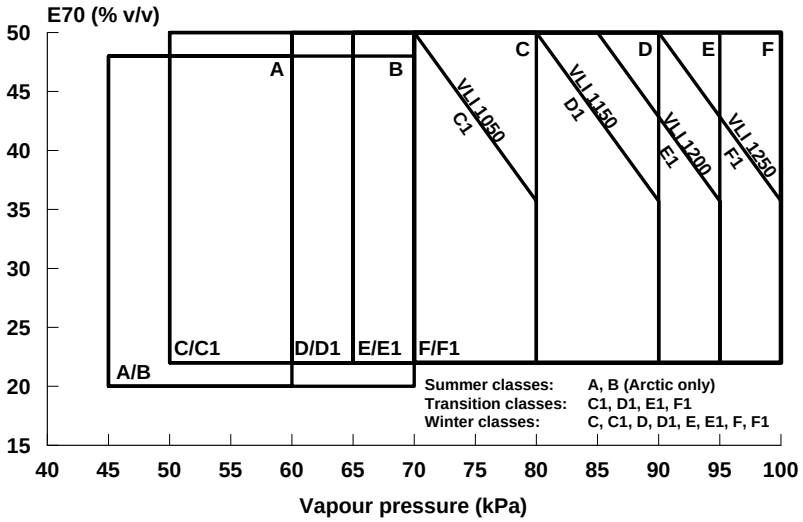


Table B.1.20 EN 228:1999 Unleaded Gasoline Volatility Classes adopted by individual countries

Country	Winter Class	Transition (1)		Summer		Transition (1)	
		Class	Period	Class	Period	Class	Period
Austria	D	D1	01/3 – 30/4	A	01/5 – 30/9	D1	01/10 – 31/10
Belgium	E	E1	01/4 - 30/4	A	01/5 – 30/9	E1	01/10 – 31/10
Denmark	E	E1	01/4 - 30/4	A	01/5 – 30/9	E1	01/10 – 31/11
Finland	F	F1	01/4 - 31/5	B	01/6 – 31/8	F1	01/9 – 31/10
France	D	C1 (2)	16/3 – 30/4	A	01/5 – 30/9	C1 (2)	01/10 – 15/11
Germany	D	D1	16/3 – 30/4	A	01/5 – 30/9	D1	01/10 – 15/11
Greece	C	-	-	A	01/4 – 31/10	-	-
Iceland	F	F1	01/5 – 31/5	B	01/6 – 31/8	F1	01/9 – 30/9
Italy	D	C1	16/3 – 30/4	A	01/5 – 30/9	C1	01/10 – 15/11
Ireland	F	F1	16/4 – 31/5	B	01/6 – 31/8	F1	01/9 – 15/10
Luxembourg	E	E1	01/4 – 30/4	A	01/5 – 30/9	E1	01/10 – 31/10
Netherlands	E	E1	01/4 – 30/4	A	01/5 – 30/9	E1	01/10 – 31/10
Norway	F	F1	01/5 – 31/5	B	01/6 – 31/8	F1	01/9 – 30/9
Portugal	D	D1	01/4 – 30/4	A	01/5 – 30/9	D1	01/10 – 31/10
Spain	C	C1	01/4 – 30/4	A	01/5 – 30/9	C1	01/10 – 31/10
Sweden North (3)	E	E1 (4)	16/4 – 15/5	B	16/5 –31/8	E1 (4)	01/9 – 30/9
Sweden South (3)	E	E1 (4)	01/4 – 30/4	B	01/5 – 15/9	E1 (4)	16/9 – 15/10
Switzerland	E (5)	E1 (5)	01/4 – 30/4	A	01/5 – 30/9	E1 (5)	01/10 – 31/10
UK	F	F1	16/4 – 31/5	B	01/6 – 31/8	F1	01/9 – 15/10

(1) During the transition period any mixture is accepted of the applicable transition grade and the summer grade. For France, different rules apply – see Note (2).

(2) In France the mixture described in Footnote (1) is only allowed during the last two weeks of the transition period in spring and the first two weeks of the transition period in autumn.

(3) Requirements for the Swedish “Environmental” EN 228 gasoline are more stringent than standard EN 228 grades.

(4) Swedish legislation has set transition periods of six weeks with slightly different requirements:
No VLI max; E100 min 47% and RVP min 45 kPa. Legal transition periods apply 01/4 – 15/5 and 01/9 – 15/10 for Sweden North and 16/9 – 31/10 for Sweden South. Class E1 VLI limits apply during four week periods, as indicated in the table.

(5) By 01/10/01, Class E will be replaced by Class D and Class E1 by Class D1.

Diesel Fuel - EN 590:1993

The EN 590:1993 standard specified six CFPP grades for temperate climates and five different classes for arctic climates. Each country had to detail requirements for summer and winter grades and may also have included intermediate and/or regional grades, which could be justified by national meteorological data.

Table B.1.21 CEN Diesel Fuel Specification EN 590:1993

All Grades						**Test Method**
Flash Point PMCC °C (min)	55					ISO 2719
Ash % m/m (max.)	0.01					EN 26245
Water mg/kg (max.)	200(1)					ASTM D1744
Particulates mg/l (max.)	24					DIN 51419
Copper Corrosion 3h at 50°C (max.)	1					ISO 2160
Oxidation Stability g/m^3 (max.)	25					ASTM D2274
Sulphur % m/m (max.)	0.20(2)					EN 24260/ISO 8754
Carbon Residue (10% btms) % m/m (max.)	0.30(3)					ISO 10370
Temperate Climate Grades (Grades A to F)						
CFPP (max.)	Note (4)					EN 116
Density at 15°C kg/m^3	820-860					ISO 3675/ASTM D4052
Viscosity at 40°C mm^2/s	2.00-4.50					ISO 3104
Cetane Number (min)	49					ISO 5165
Cetane Index (min)	46					ISO 4264
Distillation °C:						
10% v/v rec. at	report					ISO 3405
50% v/v rec. at	report					
65% v/v rec. at (min)	250					
85% v/v rec. at (max.)	350					
95% v/v rec. at (max.)	370					
Arctic Grades (Grades 0 to 4)						
Grade	**0**	**1**	**2**	**3**	**4**	
CFPP °C (max.)	-20	-26	-32	-38	-44	EN 116
Cloud Point °C (max.)	-10	-16	-22	-28	-34	ISO 3015
Density at 15°C kg/m^3 (min)	800	800	800	800	800	ISO 3675/ASTM D4052
Density at 15°C kg/m^3 (max.)	845	845	840	840	840	
Viscosity at 40°C mm^2/s (min)	1.50	1.50	1.50	1.40(5)	1.20(5)	ISO 3104
Viscosity at 40°C mm^2/s (max.)	4.00	4.00	4.00	4.00	4.00	
Cetane Number (min)	47	47	46	45	45	ISO 5165
Cetane Index (min)	46	46	46	43	43	ISO 4264
Distillation °C:						
10% v/v rec. at (max.)	180	180	180	180	180	ISO 3405
50% v/v rec. at	report	report	report	report	report	
95% v/v rec. at	340	340	340	340	340	

(1) A limit of 500 mg/kg may be specified by countries with inherently wet distribution systems until December 1995.

(2) Sulphur limit will be reduced towards 0.05% m/m. maximum, in line with EU directives or national standards.

(3) Based on fuel without ignition improver additives. if a higher value is found, fuel should be tested by ASTM D 4046 for presence of nitrates. If present the limit does not apply.

(4) Six grades (A, B, C, D, E and F), with CFPP limits from plus 5ºC to minus 20ºC, in 5ºC intervals.

(5) Arctic classes may exhibit poor lubricity characteristics and corrective measures (lubricity additives) may have to be used.

Diesel Fuel - EN590:1999

Table B.1.22 EN 590:1999 Diesel Fuel

Property	Units	Limits		Test Method (1)
		Min	Max	
Cetane Number (2)		51.0	-	EN ISO 5165:1998
Cetane Index		46.0	-	EN ISO 4264
Density @ 15°C (3)	kg/m^3	820	845	EN ISO 3675:1998 EN ISO 12185:1996
Polycyclic aromatic hydrocarbons (4, 5)	% m/m	-	11	IP 391:1995
Sulphur content (2)	mg/kg	-	350	EN ISO 14596:1998 EN ISO 8754:1995 EN 24260:1994
Flash point	°C	55	-	EN 22719
Carbon residue (6) (on 10% distillation residue)	% m/m	-	0.30	EN ISO 10370
Ash content	% m/m	-	0.01	EN ISO 6245
Water content	mg/kg	-	200	prEN ISO 12937:1996
Total contamination	mg/kg	-	24	EN 12662
Copper strip corrosion (3 h @ 50°C)	rating		class 1	EN ISO 2160
Oxidation stability	g/m^3	-	25	EN ISO 12205
Lubricity, corrected wear scar diameter (wsd 1,4) @ 60°C	μm	-	460	ISO 12156-1
Viscosity @ 40°C	mm^2/s	2.00	4.50	EN ISO 3104
Distillation (7, 8)				prEN ISO 3405:1998
% recovered @ 250°C	% v/v		<65	
% recovered @ 350°C	% v/v	85		
95% v/v recovered	°C		360	

(1) All the test methods include a precision statement. In cases of dispute, the procedures described in EN ISO 4259:1995 shall be used.

(2) For the determination of cetane number alternative methods may also be used in cases of dispute, provided that these methods originate from a recognised method series, and have a valid precision statement, derived in accordance with EN ISO 4259:1995, which demonstrates precision at least equal to that of the referenced method. The test result, when using an alternative method, shall also have a demonstrable relationship to the result obtained when using the referenced method.

(3) In cases of dispute concerning density and sulphur, the following procedures shall be used:

Property	Procedure
density	EN ISO 3675:1998
sulphur content	EN ISO 14596:1998

- Further methods for the determination of sulphur content at levels below 350mg/kg are under development by CEN/TC 19.

  For the purposes of this standard, polycyclic aromatic hydrocarbons are defined as the total aromatic hydrocarbon content less the mono-aromatic hydrocarbon content, both determined by IP391. IP 391 will be replaced by EN 12196 “Petroleum products – Determination of aromatic hydrocarbon types by high performance liquid chromatography with refractive index detection” upon publication.

(4) IP 391 is not able to distinguish between polycyclic aromatic hydrocarbons and fatty acid methyl esters (FAME). FAME, if present in diesel fuels, will give a bias which will increase the value for polycyclic aromatic hydrocarbons. An improved method for the determination of polycyclic aromatic hydrocarbons is under development by CEN/TC 19. [Notes continued on next page]

(5) The limiting value for carbon residue given above is based on product prior to the addition of ignition improver, if used. If a value exceeding the limit is obtained on finished fuel in the market, EN ISO 13759 shall be used as an indicator of the presence of a nitrate-containing compound. If an ignition improver is thus proved present, the limit value for the carbon residue of the product under test cannot be applied. The use of additives does not exempt the manufacturer from meeting the requirement of maximum 0.30% m/m of carbon residue prior to the inclusion of additives.

(6) For the calculation of cetane index the 10%, 50% and 90% v/v recovery points are also needed.

(7) The limits for distillation at 250°C and 350°C are included for diesel fuel in line with the EU Common Customs Tariff.

For climate-dependent requirements options are given to allow for seasonal grades to be set nationally. The options in temperate climates are for six cold filter plugging point (CFPP) grades, whilst arctic climates are provided with five different classes (see **Table B.1.23**, **parts A** and **B**). When tested by the methods given in the table, automotive diesel fuel shall be in accordance with the limits specified.

The cetane number limits for the arctic grades are lower than for the temperate grade (**Table B.1.23**), reflecting the correlation between ignition quality and density, and the low density of arctic grades. The values for cetane number in **Table B.1.23**, **part B** do not meet the requirements of EU Directive 98/70/EC, and are included for use in countries where the Directive does not apply or for countries where exceptions for arctic grades have been granted.

In a national annexe to this European Standard each country shall detail requirements for a summer and winter grade and may include an intermediate grade and/or regional grade(s) which shall be justified by national meteorological data.

Table B.1.23 EN 590:1999 Diesel Fuel – Climate-related requirements and test methods

Part A – Temperate Climates								
Property	**Units**	**Limits**						**Test Method (1)**
		Grade A	**Grade B**	**Grade C**	**Grade D**	**Grade E**	**Grade F**	
CFPP	°C (max)	+ 5	0	- 5	- 10	- 15	- 20	EN 116

Part B – Arctic Climates							
Property	**Units**	**Limits**					**Test Method (1)**
		Class 0	**Class 1**	**Class 2**	**Class 3**	**Class 4**	
CFPP	°C (max)	- 20	-26	- 32	- 38	- 44	EN 116
Cloud point	°C (max)	- 10	- 16	- 22	- 28	- 34	EN 23015
Density @ 15°C (2)	kg/m^3 (min)	800	800	800	800	800	EN ISO 3675:1998
	kg/m^3 (max)	845	845	840	840	840	EN ISO 12185:1996
Viscosity @ 40°C	mm^2/s (min)	1.50	1.50	1.50	1.40	1.20	EN ISO 3104
	mm^2/s (max)	4.00	4.00	4.00	4.00	4.00	
Cetane number (3)	(min)	49.0	49.0	48.0	47.0	47.0	EN ISO 5165:1998
Cetane index	(min)	46.0	46.0	46.0	43.0	43.0	EN ISO 4264
Distillation (4, 5)							prEN ISO 3405:1998
% recovered @ 180°C	% v/v (max)	10	10	10	10	10	
% recovered @ 340°C	% v/v (max)	95	95	95	95	95	

(1) All the test methods include a precision statement. In cases of dispute, the procedures described in EN ISO 4259:1995 shall be used.

(2) In cases of dispute concerning density, EN ISO 3675:1998 shall be used.

(3) For the determination of cetane number alternative methods may also be used in cases of dispute, provided that these methods originate from a recognised method series, and have a valid precision statement, derived in accordance with EN ISO 4259:1995, which demonstrates precision at least equal to that of the referenced method. The test result, when using an alternative method, shall also have a demonstrable relationship to the result obtained when using the referenced method.

(4) EU Common Customs Tariff definition of gas oil may not apply to the grades defined for use in arctic climates.

(5) For the calculation of cetane index the 10%, 50% and 90% v/v recovery points are also needed.

Table B.1.24 EN 590:1999 Diesel Fuel – Climate Grades adopted by individual countries)

Country	Winter Grade	Transition		Summer		Transition	
		Grade	Period	Grade	Period	Grade	Period
Austria	F	E	01/03 – 31/03	A	01/04 – 30/09	-	-
Belgium	E	-	-	B	01/03 – 30/11	-	-
Denmark	F	-	-	D	16/03 – 30/09 (1)	E	01/10 – 31/11 (1)
Finland	Arctic 1 (2)	-	-	C	01/04 – 31/10	-	-
France	E (3)	-	-	B	01/04 – 31/10	-	-
Germany	F	D	01/03 – 14/04	B	15/04 – 30/09	D	01/10 – 15/11
Greece	C	-	-	A	16/03 – 30/09	-	-
Iceland	Arctic 0	-	-	D	16/03 – 15/09	F	16/09 – 31/10
Italy	D	-	-	B	16/03 – 14/11	-	-
Ireland	E	-	-	C	16/03 – 21/10	-	-
Luxembourg	E	-	-	B	01/03 – 30/11	-	-
Netherlands	E	C	01/03 – 30/04	B	01/05 – 30/09	C	01/10 – 30/11
Norway	Arctic 0 & 2 (4)	Arctic 0 (4)	01/03 – 31/03	D (5)	01/04 – 15/09	Arctic 0 (4)	16/09 – 31/10
Portugal	D	C	01/03 – 31/03	B	01/04 – 14/10	C	15/10 – 30/11
Spain	D	-	_	B	01/04 – 30/09	-	-
Sweden	Environmental Class 1 (one quality all year) meets the EN 590 Arctic Class 2 limits, but overall requirements are more severe – see **Section B.1.2.7**						
Switzerland	Arctic 0 (6)	-	-	D (7)	01/05 – 30/09	-	-
UK	E	-	-	C	16/03 –21/10	-	-

(1) In Denmark the periods refer to “out of depot” dates as “ex-pump” dates are not set in the national annex.

(2) For severe cold areas during the winter season: Arctic 3.
For extreme cold areas during the winter season: Arctic 4.

(3) For extra cold winter conditions, a special “grand froid” grade, Class F, is used – see next Table.

(4) Arctic Class 0 or 2, depending on region. Requirements for both grades are more severe than those specified in EN 590:
Norwegian Class 0: Cloud Point - 15°C (max); CFPP – 24°C (max); Cetane number 51 (min).
Norwegian Class 2: Cetane number 51 (min).

(5) For Norway, CFPP is – 11°C (max) compared with – 10°C (max) for EN 590 Grade D.

(6) If used during the summer, minimum density and viscosity must satisfy the summer specification for Class D.

(7) Although Class D is accepted, most suppliers have Arctic Grade 0 available throughout the year.

B.1.2.3. French Cahier des Charges/UTAC Labelling Systems

(**Note:** These systems are no longer in use).

The French motor manufacturers developed an unofficial performance-related fuel quality labelling system called the “Cahier des Charges”. In addition to meeting national specifications, oil companies could choose to submit a dossier of information to the motor industry and have their fuels approved. They could then claim that products were “approved by the French motor industry”. The scheme was introduced in 1989 and the specifications were updated annually.

Until 1994 the scheme was jointly administered by Renault and the PSA Group. However, on 11 March 1994 it was agreed that the French Transport Ministry

Technical Advisory Committee (UTAC) would issue certificates of quality for gasoline and diesel fuel. The new labelling system was announced in June 1994 and was launched in September 1994.

A “Certification Committee” was in charge of the general administration of the scheme, and delivered certificates upon the recommendation of technical committees. These committees were also responsible for controlling conformity of production in-service and for recommending changes to the technical content of the UTAC label. Representatives of UTAC, the French administration, the oil industry, motor manufacturers and consumer associations were able to attend meetings of these committees.

The new system used the norms and specifications of the “Cahier des Charges” for gasoline and diesel fuel which are summarized in **Tables B.1.25** and **B.1.26**. Since its introduction a requirement for valve deposit weight was added to the requirements of the Mercedes M 102 E Intake Cleanliness Test for gasolines. A lubricity test and pour point limits were added to the diesel fuel requirements but the requirements for density, total aromatics and total naphthenes were deleted. Cetane Index was not specified but Cetane Number was retained.

The scheme incorporated a quality assurance system for final inspection, testing, storage and distribution of automotive fuels, equivalent to ISO 9003.

Companies producing fuels of the required quality were able to claim that their products were “UTAC approved”. As with the previous “Cahier des Charges” system, approval was available to companies outside France. The scheme is no longer in use.

Table B.1.25 French Gasoline Specification for UTAC Labelling [3] (No longer in use)

Property	Leaded Gasoline	Unleaded 98	Unleaded 95
RON min	97	98	95
MON min	86.5	88	85
Distillation : E70	<40% from 01/06 to 30/09		
(% evaporated at 70°C)	<45% from 01/12 to 28/02		
	<43% for the other months		
VLI = RVP + 7 x E70	<850 from 01/06 to 30/09		
	<1150 from 01/12 to 28/02		
	<1000 for the other months		
Equivalent Vapour Pressure - Grabner at 37.8°C (hPa)	350-700 from 01/06 to 30/09 550-900 from 01/12 to 28/02 450-800 for the other months		
Oxygenates	No alcohols and no ketones, ethers = 15% v/v[1] max.		
Lead Content	0.08 - 0.15 g/l	5 mg/l max.	
Silicon Content	<2 µg/ml		
Sulphur		<200 ppm m	= 300 ppm m
Carburettor Cleanliness Renault R5 (CEC F-03-T-81)	Merit >8		
Injector cleanliness - 205 GTI (GFC-TAE-1-87)	Flow rate losses <4%		
Intake valve cleanliness			
- Opel Kadett	Merit = 9		
(CEC F-04-A-87)			
- Mercedes M 102 E (CEC F-05-A-94)	Merit = 9 average deposit weight per valve ≤50 mg		
Octane requirement increase	KLSA[2] = 12°	KLSA = 8º	
(Renault 22700, 22710 or BTC CEC PF 28)			
Black sludge	-	Merit = 9	
(DKA/M 102E, RL 140)			
Camshaft Bearing Wear-			
Petter W1	Bearing Weight loss = 25 mg		
(CFC-L-02 A 78, 36 h)			

(1) MTBE =15% v/v, ETBE =15% v/v with residual alcohols (ethanol, TBA etc.) =1% v/v

(2) KLSA = "Knock Limited Spark Advance"

(3) Gasoline must also meet administrative specifications and additives must be approved by DHYCA

Table B.1.26 French Automotive Diesel Fuel Specification for UTAC Labelling [1] (No longer in use)

Property		Specification	Test Method
Density CN			
Viscosity at 40ºC, mm^2/s		2 - 4.5	
Distillation:			
evaporated at 250ºC, % v/v		<60	
evaporated at 350ºC, % v/v		>85	
evaporated at 370ºC, % v/v		>95	
Cetane Number		>50	
Potential gum, mg/100 ml.	max	1.5	ASTM D 2274
Anti-Corrosion	max	5% (moderate rusting)	ASTM D 655 A
Foaming Tendency		[2]	
Biological Property	max	light contamination	M 07070
Total Acid Number, mg/KOH/g	max	0.08	NF T 60 112
Lubricity, HFRR		report	ISO 12156-1
Detergents		[3]	
Cold Flow Properties[1]		01/11 to 31/03	
Cloud Point	max	- 5ºC	
CFPP	max	-15ºC	
Pour Point	max	-18°C	

(1) Diesel fuels must also meet administrative specifications and additives must be approved by DHYCA.

(2) Presence of additive to be confirmed by demonstration of efficiency.

(3) 15% maximum flow rate loss at 0.1 mm needle lift by test method CEC PF023.

B.1.2.4. Pre-2000 Gasolines – Other quality criteria

Lead Content

Within the EU, the maximum lead content of leaded gasolines was required to be within the range of 0.15 to 0.4 g/l by EU Directive 78/611/EEC. In practice, all countries were at 0.15 g/l maximum. In 1985 another EU Directive (85/210/EEC) allowed unleaded gasoline (0.013 g/l max.) to be marketed and, in addition, required the introduction of a premium unleaded grade of 95 RON/85 MON from 1 October 1989. This Directive also encouraged Member States to provide incentives (e.g. through taxation) to promote the use of unleaded grades. Subsequently several Member States banned leaded regular completely, as allowed by EU Directive 87/416/EEC.

In Eastern Europe unleaded gasoline is available in all countries, generally as 95 RON Europremium, although there is some variation in octane levels.

Aromatics and Benzene

The EU Directive (85/210/EEC), which required the introduction of unleaded gasoline, also specified a benzene level of 5% v/v maximum. From 1 October 1989 this also applied to leaded grades marketed in EU countries. This limit was also generally accepted in other countries in Europe, including Norway and Switzerland.

Austria reduced gasoline benzene content to 3% v/v maximum from 1 September 1990. (Regulation No. 239. Minister of Environment, Youth and Family, 5 March 1990, subsequently replaced by Regulation No. 123. Minister of Environment, Youth and Family, 1 March 1992). The oil industry agreed, on a voluntary basis to supply Super Plus RON 98 with 1% v/v maximum from 1 June 1996 and other grades at 2% v/v max from 1 February 1997.

In Italy the benzene content of the total gasoline pool was limited to 3.0% v/v from 1 January 1993. This was on the basis of a three-month sales weighted production average for each refinery by a voluntary agreement between the Environment Ministry and the oil companies. From January 1995 some companies distributed gasoline with benzene limited to 1.8% v/v max. From 1 July 1997 a maximum benzene limit of 1.4% v/v applied to all gasolines. This limit reduced to 1.0% v/v from 1 July 1999.

In Germany, Superplus gasoline with a 1% v/v benzene content was made available on a voluntary basis by many oil companies from October 1995.

In Finland reformulated gasolines was commercially introduced from January 1993. The benzene content was limited to 3% v/v and its sale was encouraged by tax incentives. A new grade was introduced commercially in Finland from March 1994, containing less than 1% v/v benzene.

Oxygenates

In December 1985 the EU adopted EU Directive 85/536/EEC on oxygenates in gasoline. The Directive specified that:

- By 1988 Member States must ensure that there are no legal and administrative obstacles to the sale of gasoline blends containing oxygenates, suitable for use in spark ignition engines designed to operate on gasoline.
- The components and concentrations which are deemed to meet this requirement are outlined in a Technical Annex.
- The following are acceptable for use as substitute fuel components:
  - mono-alcohols with an atmospheric boiling point lower than the final atmospheric boiling point laid down in the national gasoline standards;
  - ethers, with molecules containing 5 or more carbon atoms, and with atmospheric boiling points lower than the final atmospheric boiling point laid down in the national gasoline standards.

Member States must permit fuel blends containing levels of oxygenates not exceeding the level set out in column A of the table in the technical Annex to the Directive. If they so desire, they may authorize proportions of oxygenates above these levels.

However, if the levels so permitted exceed the limits set out in column B of the Annex table, the pumps which dispense the fuel blend must be very clearly marked

accordingly, in particular to take account of variations in the calorific value of such fuels. The main points of the Annex table are set out in **Table B.1.27**.

Table B.1.27 Maximum Oxygenates limits set out in EU Directive 85/536/EEC

Description	A (% v/v)[3]	B (% v/v)
Methanol, suitable stabilizing agents must be added[1]	3	3
Ethanol, stabilizing agents may be necessary[1]	5	5
Isopropyl alcohol	5	10
Tertiary butyl alcohol	7	7
Iso-butyl alcohol	7	10
Ethers containing 5 or more carbon atoms per molecule[1]	10	15
Other organic oxygenates[2] defined in Annex Section I[1]	7	10
Mixture of any organic oxygenates defined in Annex Section I [1]	2.5% m/m oxygen, not exceeding the individual limits fixed above for each component	3.7% m/m oxygen, not exceeding the individual limits fixed above for each component

(1) In accordance with national specifications or, where these do not exist, industry specifications.

(2) Acetone is authorized up to 0.8% by volume when it is present as by-product of the manufacture of certain organic oxygenate compounds.

(3) Not all countries permit levels exceeding those in column (A) even if the pump is labelled.

B.1.2.5. Pre-2000 Reformulated Gasolines

Both Sweden and Finland introduced reformulated gasoline specifications with special requirements for volatility and composition.

Sweden

An 'Environmental Classification' system for diesel fuel was introduced in Sweden in 1991. During 1993, a similar classification was developed for gasolines, comprising 4 different classes. Class 4 was equivalent to CEN standard, and Class 3 to the then current Swedish standard. Separate Class 2 gasoline specifications, for use in cars with and without catalyst, were introduced from 1 December 1994. The specifications were optional and use has been encouraged by tax relief. A Class 1 specification was introduced later in the decade.

Table B.1.28 Swedish Environmental Gasolines (pre 2000)

Property	Units	Classification				
		MK1 (1)	MK2a	MK2b	MK2c (2)	MK3
RON (min)	-	95	-	-	-	-
MON (min)	-	85	-	-	-	-
RVP (S/W) (max)	kPa @ 37.8°C	70/95	70/95	70/95	65	-
RVP (S/W) (min)	kPa @ 37.8°C	45/65	45/65	45/65	50	-
E70 (S/W) (min)	% v/v	-	-	-	15-42	
E100 (S/W) (min)	% v/v	47/50	47/50	47/50	45-72	-
E150 (min)	% v/v	75	-	-	-	-
E180 (min)	% v/v	-	-	-	95	-
Olefins (max)	% v/v	13	-	-	0.5	-
Benzene (max)	% v/v	1.0	3.0	3.0	0.1	5.0
Aromatics (max)	% v/v	42.0	-	-	0.5	-
Oxygen (max)	% m/m	2.3	2.3	2.3	-	-
Sulphur (max)	mg/kg	50	100	300	50	-
Lead (max)	mg/l	5.0	5.0	5.0	2.0	13.0
Phosphorous (max)	mg/l	0	0	2.0	-	-

(1) There are two stages for MK1. The first is until 2000, or until the new EU specification is included in Swedish law. The parameters affected are:

Property	Units	Limit Values	
		Current	Post 2000
Olefins	% v/v	15.0	13.0
Aromatics	Index (3)	5.5	-
Aromatics	% v/v	-	42.0
Benzene	% v/v	2.0	1.0
Sulphur	mg/kg	100	50

(2) MK2c has additional maximum limits of 0.5% v/v on n-hexane and cycloalkanes.

(3) Aromatic index = (Aromatics/13+benzene)% v/v.

Finland

In Finland reformulated gasolines was commercially introduced from January 1993. The benzene content was limited to 3% v/v and its sale was encouraged by tax incentives. A new grade was introduced commercially in Finland from March 1994, containing less than 1% v/v benzene.

B.1.2.6. Pre-2000 Diesel Fuels – Other quality criteria

Sulphur Content

EU Directive 93/12/EEC was adopted on 23 April 1993, requiring:

- A maximum limit of 0.2% m/m to be applied for all gas oils, including diesel fuel from 1 October 1994.
- A maximum limit of 0.05% m/m for diesel fuel to be implemented by 1 October 1996. Member States in the interim were required to ensure the "*progressive availability*" of a diesel fuel with a sulphur content of 0.05% m/m "*from 1 October 1995*". This was to allow the implementation of the second phase of the "*Clean Lorry*" Directive.
- For all gas oils and aviation kerosene, further reductions in sulphur content below 0.2% m/m were to be considered.

In Austria, under a regulation agreed on 1 March 1992, the sulphur limit for diesel fuel was reduced from 0.15% m/m to 0.05% m/m, with effect from 1 October 1995.

Denmark introduced tax differentiation for low sulphur (0.05% m/m) diesel fuels with effect from 1 July 1992. Two grades were involved, (a CEN Euro standard grade and a Bus diesel fuel).

The sulphur content of diesel fuel in Finland had been limited in the national specification to 0.2% m/m since 1 January 1989 and qualities were also marketed with sulphur contents of 0.005% m/m maximum. Tax incentives were applied to a 0.005% m/m low-sulphur reformulated grade on 1 July 1993.

Germany introduced a maximum sulphur content of 0.05% m/m on a voluntary basis from 1 October 1995.

In Italy the 0.05% m/m limit became mandatory from 1 December 1995.

Sweden imposed a tax levy of USD 3.9/m^3 on gas oils with a sulphur content between 0.1 and 0.2% m/m from 1 January 1991. This coincided with the introduction of environmental classifications for diesel fuel with tax relief for grades with sulphur contents of 0.001 and 0.005% m/m. In 1996 the 0.005% m/m sulphur grade was discontinued.

All EU countries adopted the 0.05% m/m limit from 1 October 1996.

Switzerland

In Switzerland, the sulphur content of diesel fuel was reduced from 0.2% m/m to 0.05% m/m from 1 January 1994.

B.1.2.7. Pre-2000 Special Diesel Fuel Grades

Denmark, Finland, Sweden and the UK marketed special environmental grades supported by tax incentives.

Denmark

In Denmark a “Bus diesel” grade, with improved volatility/ignition quality characteristics and a tax incentive was specified. On 1 June 1999 a tax incentive was introduced to promote a standard automotive diesel fuel with a low sulphur content (defined as sulphur below 50 ppm). As a result nearly all the diesel fuel sold from that date met the low sulphur specification.

Finland

In Finland a “reformulated” diesel fuel was introduced commercially from 1 July 1993. Compared with the standard specification, its characteristics included a reduced sulphur content and an aromatics limit. Its use was encouraged by means of a tax incentive and market penetration was nearly 100%. Off-road diesel vehicles and engines are allowed to use a lower taxed grade (light heating oil) with a maximum sulphur content of 0.2% m/m.

Sweden

In Sweden two “Environmental Classifications”, EC1 and EC2, were introduced for diesel fuel with sulphur contents of 0.001 and 0.005% m/m respectively and compositional constraints. The EC1 grade is supported by a tax incentive compared with the standard European EN 590 fuel. The market penetration of the EC1 grade is virtually 100%.

United Kingdom

In the UK, a city diesel was specified by the Department of Transport, Environment and the Regions in 1997 and this specification was subsequently amended in 1998. The grade is defined in HM Customs and Excise Tariff Notice No. 6/98 (issued in March 1998) as "Ultra Low Sulphur Diesel" or "ULSD"

ULSD must meet EN 590, except as follows:-

Sulphur:	0.005% m/m (max)
Density:	835 kg/m^3 at 15°C (max). Note that EN 590 minimum density limit of 820 kg/m^3 is still applicable.
T95:	345°C (max)

The tax incentive for this grade was increased in the April 1998 budget and further increased April 1999. As a direct consequence, virtually all diesel fuel in the UK met ULSD requirements. The UK differential taxation scheme was approved by Council Decision 2000/434/EC of 29 June 2000, [published in the Official Journal L172, p. 23 on 12 July 2000].

B.1.2.8. Pre-2000 Alternative Fuels

Automotive LPG - EN 589:1993

Four grades were specified, based on seasonal limits for minimum vapour pressure during the winter months. Each country had to specify which winter grade it adopted in an annex to its national standard. This specification was subsequently amended in 1998

Vegetable Oil Methyl Esters (Biodiesel)

DG VII (Transport) put forward a draft proposal for a Council Directive for a specification for vegetable oil methyl esters (biodiesels). The proposal was presented in the framework of EU's ALTENER Programme for the promotion of alternative fuels. Within this programme the EU has the objective of securing a 5% market share of total motor fuel consumption for biofuels, of which it is expected that biodiesel will form the major share. Subsequently, the Directorate-General for Energy (DGXVII) issued Mandate M/245 of 29 January 1997 to CEN for "the elaboration and adoption of standards concerning specifications, including test methods, for fatty acid methylester (FAME)".

For automotive applications CEN was asked to consider setting up two or more standards (if necessary) for the use of FAME as either:

a) a sole diesel engine fuel (100%), or:

b) as an "additive extender" to EN 590 diesel fuel, on the basis that the specification would allow variable blend percentages.

The mandate also asked that, as far as possible, the specification should follow EN 590 and that standard test methodology be employed. The following draft was subsequently ratified as a full EN specification and details will be found in **Part 1**, **Section 1.2.6**.

Table B.1.29 CEN Draft Specification for Vegetable Oil Methylester Diesel Fuel (Biodiesel, Fatty Acid Methyl Ester [FAME]) (1)

Property	Units	Proposed Limits		Test Method
		Min	Max	
Ester content	% m/m	96.5		prEN aaaa (2)
Density @ 15° C	kg/m^3	860	900	EN ISO 3675 EN ISO 12186
Viscosity @ 40° C (3)	mm^2/s	3.5	5.0	EN ISO 3104
Flash Point	°C	Above 101	-	ISO/CD 3679 (4)
Sulphur content (5)	% m/m	-	0.001	EN ISO 14596
Carbon residue (on 10% distillation residue) (6)	% m/m	-	0.3	EN ISO 10370
Cetane number		51.0		EN ISO 5165
Sulphated ash content	% m/m	-	0.02	ISO 3987
Water content	% m/m	-	0.05	PrEN ISO 12937: 1999
Total contamination (7)	mg/kg	-	24	EN 12662
Copper strip corrosion (3 h @ 50°C)	rating	Class 1		EN ISO 2160
Thermal stability (8)				
Oxidation stability, 110° C (9)	h	6	-	ISO 6886
Acid number	mg KOH/g		0.5	ISO 660
Iodine number			120	ISO 3961
Linolenic acid methyl esters	% m/m		12	prEN aaaa (2)
Content of 4+ double bonds	% m/m		1	prEN aaaa (2)
Methanol content	% m/m		0.2	prEN cccc (10)
Monoglyceride content	% m/m		0.8	prEN dddd (11)
Diglyceride content	% m/m		0.2	prEN dddd (11)
Triglyceride content	% m/m		0.2	prEN dddd (11)
Free glycerol	% m/m		0.02	prEN dddd (11)
Total glycerol	% m/m		0.25	prEN dddd (11)
Alkaline metals (Na + K)	mg/kg		5	prEN eeee (12)
Phosphorous content	mg/kg		10	prEN ffff (13)

(1) Draft as at 13 September 2000.

(2) CEN/TC 307 publication of NF T60-703: 1997

(3) Where CFPP is – 20° C or lower, the viscosity measured at – 20° C should not exceed 18 mm^2/s. In this case, EN ISO 3104 is applicable without the precision data.

(4) Apparatus equipped with a thermal detection device shall be used.

(5) Pending further work by CEN/TC 19, ISO 14596 shall be used until 31 December 2002.

(6) ASTM D 1160 shall be used to obtain the 10% distillation residue.

(7) Pending development of a suitable method by CEN/TC 19, EN 12662 shall be used until 31 December 2002. The precision of this method is, however, poor for FAME products.

(8) Pending development of a suitable method by CEN/TC 19, a limit shall be proposed by 31 December 2002.

(9) Pending qualification of suitable additives, a limit of 5 h (min.) is allowed until 31 December 2002 at the latest.

(10) CEN/TC 307 publication of NF T60-701 (procedure A) and DIN 51608 (procedure B).

(11) CEN/TC 307 publication of NF T60-704: 1997.

(12) CEN/TC 307 publication of NF T60-706: 1997. The precision of this method is under investigation by CEN/TC 307; if the precision is not satisfactory an improved test method shall be proposed by 31 December 2002.

(13) CEN/TC 307 publication of NF T60-705: 1997.

Table B.1.30 CEN Draft Specification for Vegetable Oil Methylester Diesel Fuel - Climate Dependent Requirements

Property	Unit	Proposed Limits Temperate Climate Grades						Test Method
		A	B	C	D	E	F	
CFPP	°C, max	+ 5	0	- 5	- 10	- 15	- 20	EN116

Property	Unit	Proposed Limits Arctic Climate Classes					Test Method
		0	1	2	3	4	
CFPP	°C, max	- 20	- 26	- 32	- 38	- 44	EN116

B.1.2.9. Post 2000 Regulations: EU Directives 98/70/EC and 2003/17/EC - Fuel Specifications for 2000 and 2005

One of the provisions of EU Directive 94/12/EC relating to vehicle emissions required that the EU Commission investigate the contribution that improvements in gasoline and diesel fuel quality can make to the reduction of air pollution. This aspect was considered a key element in the Auto-Oil programme. As a result, the Commission made a number of proposals in a draft Directive placed before the European Parliament and Council in 1996, which was then discussed over the next eighteen months.

The final Directive made significant changes to the original Commission proposals and 98/70/EC can be summarised as follows:

- All gasolines had to be unleaded from 1 January 2000 unless a Member State could show that this would result in technical difficulties or severe socio-economic problems would ensue. Derogations to this ruling might be possible up to 2005 (see **Section B.1.2.11**).
- From the year 2000, gasolines must comply with the specification given in **Table B.1.31**, with limitations on gasoline volatility, aromatics (including benzene), olefins and sulphur. Further reductions in aromatics and sulphur content were to be mandated in 2005. Limited derogations to the sulphur limitations may be allowed (see **Section B.1.2.11**).
- From the year 2000, diesel fuels must comply with the specification given in **Table B.1.32**, which has higher ignition quality, a limitation on polycyclic aromatic hydrocarbons and a reduction in sulphur content to 350 mg/kg. In 2005 the sulphur content was cut further. As with gasoline, limited derogations to the sulphur limits may be permitted (see **Section B.1.2.11**).
- The original Directive only specified year 2005 limits for sulphur in both fuels and for gasoline aromatics.

As stated above, the first phase was introduced in 2000 and mandatory specifications for 2005 were outlined. A further Directive (2003/17/EC) confirmed the 2005 specifications and these are detailed in **Part 1**, **Section 1.2.2**.

Table B.1.31 EU Directive 2003/17/EC: Year 2000 Limits for Gasoline

Parameter [1]	Units	Limits [2]	
		Min	Max
Research Octane Number		95 [3]	-
Motor Octane Number		85	-
Vapour pressure, Summer Period [4]	kPa	-	60.0 [5]
Distillation:			
Evaporated @ 100°C	% v/v	46.0	-
Evaporated @ 150°C	% v/v	75.0	-
Hydrocarbon Analysis:			
Olefins	% v/v	-	18.0 [6]
Aromatics	% v/v	-	42.0
Benzene	% v/v	-	1.0
Oxygen Content	% m/m	-	2.7
Oxygenates:			
Methanol, stabilising agents must be added	% v/v	-	3
Ethanol, stabilising agents may be necessary	% v/v	-	5
Iso-propyl alcohol	% v/v	-	10
Tertiary-butyl alcohol	% v/v	-	7
Iso-butyl alcohol	% v/v	-	10
Ethers containing 5 or more carbon atoms per molecule	% v/v	-	15
Other oxygenates [7]	% v/v	-	10
Sulphur content	mg/kg	-	150
Lead Content	g/l	-	0.005

(1) Test methods shall be those specified in EN 228:1999. Member States may adopt the analytical method specified in replacement EN 228:1999 standard if it can be shown to give at least the same accuracy and at least the same level of precision as the analytical method it replaces.

(2) The values quoted in the specification are “true values”. In the establishment of their limit values, the terms of ISO 4259 “Petroleum products - Determination and application of precision data in relation to methods of test” have been applied and in fixing a minimum value, a minimum difference of 2R above zero has been taken into account (R = reproducibility). The results of individual measurements shall be interpreted on the basis of the criteria described in ISO 4259 (published in 1995).

(3) Unleaded regular grade petrol may be marketed with a minimum motor octane number (MON) of 81 and a minimum research octane number (RON) of 91.

(4) The summer period shall begin no later than 1 May and shall not end before 30 September. For Member States with arctic or severe winter conditions, the summer period shall begin no later than 1 June and shall not end before 31 August.

(5) For Member States with arctic or severe winter conditions the vapour pressure shall not exceed 70 kPa during the summer period.

(6) Unleaded regular grade petrol may be marketed with a maximum olefin content of 21 % v/v.

(7) Other mono-alcohols and ethers with a final boiling point no higher than that stated in EN 228:1999.

Table B.1.32 EU Directive 2003/17/EC: Year 2000 Limits for Diesel Fuel

Parameter (1)	Units	Limits (2)	
		Min.	Max.
Cetane Number		51.0	-
Density at 15°C	kg/m^3	-	845
Distillation			
95% v/v point	°C	-	360
Polycyclic Aromatic Hydrocarbons	% m/m	-	11
Sulphur content	mg/kg	-	350

(1) Test methods shall be those specified in EN 590:1999. Member States may adopt the analytical method specified in replacement EN 590:1999 standard if it can be shown to give at least the same accuracy and at least the same level of precision as the analytical method it replaces.

(2) The values quoted in the specification are "true values". In the establishment of their limit values, the terms of ISO 4259 "Petroleum products - Determination and application of precision data in relation to methods of test" have been applied and in fixing a minimum value, a minimum difference of 2R above zero has been taken into account (R = reproducibility). The results of individual measurements shall be interpreted on the basis of the criteria described in ISO 4259 (published in 1995).

B.1.2.10. Additional Provisions of Directive 98/70/EC

In addition to the above specifications, the Directive included a number of other important provisions:

Gasoline

- The marketing of leaded gasoline was prohibited from 1 January 2000.
- Member States may permit the marketing of gasoline meeting the Year 2005 specification from 1 January 2000.
- Requests for derogations to the ban on leaded fuel had to be submitted to the EU Commission by Member States by 31 August 1999. Irrespective of any derogation, Member States may also permit the marketing of leaded gasoline in very small quantities (less than 0.5% of total sales) for distribution through "special interest groups for old vehicles of a characteristic nature."
- Requests for derogations on the sulphur content had to be submitted to the EU Commission according to the following schedule:

Sulphur Specification (mg/kg)	Application for Derogation	Time Limit to Derogation
Year 2000 – 150	31/08/99	01/01/03
Year 2005 – 50	31/08/03	01/01/07

Derogations might be permitted if it was demonstrated that "severe difficulties would ensue for a Member State's industries in making the necessary changes in their manufacturing facilities during the period of time between:" (a) the date of adoption of the Directive and 1 January 2000 or, (b) for the lower sulphur content, the date of adoption of the Directive and 1 January 2005.

Diesel Fuel

- Member States may permit the marketing of diesel fuel meeting the Year 2005 specification from 1 January 2000.
- Requests for derogations on the sulphur content had to be submitted to the EU Commission according to the following schedule:

Sulphur Specification (mg/kg)	Application for Derogation	Time Limit to Derogation
Year 2000 – 350	31/08/99	01/01/03
Year 2005 – 50	31/08/03	01/01/07

  Derogations might be permitted if it was demonstrated that "severe difficulties would ensue for a Member State's industries in making the necessary changes in their manufacturing facilities during the period of time between:" (a) the date of adoption of the Directive and 1 January 2000 or, (b) for the lower sulphur content, the date of adoption of the Directive and 1 January 2005.
- Member States, if they wish, may also apply the sulphur content specifications in this Directive to gas oils for off-road vehicles and agricultural tractors.

Fuels with More Stringent Specifications

By way of derogation, Member States may apply to market in specific areas fuels with more stringent environmental specifications. Submissions to the EU Commission must provide a justification on the following basis:

- The fuel(s) is/are required for all or part of the vehicle fleet to protect human health in specific areas.
- The derogation respects the principle of proportionality and will not disrupt the free movement of people and goods.
- The predicted effects on air quality support the use of these fuels.

Fuel Quality Monitoring

Member States have to monitor compliance of automotive fuels in lines with the specifications tabulated above. The EU Commission is to promote a uniform system for fuel quality monitoring with the assistance of CEN. A common format for reporting summaries of national fuel quality data is to be established by 30 June 2001. Member States will be required to submit their summary for the previous calendar year no later than 30 June of the following year and it is anticipated that reporting will commence in 2003.

Other Proposals

EU Directive 98/70/EC also requires the EU Commission to periodically submit proposals for revisions to the Directive "as an integral part of the strategy designed to meet the requirements of Community air quality standards". In addition, the EU Commission may bring forward proposals to:

- Consider captive fleets and the need to put forward specifications for any special fuels they may use.
- Set specifications for LPG, natural gas and biofuels.

B.1.2.11. Derogations to EU Directive 98/70/EC

A number of Member States sought derogations to EU Directive 98/70/EC so that they could continue marketing leaded gasoline. As a separate issue, Portugal requested derogations to the maximum sulphur content for both gasoline and diesel fuel. The basis of the argument for the retention of leaded gasoline was as follows:

- Older cars, requiring leaded fuel, were still in circulation in large numbers.
- These older cars required a higher octane grade and could suffer from valve seat recession in the absence of lead.
- In some cases it was also suggested that lead phase-out would not result in any overall environmental benefits.

The EU Commission's assessment was, however, that (with one exception) the Member States in question had not "convincingly demonstrated" that severe socio-economic problems would ensue or that there would be no overall environmental benefit from the withdrawal of leaded gasoline. The Commission pointed out that valve seat protection additives were available, as was higher octane unleaded fuel. Nevertheless, the Commission recognised that there was widespread consumer uncertainty in these Member States and therefore allowed limited derogations, as detailed below:

French Overseas "Départements"

In their submission the French authorities pointed out that its Overseas "Départements" (Guadeloupe, Guyana, Martinique and Réunion) were so remote that their fuel supplies depended on sources requiring less stringent specifications than those pertaining to the EU. The EU Commission agreed that special circumstances prevailed and all four territories were authorised to use leaded gasoline until 1 January 2005. In addition, Réunion was exempt from the sulphur specifications of 98/70/EC until January 2003.

Greece

Greece requested a derogation to continue marketing leaded gasoline until 1 January 2005. A relaxation until 1 January 2002 was granted.

Italy

Italy sought a derogation for the sale of leaded gasoline until 1 January 2003. Italy was allowed to continue marketing leaded gasoline until 1 January 2002.

Spain

Spain requested a derogation to continue marketing leaded gasoline until 1 July 2003. If by that date the proportion of the fleet requiring leaded fuel had not been reduced, a further extension until 1 January 2005 would have been sought. Spain was allowed to continue marketing leaded gasoline until 1 January 2002.

Portugal

Portugal requested a derogation on sulphur content for both gasoline and diesel fuel, presenting the EU Commission with data to support their case that the local refineries required time to upgrade their facilities. The Commission accordingly

granted an additional 2 years to comply with the gasoline sulphur limit and until 1 January 2001 to meet the diesel sulphur maximum.

Other Quality Considerations

The derogations went beyond a simple waiver of the key points of the new specifications. In the case of the French Overseas "Départements", the original submission requested that the benzene specification be maintained at 5% v/v for both leaded and unleaded gasolines and that the aromatics limit for unleaded gasoline be waived. The EU Commission decision, whilst recognising the local difficulties, pointed out that the Commission did not have powers under EU Directive 98/70/EC to grant derogations to the benzene and aromatics content of unleaded gasoline. This suggests that the unleaded grade had to comply with the aromatics and benzene limits as laid down in the Directive, whilst leaded gasoline could continue at 5% v/v benzene.

Similarly, leaded gasoline in the other Member States granted derogations would not have to comply with the aromatics and benzene limits of EU Directive 98/70/EC. In Italy, however, a national law fixes the maximum legal limits on the benzene and aromatics content of all grades of gasoline at 1.0% v/v and 40.0% v/v respectively. These limits became effective from 1 July 1998.

B.1.2.12. Post 2000 Reformulated Gasolines

Finland

In Finland an interim reformulated gasoline "City gasoline" was introduced commercially from January 1993, supported with a tax incentive. In April 1994 a reformulated gasoline with 1% benzene was introduced commercially and the specification was updated with effect from 1 April 1999 (see the following table).

Table B.1.33 Finland Reformulated Gasoline

Property	Reformulated Gasoline (1)	Citygasoline	Standard Gasoline
Oxygen % m/m	2.0 - 2.7	2.0 - 2.7	-
Benzene % v/v (max.)	1.0	3.0	5.0
Sulphur ppm m/m (max.)	100	400	1000
RVP (S/W) kPa (max.)	70/90	70/90	80/100

(1) Introduced from 1 April 1999, earlier specification limits represented by "Citygasoline".

This grade enjoys a tax incentive and has a market penetration of practically 100 %. Other requirements as in directive 2003/17/EC. EN 228 is not required by legislation but is followed voluntarily.

Germany

Germany brought into force on 1 January 2000 new regulations which provided for differentiating levels of mineral oil duty on fuels according to their sulphur content. This allowed the mineral oil duty on petrol and diesel fuel with a sulphur content exceeding 50 mg/kg to be increased by from 1 November 2001 and for this higher tax to be applied to fuels with a sulphur content exceeding 10 mg/kg from

1 January 2003. The 50 mg/kg differentiated tax was authorised by the EU Council of Ministers on 12 March 2001 - this applied from 1 November 2001 to 31 December 2002. Similarly, the Federal Republic of Germany was authorised by the Council to apply a differentiated rate of excise duty to fuels with a maximum sulphur content of 10 mg/kg from 1 January 2003 until 31 December 2005.

Sweden

During 1993 Sweden developed a classification for gasolines, comprising four different classes. Class 4 was equivalent to CEN standard, and Class 3 to the then current Swedish standard. Specifications for Class 2 gasolines were drawn up and the product was introduced on 1 December 1994, this was later followed by Environmental Class 1. The specifications are optional and use is encouraged by tax relief. New environmental classifications for gasoline were introduced with effect from 1 January 2000. This simplified the previous grade structure which involved five classifications. The environmental classifications were amended again with effect from 1 January 2005.

UK

The UK introduced tax incentives for "Ultra-low sulphur gasoline". This is based on the outline specification for 2005, published in Directive 98/70/EC, i.e. 35% v/v max. aromatics content and 50 mg/kg max. sulphur content.

B.1.2.13. Post 2000 Special Diesel Fuels

Denmark

In Denmark a "Bus diesel" grade, with improved volatility/ignition characteristics and a tax differential, was specified. This was withdrawn following the introduction of the 2004 EN standards. Details will be found in **Table B.1.34**. On 1 June 1999 a tax incentive was introduced to promote a standard automotive diesel fuel with a maximum sulphur content of 50 mg/kg. As a result nearly all the diesel fuel sold from that date has met the low sulphur specification.

Finland

In Finland a "reformulated" diesel fuel was introduced commercially on 1 July 1993. Compared with the standard specification, its characteristics include a reduced sulphur content and an aromatics limit (see **Table B.1.34**). This grade was replaced in September 2004 and details will be found in **Part 1**, **Section 1.2.5**.

Germany

Germany brought into force on 1 January 2000 new regulations which provided for differentiating levels of mineral oil duty on fuels according to their sulphur content. The regulation is the same as that described for gasoline in **Section B.1.2.12**.

Sweden

In Sweden two "Environmental Classifications", EC1 and EC2, were introduced on 1 January 1991 for diesel fuels specifying compositional constraints and sulphur contents of 10 and 50 mg/kg respectively. The EC2 grade was discontinued in

1996. The EC1 grade is supported by a tax incentive and its market penetration is almost 100% (see **Part 1**, **Section 1.2.5**).

UK

In the UK, a city diesel was specified by the Department of Transport, Environment and the Regions in 1997 (now the Department for Transport) and this specification was subsequently amended in 1998. The grade is defined in HM Customs and Excise Tariff Notice No. 6/98 (issued in March 1998) as "Ultra Low Sulphur Diesel" or "ULSD". Details will be found in **Part 1**, **Section 1.2.5**

Table B.1.34 European National Specifications for Diesel Fuel: Special Low Sulphur and Low Aromatics Grades

Country	Grade	Cetane No. (Index) min	Cloud Point °C max	CFPP °C max	Density @ 15°C kg/m^3	Viscosity @40°C mm^2/s	T95E°C (max)	Sulphur mg/kg max	Aromatics % v/v max	PAH % v/v max
Denmark (1)	Summer	50 (47)		-18	820-855	2.0-4.5	325	EN limit	5	-
	Winter	50 (47)		-25	820-855	2.0-4.5	325	EN limit	5	-
Finland (2)	Summer	49 (49)	-5	-15	820-850	2.0-3.5	350	50	20	-
	Winter	47 (47)	-29	-34	800-820	1.4-2.6	310	50	20	-
Sweden (3)	EC2 (4)	51 (47)	-	-	800-820	-	360	350	20	0.1

(1) Public Bus Service Ultra Light Diesel ("Bus Diesel"). A tax incentive applied before the grade was withdrawn with the introduction EN 590:2004.

(2) Reformulated Diesel. A tax incentive applies. This grade has been replaced – see **Part 1**, **Section 1.2.5**.

(3) EC represents "Environmental Classifications" – EC3 is specified according to EN 590. A tax incentive applies.

(4) Grade withdrawn, EC1 dominates the Swedish market – see **Part 1**, **Section 1.2.5**.

B.1.2.14. Post-2000 Alternative Fuels

European Standard LPG Specification

The European Union has adopted the CEN LPG Specification EN 589:2004 (see **Part 1**, **Section 1.2.6**), which was approved by CEN on 24 December 2003.

CEN Fatty Acid Methyl Ester (Biodiesel) Standard

See **Part 1**, **Section 1.2.6**.

B.1.2.15. Fuels Legislation - Future EU Review

EU Directive 2003/17/EC also required the EU Commission to review various provisions of the Directives no later than 31 December 2005. These review items are summarised in **Part 1**, **Section 1.2.7**

B.1.3. EMISSIONS AND FUEL ECONOMY TEST PROCEDURES

B.1.3.1. Introduction

The current regulations, designed to limit the emission of exhaust gases by motor vehicles, prescribe throughout the world maximum emission standards for the following exhaust gas components:

- carbon monoxide (CO);
- hydrocarbons (HC);
- oxides of nitrogen (NOx);
- particulates (PM).

In addition, a number of so-called "unregulated" emissions, (e.g. benzene and aldehydes) may also be incorporated in national standards. It is also common practice to use part or all of an emissions cycle to measure fuel economy, calculated by mass balance in conjunction with carbon dioxide measurements.

The method of gauging emission rates is determined by statutory test procedures, the objective being to establish the mass of each exhaust component emitted during the test. The mass is computed from the measured concentrations of each pollutant in the known exhaust gas volume. Exhaust species are generated when the vehicle is operated on a chassis dynamometer according to certain standard driving cycles, which are designed to simulate driving conditions in urban traffic. A number of these urban cycles have been augmented with higher speed sections (e.g. the European extra urban driving cycle - see **Figure B.1.3**).

Evaporative emissions from gasoline powered vehicles are also controlled. These emissions are determined either by collection in activated carbon traps, or by putting the vehicle in an airtight housing, or "Sealed Housing for Evaporative Determination" (SHED), and measuring the hydrocarbon concentration. This latter approach is favoured in Europe and the United States and has now been adopted in Japan.

These procedures are reviewed in this Section and the relevant Sections relating to other regions in the world.

The ECE15 and EUDC cycles for Light Duty and Light Commercial vehicles and the ECE R 49 Heavy Duty procedure remained in use in the EU until 31 December 1999. Thereafter modified or new cycles have been employed and all these are described in the **Appendix to Part 1**, **Section A.1.3.3**.

B.1.3.2. NEDC Cycle (Formerly ECE 15 and EUDC) for Light Duty Vehicles

ECE 15 defines an urban test cycle to be used for emission measurements, as shown in **Figure B.1.3**. The cycle was devised to be representative of city-centre driving (e.g. Rome) and thus has a maximum speed of only 50 km/h. The complete first ECE 15 emissions procedure consists of three tests, Type I, II and III as follows:

Type I Test Emission test cycle:

Prior to testing, the vehicle must be preconditioned by driving at least 3500 km (1800 miles). The vehicle is allowed to soak for at least 6 h at a test temperature of between 20 and 30°C. It is then started and, up to 31 December 1999, was allowed to idle for 40 seconds. The 15 mode driving cycle (**Figure B.1.3**) was then repeated

four times without interruption. This gave a total test cycle time of 780 s, a total distance of 4.052 km (2.5 miles) and thus an average speed of 19 km/h (11.8 miles/h).

Up to Amendment 15/04, total emissions were collected in one bag. CO and HC emissions were determined by NDIR (Non-Dispersive Infra-Red) analyzers and NOx by chemiluminescent technique. From 15/04, however, emissions were measured by the "*Constant Volume Sampling*" (CVS) technique, as used in the US procedure (**Figure B.1.4**). Hydrocarbon emissions are also determined by use of a FID (Flame Ionization Detector) analyzer.

The ECE 15 cycle is very low duty (maximum speed 50 km/h) and is thus not representative of many modes of driving. Specifically, it tends to give unrealistically low figures for NOx emissions. After much discussion, an additional "*high speed*" test cycle, the Extra Urban Driving Cycle (EUDC) was agreed (see **Figure B.1.3**), with a maximum speed of 120 km/h. This test is carried out after the standard ECE 15 test. This combination of the ECE 15 and EUDC test cycles was required in the EU "Consolidated Emissions Directive" and subsequent legislation, up to the adoption of Year 2000 standards. The test was modified from 1 January 2000 (please see the **Appendix to Part 1**, **Section A.1.3.2**).

Type II Test

Warmed-up idle CO test, conducted immediately after the fourth cycle of the Type I test; tailpipe sampling probe.

Type III Test

Chassis dynamometer procedure for crankcase emissions (idle and 50 km/h constant speed modes). The system is certified if the crankcase operates at partial vacuum (as in PCV systems), or if crankcase emissions meet specified standards.

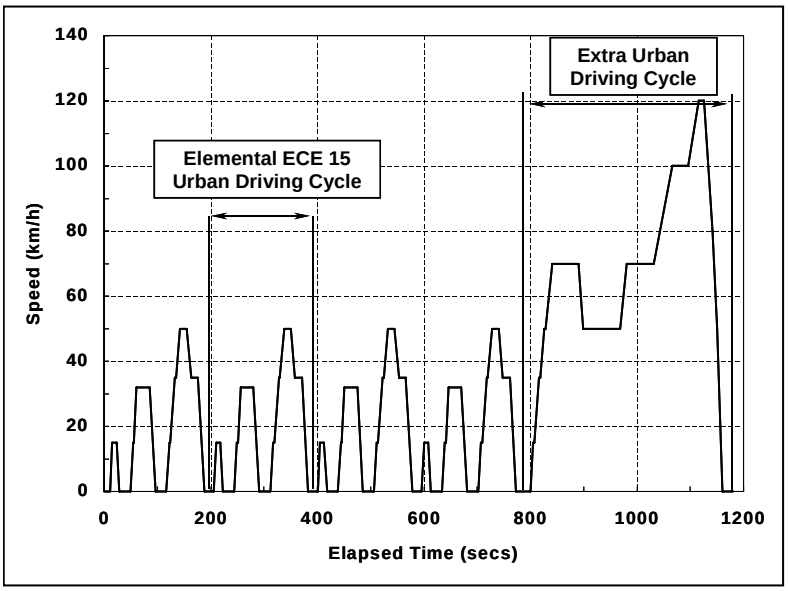
Fuel Economy and Carbon Dioxide Emissions

Fuel economy (by mass balance) and carbon dioxide emissions were also measured over the ECE 15 and EUDC cycles and these tests were replaced by the NEDC procedure in 2000. One figure for the combined cycle is reported for carbon dioxide, whereas fuel economy is reported separately for the two cycles and in combination.

Cold Start (-7°C) Requirements

EU Directive 98/69/EC stipulates that, from 1 January 2002, all new types of gasoline powered M_1 and N_1 Class I vehicles must meet certain emissions limits when tested at -7°C. The test (designated the Type VI test) is conducted over the four urban elements of the revised Type I test cycle.

Figure B.1.3 LD Test Cycle (Type 1 Test)



Characteristics		ECE 15 Cycle	EUDC Cycle
Distance	km	4 x 1.013 = 4.052	6.955
Time	s	4 x 195 = 780	400
Average Speed	km/h	19	62.6
Maximum Speed	km/h	50	120
Acceleration	% Time	21.6	-
Acceleration	m/s^2 (max.)	-	0.833
Deceleration	% Time	13.8	
Deceleration	m/s^2(max.)	-	-1.389
Idle	% Time	35.4	-
Steady Speed	% Time	29.3	-

B.1.3.3. ECE R49 Heavy Duty Engine Exhaust Emission Test Procedure (Superseded)

This procedure, withdrawn in the EU in 2000, was developed as a test for medium and heavy duty diesel engines operating in Europe. Accordingly it is an engine rather than a vehicle test and basically follows the format of the obsolete US 13-mode procedure. However, the minimum load condition is 10% (US 2%) and the weighting factors are changed to take into account the differences between European and US driving patterns. The modes employed are as follows:

Table B.1.35 ECE R49 Test Modes

Mode	Speed	Load %	Weighting Factor
1	Idle	0	0.083
2	Intermediate	10	0.080
3	Intermediate	25	0.080
4	Intermediate	50	0.080
5	Intermediate	75	0.080
6	Intermediate	100	0.250
7	Idle	10	0.083
8	Rated	100	0.100
9	Rated	75	0.020
10	Rated	50	0.020
11	Rated	25	0.020
12	Rated	10	0.020
13	Idle	0	0.083

The measuring analysers are as for the US test, whilst the calculation method follows the early US procedure based on measuring exhaust flow.

B.1.3.4. European Heavy Duty Engine Exhaust Emissions Test Procedures from January 2000

A GRPE sub-group was set up to develop a new exhaust emissions procedure for heavy duty vehicles for implementation with the Euro 3 emissions limits in 2000. The sub-group reported its conclusions in May 1996 and the outcome is reported in the **Appendix to Part 1**, **Section A.1.3.3**.

B.1.3.5. Motor Cycle Test Protocols

Directive 2003/77/EC defines the test cycles for year 2003 and 2006 motorcycle emissions requirements. These were previously stipulated according to UN ECE R40. For 2003, two preconditioning urban cycles are followed by four measured cycles. In 2006, all six urban cycles are measured and, in addition, an extra-urban cycle is included for machines over 150 cm^2.

B.1.3.6. Evaporative Emissions Test Procedures

In Europe the SHED (Sealed Housing for Evaporative Determination) is used to determine evaporative emissions from vehicles. The SHED method collects all evaporative emissions in a sealed enclosure which contains the test vehicle. The hydrocarbon concentration in the SHED atmosphere is measured and used to calculate total emissions. This technique has been used for many years in the US.

Evaporative emissions can be divided into three areas:

- ***Diurnal losses:*** these occur when the vehicle is stationary with the engine off and are due to emission of vapour from the fuel tank as a result of normal temperature changes which occur over a 24 hour period.
- ***Hot soak losses:*** these occur when a fully warmed up vehicle is left to stand, as engine heat is transferred to the fuel tank and/or fuel system.
- ***Running losses:*** these occur while the vehicle is being driven normally.

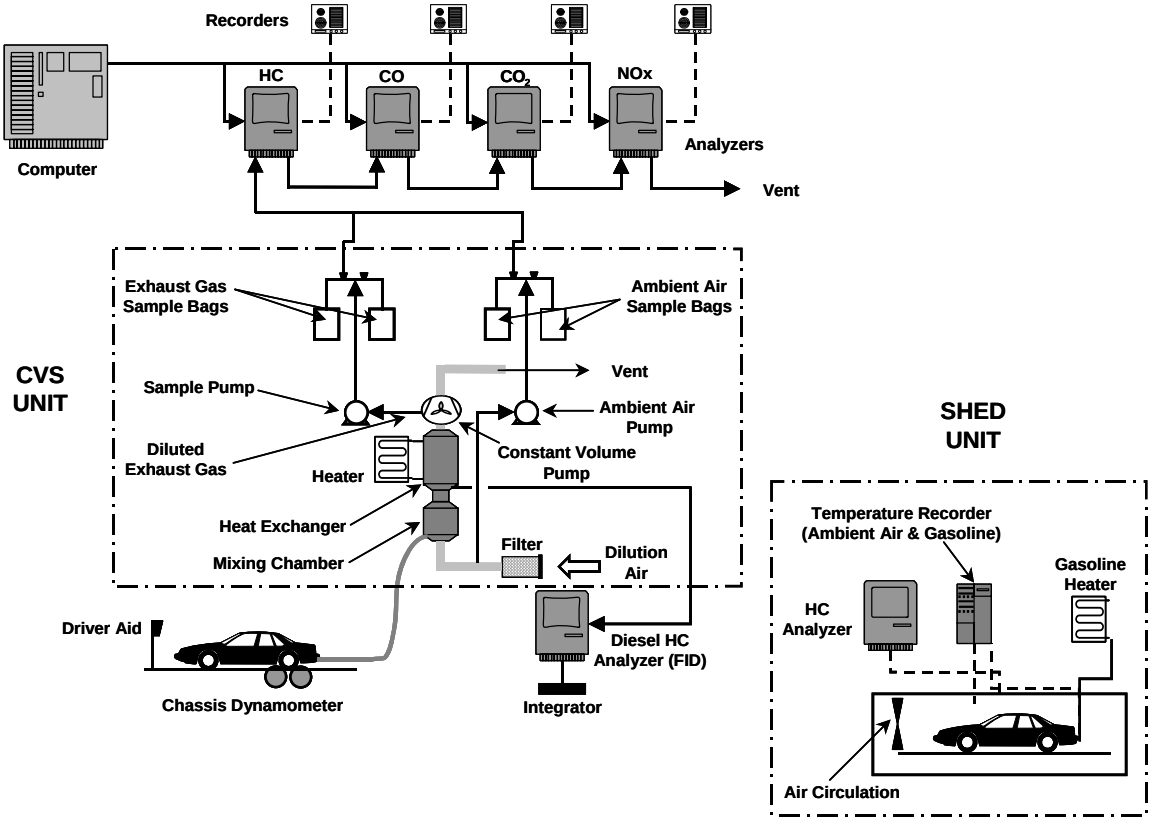
A summary of the former EU and EPA test procedures is given in **Table B.1.36**. The major differences between these tests are summarized below (see also **Table B.1.36**).

- ***Preconditioning:*** The EU procedure used a complex purge/load technique. The former US test did not precondition the canister apart from driving one LA-4 cycle. However, the new procedure will load the canister to breakthrough before driving the cold start test.
- ***Diurnal test:*** The former EU and US procedures are similar. The new EPA procedure has three diurnal cycles over a higher temperature range.
- ***Running losses:*** These are not measured in the EU test. They may be measured over the current EPA cycle, but in practice this is not usually carried out.
- ***Hot soak:*** There is a small difference in temperature ranges between the former EU and EPA methods, but this is not significant in view of the high fuel temperature after the diurnal test.

Table B.1.36 Comparison of former EU and EPA Evaporative Emission Test Procedures

PREPARATION AND TESTING	EU PROCEDURE	FORMER US EPA PROCEDURE
CANISTER CONDITION	Unspecified	Unspecified
PRECONDITIONING	60 km/h for 30 min or equivalent air purge of canister. 2x diurnal heat build at 16-30°C. Drive ECE 15 + 2 EUDC cycles	1 x LA4 drive cycle
SOAK PARKING	10-36 h at 20-30 °C	11-35 h at 20-30 °C
FUEL DRAIN AND FILL	40 ±2% of tank capacity, at 10-14°C	40 ±2% of tank capacity
DIURNAL TEST	16-30°C (±1°C) over 60 ±2 min HC measured in SHED	15-29 °C in 1 h HC measured in SHED
DYNAMOMETER TEST	ECE 15 + EUDC driving cycles. Running losses not measured Exhaust emissions measurements optional	1.5 x LA4 drive cycles. Cold and hot exhaust tests. Running losses measured, with carbon traps if necessary.
HOT SOAK	One hour at 23-31°C in SHED	One hour at 20-30°C in SHED
FUEL DRAIN AND FILL	N/A	Ability to control Diurnal losses after soak not tested
END	Calculation of Total Emissions = Diurnal + Hot Soak	Calculation of Total Evaporative Emissions = Diurnal + Running Losses + Hot Soak

Figure B.1.4 Exhaust Gas Constant Volume Sampling (CVS) and SHED Procedures



B.1.4. REFERENCE FUELS

B.1.4.1. Introduction

Type approval and conformity of production testing is, of necessity, conducted under carefully controlled conditions which are specified in the relevant emissions legislation. This control naturally extends to the fuels used in such testing, and these are generally described as “reference fuels”, “certification fuels” or “homologation fuels”.

Reference fuels should be specified with much tighter limits than those pertaining in the market. This is essential as variations in fuel characteristics can create variations in emissions performance which might result in an incorrect pass (or fail) of the test. The actual level specified has been much debated and reference fuel characteristics are typically set to represent a “market average” – this principle has been adopted in Europe.

Vehicles or engines in service are likely to encounter fuels of differing characteristics, albeit still within market specification, and this can result in variation in emissions performance. For example, a diesel engine certified on a reference fuel of 835 kg/m^3 density may subsequently be run on a market fuel with a density of 855 kg/m^3, which could lead to an increase in emissions. It has been suggested that it would therefore be prudent to set reference fuel specifications closer to the “worse case” market fuel to avoid this type of anomaly. It has equally been argued that market specifications be tightened to overcome such difficulties but this is unlikely to provide a cost-effective solution. On balance, setting reference fuel specifications based on average market qualities should ensure that overall emissions control targets are realised across the market.

B.1.4.2. Reference Gasolines

Table B.1.37 CEC Legislative Fuel RF-08-A-85*
Specification Type: Premium Gasoline, Unleaded (1) (Superseded)

Property	Units (4)	Limits		Method
		Min	Max	
Research Octane Number		95		ISO 5164
Motor Octane Number		85		ISO 5163
Density 15°C	kg/m^3	748	762	ISO 3675
Reid Vapour Pressure	bar	0.56	0.64	ISO 3007
Distillation (2)				ISO 3405
IBP	°C	24	40	
10% v/v Point	°C	42	58	
50% v/v Point	°C	90	110	
90% v/v Point	°C	155	180	
FBP	°C	190	215	
Residue	% v/v		2	
Hydrocarbon Analysis	% v/v			ISO 3837
Olefins			20	
Aromatics			45	
Saturates		Balance		
Benzene	% v/v		5	ASTM D3606
Carbon/Hydrogen Ratio		Report		
Oxidation Stability (3)				
Induction Period	mins	480		ISO 7536
Existent gum	mg/100 ml		4	ISO 6246
Copper Corrosion at 50°C			1	ISO 2160
Lead Content	g/l		0.005	ASTM D3237
Sulphur Content	% m/m		0.04	ISO 4260/ISO 8754/ ASTM D2622
Phosphorus Content	g/l		0.0013	ASTM D3231
Oxygenates	PROHIBITED			

* EU Directive 91/441/EEC

(1) The blending of this fuel should only involve use of conventional European refinery components.

(2) The figures quoted show the total evaporated quantities (% volume recovered + % volume loss).

(3) The fuel may contain oxidation inhibitors and metal de-activators normally used to stabilise refinery gasoline streams, but detergent/ dispersing additives and solvent oils must not be added.

(4) The values quoted in the specification are “true values”.

- In establishment of their limit values the terms of ASTM D3244 “Defining a Basis for Petroleum Product Quality Disputes” have been applied and in fixing a maximum value, a minimum difference of 2R above zero has been taken into account; in fixing a maximum and minimum value, the minimum difference is 4R (R= Reproducibility).
- Notwithstanding this measure, which is necessary for statistical reasons, the manufacturer of a fuel should nevertheless aim at a zero value where the stipulated maximum value is 2R and at the mean value in the case of quotations of maximum and minimum limits.
- Should it be necessary to clarify the question as to whether a fuel meets the requirements of the specification, the terms of ASTM D3244 should be applied.
- ***Superseded, with effect from 1 January 2000, by the reference fuels specified in EU Directive 98/69/EC (see overleaf).***

Table B.1.38 EU Directive 98/69/EC Technical Data of the Reference Fuel for Testing Vehicles with Positive Ignition Engines; Specification Type: Unleaded Petrol (Superseded)

Property	Units	Limits (1)		Test	
		Min	Max	Method	Date
Research Octane Number		95.0	-	EN 25164	1993
Motor Octane Number		85.0	-	EN 25163	1993
Density at 15°C	kg/m^3	748	762	ISO 3675	1995
Reid Vapour Pressure	kPa	56.0	60.0	EN 12	1993
Distillation:				EN-ISO 3405	1998
IBP	°C	24	40		
Evaporated @ 100°C	% v/v	49.0	57.0		
Evaporated @ 150°C	% v/v	81.0	87.0		
FBP	°C	190	215		
Residue	% v/v	-	2		
Hydrocarbon Analysis:	.			-	
Olefins	% v/v	-	10	ASTM D 1319	1995
Aromatics (2)	% v/v	28.0	40.0	ASTM D 1319	1995
Benzene	% v/v	-	1.0	pr. EN 12177	1998
Saturates	% v/v	-	Balance	ASTM D 1319	1995
Carbon/Hydrogen Ratio		Report	Report		
Oxidation Stability (3)	mins	480	-	EN-ISO 7536	1996
Oxygen Content (4)	% m/m	-	2.3	EN 1601	1997
Existent gum	mg/ml	-	0.04	EN-ISO 6246	1997
Sulphur Content (5)	mg/kg	-	100	pr. EN-ISO/DIS 14596	1998
Copper Corrosion @ 50°C		-	1	EN-ISO 2160	1995
Lead Content	g/l	-	0.005	EN 237	1996
Phosphorus Content	g/l	-	0.0013	ASTM D3231	1994

(1) The values quoted in the specification are "true values". In establishment of their limit values the terms of ISO 4259, "Petroleum products – Determination and application of precision data in relation to methods of test" have been applied and in fixing a minimum value, a difference of 2R above zero has been taken into account; in fixing a maximum and minimum value, the minimum difference is 4R (where R = reproducibility). Notwithstanding this measure, which is necessary for statistical reasons, the fuel manufacturer should nevertheless aim at a zero value where the stipulated maximum value is 2R and the mean value in the case of quotations of maximum and minimum limits. Should it be necessary to clarify the question as to whether a fuel meets the requirements of the specifications, the terms of ISO 4259 should be applied.

(2) The reference fuel used to approve a vehicle against the limit values set out in Row B of the Directive shall have a max. aromatics content of 35% v/v. The EU Commission will, by 31/12/99, forward a modification to this specification reflecting the market average aromatics content.

(3) The fuel may contain oxidation inhibitors and metal deactivators normally used to stabilise refinery gasoline streams, but detergent/dispersant additives and solvent oils must not be used.

(4) The actual oxygen content of the fuel for the Type I and IV tests shall be reported. In addition, the maximum oxygen content of the reference fuel used to approve a vehicle against the limit values set out in Row B of the Directive shall have a max. oxygen content of 2.3% m/m. The EU Commission will, by 31/12/99, forward a modification to this specification reflecting the market average oxygen content.

(5) The actual sulphur content of the fuel used for the Type I test shall be reported. In addition, the maximum sulphur content of the reference fuel used to approve a vehicle against the limit values set out in Row B of the Directive shall have a max. sulphur content of 50ppm. The EU Commission will, by 31/12/99, forward a modification to this specification reflecting the market average sulphur content.

- For the low ambient temperature Type VI test, manufacturers may opt for a higher RVP fuel. This gasoline must have an identical specification to the above grade with the exception that a maximum RVP of 95.0 kPa is allowed.
- ***Superseded by the reference fuels specified in EU Directive 2002/80/EC (see overleaf).***

Table B.1.39 Reference Gasoline, Directive 2002/80/EC - Type I Emissions Certification Test (Euro 3 Limits)

Property	Units	Limits (1)		Test Method
		Min	Max	
Research octane number		95.0	-	EN 25164
Motor octane number		85.0	-	EN 25163
Density 15°C	kg/m^3	748	762	ISO 3675
Vapour pressure	kPa	56.0	60.0	EN 12
Distillation:				
Initial boiling point	°C	24.0	40.0	
Evaporated @ 100°C	% v/v	49.0	57.0	EN-ISO 3405
Evaporated @ 150°C	% v/v	81.0	87.0	
FBP	°C	190	215	
Residue	% v/v.	-	2	
Hydrocarbon analysis:				
Olefins	% v/v	-	10	ASTM D 1319
Aromatics	% v/v	28.0	40.0	ASTM D 1319
Benzene	% v/v	-	1.0	pr. EN 12177
Saturates	% v/v	-	balance	ASTM D 1319
Carbon/Hydrogen ratio		report	report	
Induction period (2)	minutes	480	-	EN-ISO 7536
Oxygen content	% m/m	-	2.3	EN 1601
Existent gum	mg/ml	-	0.04	EN-ISO 6246
Sulphur content (3)	mg/kg	-	100	pr. EN-ISO/DIS 14596
Copper corrosion @ 50°C		-	Class 1	EN-ISO 2160
Lead content	mg/l	-	5	EN 237
Phosphorus content	mg/l	-	1.3	ASTM D3231

(1) The values quoted in the specification are “true values”. In establishment of their limit values the terms of ISO 4259, “Petroleum products - Determination and application of precision data in relation to methods of test” have been applied and in fixing a minimum value, a difference of 2R above zero has been taken into account; in fixing a maximum and minimum value, the minimum difference is 4R (where R = reproducibility). Notwithstanding this measure, which is necessary for statistical reasons, the fuel manufacturer should nevertheless aim at a zero value where the stipulated maximum value is 2R and the mean value in the case of quotations of maximum and minimum limits. Should it be necessary to clarify the question as to whether a fuel meets the requirements of the specifications, the terms of ISO 4259 should be applied.

(2) The fuel may contain oxidation inhibitors and metal deactivators normally used to stabilise refinery gasoline streams, but detergent/dispersant additives and solvent oils must not be used.

(3) The actual sulphur content of the fuel used for the Type I test shall be reported.

Table B.1.40 Reference Gasoline, Directive 2002/80/EC - Type VI Low Temperature Emissions Certification Test

Property	Units	Limits (1)		Test Method
		Min	Max	
Research octane number		95.0	-	EN 25164
Motor octane number		85.0	-	EN 25163
Density 15°C	kg/m^3	740	754	ISO 3675
Vapour pressure	kPa	56.0	95.0	prEN ISO 13016-1 (DVPE)
Distillation:				
Evaporated @ 70ºC	% v/v	24.0	40.0	EN-ISO 3405
Evaporated @ 100°C	% v/v	50.0	58.0	
Evaporated @ 150°C	% v/v	83.0	89.0	
FBP	°C	190	210	
Residue	% v/v.	-	2	
Hydrocarbon analysis:				
Olefins	% v/v	-	10	ASTM D 1319
Aromatics	% v/v	29.0	35.0	ASTM D 1319
Benzene	% v/v	-	1.0	pr. EN 12177
Saturates	% v/v	report	report	ASTM D 1319
Carbon/Hydrogen ratio		report	report	
Induction period (2)	minutes	480	-	EN-ISO 7536
Oxygen content	% m/m	-	1.0	EN 1601
Existent gum	mg/ml	-	0.04	EN-ISO 6246
Sulphur content (3)	mg/kg	-	10	pr. EN-ISO/DIS 14596
Copper corrosion @ 50°C		-	Class 1	EN-ISO 2160
Lead content	mg/l	-	5	EN 237
Phosphorus content	mg/l	-	1.3	ASTM D3231

(1) The values quoted in the specification are “true values”. In establishment of their limit values the terms of ISO 4259, “Petroleum products - Determination and application of precision data in relation to methods of test” have been applied and in fixing a minimum value, a difference of 2R above zero has been taken into account; in fixing a maximum and minimum value, the minimum difference is 4R (where R = reproducibility). Notwithstanding this measure, which is necessary for statistical reasons, the fuel manufacturer should nevertheless aim at a zero value where the stipulated maximum value is 2R and the mean value in the case of quotations of maximum and minimum limits. Should it be necessary to clarify the question as to whether a fuel meets the requirements of the specifications, the terms of ISO 4259 should be applied.

(2) The fuel may contain oxidation inhibitors and metal deactivators normally used to stabilise refinery gasoline streams, but detergent/dispersant additives and solvent oils must not be used.

(3) The actual sulphur content of the fuel used for the Type VI test shall be reported.

B.1.4.3. Reference Diesel Fuels for Light Duty Engines

Table B.1.41 CEC Legislative Fuel RF-03-A-84* Specification Type: Diesel Fuel [4] (Superseded)

Property	Units [2]	Limits		Test Method
		Min.	Max.	
Cetane Number [3]		49	53	ISO 5165
Density at 15°C	kg/m^3	835	845	ISO 3675
Distillation [1]				ISO 3405
50% v/v Point	°C	245		
90% v/v Point	°C	320	340	
FBP	°C		370	
Flash Point	°C	55		ISO 2719
Cold Filter Plugging Point, °C			-5	EN 116
Viscosity at 40°C	mm^2/s	2.5	3.5	ISO 3104
Sulphur Content**	% m/m	To be reported	0.3	ISO 4260/ISO 8754 ASTM D2622
Copper Corrosion			1	ISO 2160
Conradson Carbon Residue on 10% Dist. Residue	% m/m		0.2	ISO 6615
Ash Content	% m/m		0.01	ISO 6245
Water Content	% m/m		0.05	ASTM D1744
Neutralisation (Strong Acid) Number	mg KOH/g		0.20	ASTM D974
Oxidation Stability [5]	mg/100ml		2.5	ISO 12205
Additives [4]				

* EU Directive 91/441/EEC

**According to EU Directive 93/12/EEC the sulphur level was changed to
- max. 0.2% m/m from October 1994; - max 0.05% m/m from October 1996.

(1) The figures quoted show the total evaporated quantities (% volume recovered + % volume loss).

(2) The values quoted in the specification are “true values”.

- In establishment of their limit values the terms of ASTM D3244 “Defining a Basis for Petroleum Product Quality Disputes” have been applied and in fixing a maximum value, a minimum difference of 2R above zero has been taken into account; in fixing a maximum and minimum value, the minimum difference is 4R (R = Reproducibility).
- Notwithstanding this measure, which is necessary for statistical reasons, the manufacturer of a fuel should nevertheless aim at a zero value where the stipulated maximum value is 2R and at the mean value in the case of quotations of maximum and minimum limits.
- Should it be necessary to clarify the question as to whether a fuel meets the requirements of the specification, the terms of ASTM D 3244 should be applied.

(3) The range for cetane is not in accordance with the requirement of a minimum range of 4R. However, in cases of dispute between fuel supplier and user, the terms in ASTM D3244 can be used to resolve such disputes provided replicate measurements, of sufficient number to achieve the necessary precision, are made in preference to single determinations.

(4) This fuel should be based on straight run and cracked hydrocarbon distillate components only; desulphurization is allowed. It must not contain any metallic additives or cetane improver additives.

(5) Even though oxidation stability is controlled it is likely that shelf life will be limited. Advice should be sought from the supplier as to storage conditions and life.

(6) If it is required to calculate the Thermal Efficiency of an engine or vehicle, the Calorific value of the fuel can be calculated from:
Specific energy (calorific value) (net) MJ/kg = (46.423 - 8.792d² + 3.170d) (l -(x + y + s)) + 9.420s - 2.499x; where:
d is the density at 15°C kg/l; x is the proportion by mass of water (% divided by 100); y is the proportion by mass of ash (% divided by 100) and s is the proportion by mass of sulphur (% divided by 100).

(7) Aromatic content should be measured and reported with the method of measurement stated.

- ***Used for both light and heavy duty vehicles but superseded, with effect from 1 January 2000, by the reference fuel specified in EU Directive 98/69/EC (see overleaf).***

Table B.1.42 EU Directive 98/69/EC Technical Data of the Reference Fuel for Testing Vehicles with Compression Ignition Engines; Specification Type: Diesel Fuel (Superseded)

Property	Units	Limits (1)		Test	
		Min.	Max.	Method	Date
Cetane Number (2)		52.0	54.0	EN-ISO 5165	1998
Density at 15°C	kg/m^3	833	837	EN-ISO 3675	1995
Distillation				EN-ISO 3405	1988
50% v/v Point	°C	245	-		
95% v/v Point	°C	345	350		
FBP	°C		370		
Flash Point	°C	55	-	EN 22719	1993
CFPP	°C	-	-5	EN 116	1981
Viscosity at 40°C	mm^2/s	2.5	3.5	EN-ISO 3104	1996
Polycyclic Aromatic Hydrocarbons	% m/m	3.0	6.0	IP 391	1995
Sulphur Content (3)	mg/kg	-	300	pr. EN-ISO/DIS 14596	1998
Copper Corrosion		-	1	EN-ISO 2160	1995
Conradson Carbon Residue on 10% Dist. Residue	% m/m	-	0.2	EN-ISO 10370	1995
Ash Content	% m/m	-	0.01	EN-ISO 6245	1995
Water Content	% m/m	-	0.05	EN-ISO 12937	1998
Neutralisation (Strong Acid) Number	mg KOH/g	-	0.20	ASTM D974-95	1998
Oxidation Stability (4)	mg/ml	-	0.025	EN-ISO 12205	1996

(1) The values quoted in the specification are “true values”. In establishment of their limit values the terms of ISO 4259, “Petroleum products – Determination and application of precision data in relation to methods of test” have been applied and in fixing a minimum value, a difference of 2R above zero has been taken into account; in fixing a maximum and minimum value, the minimum difference is 4R (where R = reproducibility). Notwithstanding this measure, which is necessary for statistical reasons, the fuel manufacturer should nevertheless aim at a zero value where the stipulated maximum value is 2R and the mean value in the case of quotations of maximum and minimum limits. Should it be necessary to clarify the question as to whether a fuel meets the requirements of the specifications, the terms of ISO 4259 should be applied.

(2) The range for cetane number is not in accordance with the 4R requirement. However, in the case of a dispute with a fuel supplier, the terms of ISO 4259 may be used - provided replicate measurements of sufficient number to archive the necessary precision are made in preference to a single determination.

(3) The actual sulphur content of the fuel used for the Type I test shall be reported. In addition, the maximum sulphur content of the reference fuel used to approve a vehicle against the limit values set out in Row B of the Directive shall have a max. sulphur content of 50ppm. The EU Commission will, by 31/12/99, forward a modification to this specification reflecting the market average sulphur content.

(4) Even though the oxidation stability is controlled, it is likely that shelf life will be limited. Advice should be sought from the supplier as to storage conditions and life.

- ***Used for both light and heavy duty vehicles but superseded by the reference fuel specified in EU Directive 2002/80/EC).***

Table B.1.43 Reference Diesel Fuel, Directive 2002/80/EC - Type I Emissions Certification Test (Euro 3 Limits)

Property	Units	Limits (1)		Test Method
		Min.	Max.	
Cetane number (2)		52.0	54.0	EN-ISO 5165
Density at 15°C	kg/m^3	833	837	EN-ISO 3675
Distillation				EN-ISO 3405
50% v/v point	°C	245	-	
95% v/v point	°C	345	350	
FBP	°C		370	
Flash point	°C	55	-	EN 22719
CFPP	°C	-	-5	EN 116
Viscosity at 40°C	mm^2/s	2.5	3.5	EN-ISO 3104
Polycyclic aromatic hydrocarbons	% m/m	3.0	6.0	IP 391
Sulphur content (3)	mg/kg	-	300	pr. EN-ISO/DIS 14596
Copper corrosion		-	Class 1	EN-ISO 2160
Conradson carbon residue on 10% Dist. Residue	% m/m	-	0.2	EN-ISO 10370
Ash content	% m/m	-	0.01	EN-ISO 6245
Water content	% m/m	-	0.02	EN-ISO 12937
Neutralisation (strong acid) number	mg KOH/g	-	0.02	ASTM D974
Oxidation stability (4)	mg/ml	-	0.025	EN-ISO 12205
New and better method for polycyclic aromatics under development	% m/m			EN 12916

(1) The values quoted in the specification are “true values”. In establishment of their limit values the terms of ISO 4259, “Petroleum products - Determination and application of precision data in relation to methods of test” have been applied and in fixing a minimum value, a difference of 2R above zero has been taken into account; in fixing a maximum and minimum value, the minimum difference is 4R (where R = reproducibility). Notwithstanding this measure, which is necessary for statistical reasons, the fuel manufacturer should nevertheless aim at a zero value where the stipulated maximum value is 2R and the mean value in the case of quotations of maximum and minimum limits. Should it be necessary to clarify the question as to whether a fuel meets the requirements of the specifications, the terms of ISO 4259 should be applied.

(2) The range for cetane number is not in accordance with the 4R requirement. However, in the case of a dispute with a fuel supplier, the terms of ISO 4259 may be used - provided replicate measurements of sufficient number to archive the necessary precision are made in preference to a single determination.

(3) The actual sulphur content of the fuel used for the Type I test shall be reported.

(4) Even though the oxidation stability is controlled, it is likely that shelf life will be limited. Advice should be sought from the supplier as to storage conditions and life.

B.1.4.4. Reference Gaseous Fuels for Light Duty Vehicles

Table B.1.44 Reference LPG, Directive 2002/80/EC - Type I Emissions Certification Test (Euro 3 and Euro 4 Limits)

Property	Unit	Fuel A	Fuel B	Test Method
Composition				
C_3 content		30 ± 2	85 ± 2	
C_4 content	% v/v	balance	balance	ISO 7941
< C_3, > C_4		2 (max)	2 (max)	
Olefin content		12 (max)	15 (max)	
Evaporation residue	mg/kg	50 (max)	50 (max)	ISO 13757
Water at 0°C		free	free	Visual inspection
Total sulphur content	mg/kg	50 (max)	50 (max)	EN 24260
Hydrogen sulphide	-	none	none	ISO 8819
Copper strip corrosion	rating	class 1	class 1	ISO 6251 (1)
Odour		characteristic		
Motor octane number		89 (min)	89 (min)	EN 589 Annex B

(1) This method may not accurately determine the presence of corrosive materials if the sample contains corrosion inhibitors or other chemicals which diminish the corrosivity of the sample to the copper strip. Therefore, the addition of such compounds for the sole purpose of biasing the test method is prohibited.

Table B.1.45 Reference Natural Gas, Directive 2002/80/EC - Type I Emissions Certification Test (Euro 3 and Euro 4 Limits)

Property	Unit	Basis	Limits		Test Method
			Min.	Max.	
Reference Fuel G_{20}					
Composition					
Methane	% mole	100	99	100	ISO 6794
Balance (1)		-	-	1	
N_2					
Sulphur content	mg/m^3 (2)	-	-	10	ISO 6326-5
Wobbe index (net)	MJ/m^3 (3)	48.2	47.2	49.2	
Reference Fuel G_{20}					
Composition					
Methane	% mole	86	84	88	ISO 6794
Balance (1)		-	-	1	
N_2		14	12	16	
Sulphur content	mg/m^3 (2)	-	-	10	ISO 6326-5
Wobbe index (net)	MJ/m^3 (3)	39.4	38.2	40.6	

(1) Inerts (different from N_2) + C_2 + C_{2+}.

(2) Value to be determined at 293.2 K (20ºC) and 101.3 kPa.

(3) Value to be determined at 273.2 K (0ºC) and 101.3 kPa.

B.1.4.5. Reference Diesel Fuels for Heavy Duty On-Road & Off-Road Engines

Table B.1.46 Heavy Duty Reference Diesel Fuel - Directive 1999/96/EC

Property (1)	Units	Limits (2)		Test	
		Min.	Max.	Method	Date
Cetane number (3)		52	54	EN-ISO 5165	1998
Density at 15°C	kg/m^3	833	837	EN-ISO 3675	1995
Distillation				EN-ISO 3405	1988
50% v/v point	°C	245	-		
95% v/v point	°C	345	350		
FBP	°C		370		
Flash point	°C	55	-	EN 22719	1993
CFPP	°C	-	-5	EN 116	1981
Viscosity at 40°C	mm^2/s	2.5	3.5	EN-ISO 3104	1996
Polycyclic aromatic hydrocarbons	% m/m	3.0	6.0	IP 391 (*)	1995
Sulphur content (4)	mg/kg	-	300	pr. EN-ISO/ DIS 14596	1998
Copper corrosion		-	1	EN-ISO 2160	1995
Conradson carbon residue on 10% Dist. Residue	% m/m	-	0.2	EN-ISO 10370	1995
Ash content	% m/m	-	0.01	EN-ISO 6245	1995
Water content	% m/m	-	0.05	EN-ISO 12937	1998
Neutralisation (strong acid) number	mg KOH/g	-	0.02	ASTM D974-95	1998
Oxidation stability (5)	mg/ml	-	0.025	EN-ISO 12205	1996
(*) New and better method for polycyclic aromatics under development	% m/m	-	-	EN 12916	

(1) If it is required to calculate the thermal efficiency of an engine or vehicle, the calorific value of the fuel can be calculated from:
Specific energy (calorific value) (net) in MJ/kg =
$(46.423 - 8.792d^2 + 3.170d)(1 - (x + y + s)) + 9.420s - 2.499x$
where,
d = the density @ 15ºC
x = the proportion by mass by water (% divided by 100)
y = the proportion by mass of ash (% divided by 100)
s = the proportion by mass of sulphur (% divided by 100)

(2) The values quoted in the specification are “true values”. In establishment of their limit values the terms of ISO 4259, “Petroleum products - Determination and application of precision data in relation to methods of test” have been applied and in fixing a minimum value, a difference of 2R above zero has been taken into account; in fixing a maximum and minimum value, the minimum difference is 4R (where R = reproducibility). Notwithstanding this measure, which is necessary for statistical reasons, the fuel manufacturer should nevertheless aim at a zero value where the stipulated maximum value is 2R and the mean value in the case of quotations of maximum and minimum limits. Should it be necessary to clarify the question as to whether a fuel meets the requirements of the specifications, the terms of ISO 4259 should be applied.

(3) The range for cetane number is not in accordance with the 4R requirement. However, in the case of a dispute with a fuel supplier, the terms of ISO 4259 may be used - provided replicate measurements of sufficient number to archive the necessary precision are made in preference to a single determination.

(4) The actual sulphur content of the fuel used for the test shall be reported. In addition, the sulphur content of the reference fuel used to approve a vehicle against the limit values set out in Row B of the Directive shall have a max. sulphur content of 50mg/kg. The EU Commission will, by 31/12/99, forward a modification to this specification reflecting the market average sulphur content.

(5) Even though the oxidation stability is controlled, it is likely that shelf life will be limited. Advice should be sought from the supplier as to storage conditions and life.

Table B.1.47 EU Reference Diesel Fuel for Non-Road Mobile Machinery [1]

Property		Limits and Units [2]	Test Method
Cetane Number [4]	min	45 [7]	ISO 5165
	max	50	
Density @ 15°C	min	835 kg/m^3	ISO 3675, ASTM D 4052
	max	845 kg/m^3	
Distillation – 95% point [3]	max	370°C	ISO 3405
Viscosity @ 40°C	min	2.5 mm^2/s	ISO 3104
	max	3.5 mm^2/s	
Sulphur content	min	0.10% m/m	ISO 8754, EN 24260
	max	0.20% m/m	
Flash point	min	55°C	IO 2719
CFPP	min	-	EN 116
	max	+5°C	
Copper corrosion	max	1	ISO 2160
Conradson carbon residue (10% DR)	max	0.3% m/m	ISO 10370
Ash content	max	0.01% m/m	ASTM D 482 [12]
Water content	max	0.05% m/m	ASTM D 95, D 1744
Neutralisation (strong acid) number	min	0.20mg KOH/g	
Oxidation stability [5]	max	2.5mg/100ml	ASTM D 2274
Additives [4]			

(1) If it is required to calculate thermal efficiency of an engine or vehicle, the calorific value of the fuel can be calculated from:
Specific energy [calorific value] (net) MJ/kg =
$(46.423 – 8.792 \times d^2 + 3.17 \times d) \times (1 – [x + y + s]) + 9.42 \times s – 2.499 \times x$
where:
d = density @ 15C
x = proportion by mass of water (%/100)
y = proportion by mass of ash (%/100)
s = proportion by mass of sulphur (%/100).

(2) The values quoted in the specification are “true values”. In establishment of their limit values the terms of ASTM D 3244, “Defining a basis for petroleum produce quality disputes” have been applied and in fixing a minimum value, a difference of 2R above zero has been taken into account; in fixing a maximum and minimum value, the minimum difference is 4R (where R = reproducibility). Notwithstanding this measure, which is necessary for statistical reasons, the fuel manufacturer should nevertheless aim at a zero value where the stipulated maximum value is 2R and the mean value in the case of quotations of maximum and minimum limits. Should it be necessary to clarify the question as to whether a fuel meets the requirements of the specifications, the terms of ASTM D 3244 should be applied.

(3) The figure quoted shows the evaporated quantities (percentage recovered + percentage loss).

(4) The range of cetane is not in accordance with the requirement of a minimum range of 4R. However, in cases of dispute between fuel supplier and fuel user, the terms of ASTM D 3244 can be used to resolve such disputes provided replicate measurements, of sufficient number to achieve the necessary precision, are made in preference to single determinations.

(5) Even though oxidation stability is controlled, it is likely that shelf life will be limited. Advice should be sought from the supplier as to storage conditions and life.

(6) This fuel should be based on straight run and cracked hydrocarbon distillate components only; desulphurisation is allowed. It must not contain any metallic additives or cetane improver additives.

(7) Lower values are permitted, in which case the cetane number of the reference fuel is to be reported.

(8) Higher values are permitted, in which case the sulphur content of the reference fuel is to be reported.

(9) To be kept under constant review in the light of trends in the markets. For the purpose of the initial approval of an engine with no exhaust gas after-treatment on request of the applicant a 0.05% m/m sulphur minimum is permissible. In this case the measured particulate level must be corrected upward to the average value that is nominally specified for fuel sulphur content (0.15% m/m) as per the equation below:

PT_{adj} = PT + [SFC × 0.0917 × (NSLF – FSF)]

where:

PT_{adj} = adjusted PT value (g/kWh)
PT = measured weighted specific emission value for particulate emission (g/kWh)
SFC = weighted specific fuel consumption (g/kWh), calculated according to the formula below
NSLF = average of the nominal specification of sulphur content mass fraction (i.e. 0.15%/100)
FSF = fuel sulphur content mass fraction (%/100)

Equation for the calculation of the weighted specific fuel consumption:

$$SFC = \frac{\sum_{i=1}^{n} G_{Fueli} \times WF_i}{\sum_{i=1}^{n} P_i \times WF_i}$$

where:

$P_I = P_{mi} + P_{Aei}$

For the purpose of conformity of production assessments in accordance with the Directive, the requirements must be met using reference fuel with a sulphur content which complies with the minimum/maximum level of 0.10/0.20% m/m.

(10) Higher values are permitted up to 855 kg/m^3, in which case the density of the reference fuel used is to be reported. For the purpose of conformity of production assessments in accordance with the Directive, the requirements must be met using reference fuel with a density which complies with the minimum/maximum level of 835/845 kg/m^3.

(11) All fuel characteristics and limit values are to be kept under review in light of trends in the markets.

(12) To be replaced by EN/ISO 6245 with effect from the date of implementation.

Table B.1.48 Non-Road Mobile Machinery Reference Diesel Fuel - Stages I and II Type Approval

Property (1)		Limits and Units (2)	Test Method
Cetane number (4)	min	45 (7)	ISO 5165
	max	50	
Density @ 15°C	min	835 kg/m^3	ISO 3675, ASTM D 4052
	max	845 kg/m^3 (10)	
Distillation - 95% point (3)	max	370°C	ISO 3405
Viscosity @ 40°C	min	2.5 mm^2/s	ISO 3104
	max	3.5 mm^2/s	
Sulphur content	min	0.10% m/m (9)	ISO 8754, EN 24260
	max	0.20% m/m (8)	
Flash point	min	55°C	IO 2719
CFPP	min	-	EN 116
	max	+ 5°C	
Copper corrosion	max	1	ISO 2160
Conradson carbon residue (10% DR)	max	0.3% m/m	ISO 10370
Ash content	max	0.01% m/m	ASTM D 482 (12)
Water content	max	0.05% m/m	ASTM D 95, D 1744
Neutralisation (strong acid) number	min	0.20 mg KOH/g	
Oxidation stability (5)	max	2.5 mg/100 ml	ASTM D 2274
Additives (6)			

(1) If it is required to calculate thermal efficiency of an engine or vehicle, the calorific value of the fuel can be calculated from:
Specific energy [calorific value] (net) MJ/kg =
$(46.423 - 8.792 \times d^2 + 3.17 \times d) \times (1 - [x + y + s]) + 9.42 \times s - 2.499 \times x$
where:
d = density @ 15C
x = proportion by mass of water (%/100)
y = proportion by mass of ash (%/100)
s = proportion by mass of sulphur (%/100)

(2) The values quoted in the specification are “true values”. In establishment of their limit values the terms of ASTM D 3244, “Defining a basis for petroleum produce quality disputes” have been applied and in fixing a minimum value, a difference of 2R above zero has been taken into account; in fixing a maximum and minimum value, the minimum difference is 4R (where R = reproducibility). Notwithstanding this measure, which is necessary for statistical reasons, the fuel manufacturer should nevertheless aim at a zero value where the stipulated maximum value is 2R and the mean value in the case of quotations of maximum and minimum limits. Should it be necessary to clarify the question as to whether a fuel meets the requirements of the specifications, the terms of ASTM D 3244 should be applied.

(3) The figure quoted shows the evaporated quantities (percentage recovered + percentage loss).

(4) The range of cetane is not in accordance with the requirement of a minimum range of 4R. However, in cases of dispute between fuel supplier and fuel user, the terms of ASTM D 3244 can be used to resolve such disputes provided replicate measurements, of sufficient number to achieve the necessary precision, are made in preference to single determinations.

(5) Even though oxidation stability is controlled, it is likely that shelf life will be limited. Advice should be sought from the supplier as to storage conditions and life.

(6) This fuel should be based on straight run and cracked hydrocarbon distillate components only; desulphurisation is allowed. It must not contain any metallic additives or cetane improver additives.

(7) Lower values are permitted, in which case the cetane number of the reference fuel is to be reported.

(8) Higher values are permitted, in which case the sulphur content of the reference fuel is to be reported.

(9) To be kept under constant review in the light of trends in the markets. For the purpose of the initial approval of an engine with no exhaust gas after-treatment on request of the applicant a 500 mg/kg sulphur minimum is permissible. In this case the measured particulate level must be corrected upward to the average value that is nominally specified for fuel sulphur content (1500 mg/kg) as per the equation below:

$PT_{adj} = PT + [SFC \times 0.0917 \times (NSLF - FSF)]$

where:
PT_{adj} = adjusted PT value (g/kWh)
PT = measured weighted specific emission value for particulate emission (g/kWh)
SFC = weighted specific fuel consumption (g/kWh), calculated according to the formula below
NSLF = average of the nominal specification of sulphur content mass fraction (i.e. 0.15%/100)
FSF = fuel sulphur content mass fraction (%/100)

Equation for the calculation of the weighted specific fuel consumption:

$$SFC = \frac{\sum_{i=1}^{n} G_{Fueli} \times WF_i}{\sum_{i=1}^{n} P_i \times WF_i}$$

where:

$P_I = P_{mi} + P_{Aei}$

For the purpose of conformity of production assessments in accordance with the Directive, the requirements must be met using reference fuel with a sulphur content which complies with the minimum/maximum level of 1000/2000 mg/kg.

(10) Higher values are permitted up to 855 kg/m^3, in which case the density of the reference fuel used is to be reported. For the purpose of conformity of production assessments in accordance with the Directive, the requirements must be met using reference fuel with a density which complies with the minimum/maximum level of 835/845 kg/m^3.

(11) All fuel characteristics and limit values are to be kept under review in light of trends in the markets.

(12) To be replaced by EN/ISO 6245 with effect from the date of implementation.

B.1.4.6. Heavy Duty Engine Reference Fuels: Gases and Ethanol (Directive 2001/27/EC)

The following reference natural gases, LPGs and ethanol for diesel engines were stipulated in EU Directive 2001/27/EC. The gaseous fuels are specified with varying compositions to reflect the European market**.**

Natural Gas

European market fuel are available in two ranges:

- The H range, whose two extreme reference fuels are G_R and G_{23}
- The L range, whose two extreme reference fuels are G_{23} and G_{25}

The characteristics of these fuels are summarised below:

Table B.1.49 Heavy Duty Engine Reference Natural Gases

Reference Fuel G_R					
Property	**Units**	**Basis**	**Limits**		**Test Method**
			Min	**Max**	
Composition:					
Methane		87.0	84.0	89.0	
Ethane	% mole	13.0	11.0	15.0	ISO 6794
Balance		-	-	1.0	
[Inerts + C_{2+}]					
Sulphur content	mg/m^3 (1)			10	ISO 6326-5
Reference Fuel G_{23}					
Property	**Units**	**Basis**	**Limits**		**Test Method**
			Min	**Max**	
Composition:					
Methane	% mole	92.5	91.5	93.5	ISO 6794
Balance		-	-	1.0	
N_2		7.5	6.5	8.5	
Sulphur content	mg/m^3 (1)			10	ISO 6326-5
Reference Fuel G_{25}					
Property	**Units**	**Basis**	**Limits**		**Test Method**
			Min	**Max**	
Composition:					
Methane	% mole	86.0	84.0	88.0	ISO 6794
Balance		-	-	1.0	
N_2		14.0	12.0	16.0	
Sulphur content	mg/m^3 (1)			10	ISO 6326-5

(1) Value to be determined at standard conditions (293,2 K (20°C) and 101,3 kPa).

Table B.1.50 Heavy Duty Engine Reference LPGs

Property	Unit	Limits Fuel A		Limits Fuel B		Test Method
		Minimum	Maximum	Minimum	Maximum	
Motor octane number		92.5 (1)		92.5		EN 589 Annex B
Composition						
C_3 content	% v/v	48	52	83	87	ISO 7941
C_4 content		48	52	13	17	
Olefin content		0	12	0	14	
Evaporation residue	mg/kg		50		50	NFM 41-015
Total sulphur content	mg/kg (1)		50		50	EN 24260
Hydrogen sulphide	-		None		None	ISO 8819
Copper strip corrosion	rating		Class 1		Class 1	ISO 6251 (2)
Water @ 0°C			Free		Free	Visual inspection

(1) Value to be determined at standard conditions 293,2 K (20°C) and 101,3 kPa.

(2) This method may not accurately determine the presence of corrosive materials if the sample contains corrosion inhibitors or other chemicals which diminish the corrosivity of the sample to the copper strip. Therefore, the addition of such compounds for the sole purpose of biasing the test method is prohibited.

Table B.1.51 Heavy Duty Engine Reference Ethanol (1)

Parameter	Units	Limit (2)		Test Method (3)
		Min	Max	
Alcohol, mass	% m/m	92.4	-	ASTM D 5501
Alcohol other than ethanol contained in total alcohol, mass	% m/m	-	2.0	ASTM D 5501
Density at 15°C	kg/m^3	795	815	ASTM D 4052
Ash content	% m/m	-	0.001	ISO 6245
Flash point	°C	10		ISO 2719
Acidity, calculated as acetic acid	% m/m	-	0.0025	ISO 1388-2
Neutralization (strong acid) number	KOH mg/l	-	1.0	
Colour	According to scale	-	10	ASTM D 1209
Dry residue at 100 °C	mg/kg		15	ISO 759
Water content	% m/m	-	6.5	ISO 760
Aldehydes calculated as acetic acid	% m/m	-	0.0025	ISO 1388-4
Sulphur content	mg/kg	-	10	ASTM D 5453
Esters, calculated as ethyl-acetate	% m/m	-	0.1	ASTM D 1617

(1) Cetane improver, as specified by the engine manufacturer, may be added to the ethanol fuel. The maximum allowed amount is 10% m/m.

(2) The values quoted in the specification are “true values”. In establishment of their limit values the terms of ISO 4259, Petroleum products - Determination and application of precision data in relation to methods of test, have been applied and in fixing a minimum value, a minimum difference of 2R above zero has been taken into account in fixing a maximum and minimum value, the minimum difference is 4R (R - reproducibility). Notwithstanding this measure, which is necessary for statistical reasons, the manufacturer of a fuel should nevertheless aim at a zero value where the stipulated maximum value is 2R and at the mean value in the case of quotations of maximum and minimum limits. Should it be necessary to clarify the question as to whether a fuel meets the requirements of the specification, the terms of ISO 4259 should be applied.

(3) Equivalent ISO methods will be adopted when issued for all properties listed above.

B.1.4.7. Gaseous Fuels – Outdated Reference Fuels and Current Heavy-Duty Type Approval

The following reference natural gases and LPGs were stipulated in EU Directive 1999/96/EC. They were specified with varying compositions to reflect the European market.

Natural Gas

European market fuels are available in two ranges:

- The H range, whose two extreme reference fuels are G20 and G 23
- The L range, whose two extreme reference fuels are G23 and G 25

The characteristics of these fuels are summarised below:

Table B.1.52 EU Directive 1999/96/EC Reference natural gases

Reference Fuel G20					
Property	**Units**	**Basis**	**Limits**		**Test Method**
			Min	**Max**	
Composition:					
Methane		100.0	99.0	100.0	
Balance	% mole	-	-	1.0	ISO 6794
[Inerts + C_2/C_2+]					
N_2					
Sulphur content	mg/m^3 (1)	-	-	50	ISO 6326-5
Reference Fuel G23					
Property	**Units**	**Basis**	**Limits**		**Test Method**
			Min	**Max**	
Composition:					
Methane		92.5	91.5	93.5	
Balance	% mole	-	-	1.0	ISO 6794
[Inerts + C_2/C_2+]					
N_2		7.5	6.5	8.5	
Sulphur content	mg/m^3 (1)			50	ISO 6326-5
Reference Fuel G25					
Property	**Units**	**Basis**	**Limits**		**Test Method**
			Min	**Max**	
Composition:					
Methane		86.0	84.0	88.0	
Balance	% mole	-	-	1.0	ISO 6794
[Inerts + C_2/C_2+]					
N_2		14.0	12.0	16.0	
Sulphur content	mg/m^3 (1)				ISO 6326-5

(1) Value to be determined at standard conditions (293.2 K (20°C) and 101.3 kPa).

Table B.1.53 EU Directive 1999/96/EC Reference Liquid Petroleum Gases

Property	Unit	Limits Fuel A		Limits Fuel B		Test Method
		Minimum	Maximum	Minimum	Maximum	
Motor Octane Number		93.5		93,5		EN 589 Annex B
Composition						
C_3 content	% v/v	48	52	83	87	
C_4 content		48	52	13	17	ISO 7941
Olefin content		0	12	9	15	
Evaporation residue	mg/kg		50		50	NFM 41-015
Total sulphur content	ppm m/m (1)		50		50	EN 24260
Hydrogen sulphide	-		None		None	ISO 8819
Copper strip corrosion	rating		Class 1		Class 1	ISO 6251 (2)
Water @ 0°C			Free		Free	Visual inspection

(1) Value to be determined at standard conditions 293,2 K (20 °C) and 101,3 kPa.

(2) This method may not accurately determine the presence of corrosive materials if the sample contains corrosion inhibitors or other chemicals which diminish the corrosivity of the sample to the copper strip. Therefore, the addition of such compounds for the sole purpose of biasing the test method is prohibited.

Heavy Duty Type Approval with Gaseous Reference Fuels (Directive 2001/27/EC)

In the case of natural gas the parent engine should demonstrate its capability to adapt to any fuel composition that may occur across the market. There are generally two types available, high calorific fuel (H-gas) and low calorific fuel (L-gas). However, there is a significant spread within both ranges and they differ significantly in their energy content expressed by the Wobbe Index and in their λ-shift factor (S_λ). Natural gases with a λ-shift factor between 0,89 and 1,08 ($0,89 < S_\lambda < 1,08$) are considered to belong to H-range, while natural gases with a λ-shift factor between 1,08 and 1,19 ($1,08 < S_\lambda < 1,19$) are considered to belong to L-range. The composition of the reference fuels reflects the extreme variations of S_λ. The parent engine shall meet the requirements of this Directive on the reference fuels G_R (fuel 1) and G_{25} (fuel 2), without any readjustment to the fuelling between the two tests. However, one adaptation run over one ETC cycle without measurement is permitted after the change of the fuel. Before testing, the parent engine shall be run-in using the procedure given in the Directive.

On the manufacturer's request the engine may be tested on a third fuel (fuel 3) if the λ-shift factor (S_λ) lies between 0,89 (i.e. the lower range of G_R) and 1,19 (i.e. the upper range of G_{25}), for example when fuel 3 is a market fuel. The results of this test may be used as a basis for the evaluation of conformity of production.

In the case of an engine fuelled with natural gas which is self-adaptive for both the range of H-gases and the range of L-gases, and which switches between the H-range and the L-range by means of a switch, the parent engine shall be tested on the two relevant reference fuels for each range, at each position of the switch. The fuels are G_R (fuel 1) and G_{23} (fuel 3) for the H-range of gases and G_{25} (fuel 2) and G_{23} (fuel 3) for the L-range of gases. The parent engine must meet the

requirements of this Directive at both positions of the switch without any readjustment to the fuelling between the two tests at each position of the switch. However, one adaptation run over one ETC cycle without measurement is permitted after the change of the fuel. Before testing the parent engine shall be run-in using the procedure given in the Directive.

At the manufacturer's request the engine may be tested on a third fuel instead of G_{23} (fuel 3) if the λ-shift factor (S_λ)lies between 0,89 (i.e. the lower range of G_R) and 1,19 (i.e. the upper range of G_{25}), for example when fuel 3 is a market fuel. The results of this test may be used as a basis for the evaluation of conformity of production. The ratio of emission results, "r" shall be determined for each pollutant as follows:

r = emission result on reference fuel 2/emission result on reference fuel 1

or, r_a = emission result on reference fuel 2/emission result on reference fuel 3

and, r_b = emission result on reference fuel 1/emission result on reference fuel 3

In the case of LPG the parent engine should demonstrate its capability to adapt to any fuel composition that may occur across the market because there are variations in C_3/C_4 composition. These variations are reflected in the reference fuels. The parent engine should meet the emission requirements on the reference fuels A and B without any readjustment to the fuelling between the two tests. However, one adaptation run over one ETC cycle without measurement is permitted after the change of the fuel. Before testing the parent engine shall be run-in using the procedure defined in the Directive.

The ratio of emission results, "r" shall be determined for each pollutant as follows:

r = emission result on reference fuel 2/emission result on reference fuel 1

Granting of a fuel range restricted EC type-approval

At the present state of technology it is not yet possible to make lean-burn natural gas engines self-adaptive. Yet these engines offer an advantage in efficiency and CO_2 emissions. If a user has the guarantee of a supply of fuel of uniform composition, he may opt for a lean-burn engine. Such an engine could be given a fuel restricted approval. In the interest of international harmonisation it is regarded desirable that a specimen of such an engine is granted international approval. Fuel restricted variants would then need to be identical except for the contents of the database of the ECU of the fuelling system, and such parts of the fuelling system (such as injector nozzles) that need to be adapted to the different fuel flow.

Fuel range restricted EC type-approval is granted subject to the following requirements:

The fuels are G_R (fuel 1) and G_{23} (fuel 3) for the H-range of gases and G_{25} (fuel 2) and G_{23} (fuel 3) for the L-range of gases.

The parent engine shall meet the requirements of this Directive without any readjustment to the fuelling between the two tests. However, one adaptation run over one ETC cycle without measurement is permitted after the change of the fuel.

Before testing the parent engine shall be run-in using the procedure defined in the Directive.

At the manufacturer's request the engine may be tested on a third fuel instead of G_{23} (fuel 3) if the λ-shift factor (S_λ) lies between 0,89 (i.e. the lower range of G_R) and 1,19 (i.e. the upper range of G_{25}), for example when fuel 3 is a market fuel. The results of this test may be used as a basis for the evaluation of conformity of production.

The ratio of emission results, "r" shall be determined for each pollutant as follows:

r = emission result on reference fuel 2/emission result on reference fuel 1

or, r_a = emission result on reference fuel 2/emission result on reference fuel 3

and, r_b = emission result on reference fuel 1/emission result on reference fuel 3

Upon delivery to the customer the engine has to bear a label stating for which range of gases the engine is approved.

B.1.5. FUEL CONSUMPTION AND $C0_2$ REGULATIONS

There are currently no formal fuel consumption or CO_2 limits for motor vehicles within the EU. However the EU Council of Ministers has called on numerous occasions for measures to reduce greenhouse gases emissions, which will indirectly act as a move to introduce fuel consumption regulations. Such calls have received even greater emphasis since the Kyoto Protocol was signed in December 1997. Details and background information will be found in the **Appendix to Part 1**, **Section A.1.5**.

B.1.6. IN-SERVICE EMISSIONS LEGISLATION AND ON-BOARD DIAGNOSTICS

B.1.6.1. Introduction

Legislation with respect to in-service emissions testing for road vehicles within the EU was promulgated by EU Directive 77/143/EEC and subsequently amended by EU Directive 88/449/EEC. These Directives covered buses, coaches, light and heavy goods vehicles, trailers and semi-trailers over 3.5 t, taxis and ambulances. Although the directives stipulated that noise and exhaust emissions should be incorporated in the roadworthiness tests, no limits were specified. Furthermore, passenger cars were not included in that legislation. Subsequently, EU Directive 92/55/EEC, dated 22 June 1992, set out limit values and test procedures for all vehicles including passenger cars. These are described in **Part 1**, **Section 1.6.1**. In the intervening period, a number of EU countries introduced their own test regimes and limit values. These are detailed in **Section B.1.6.3**.

B.1.6.2. Control of Compliance of Vehicles in Service

The Auto/Oil programme identified improved inspection and maintenance as being a highly cost-effective means of reducing pollutant emissions. It is estimated that the worst 10% of the vehicles on the road cause 50% of the pollution. Following the completion of a study during 1996, the EU Commission came forward during 1997 with proposals to strengthen the requirements of the 92/55/EEC Directive. This is described in the **Appendix to Part 1**, **Section A.1.6.2**.

B.1.6.3. Europe - Other In-Service Emissions Legislation

Austria

Regulation: KFG Article 57a/40, Amendment to KDV of 1967 from 24 March 1995.

Frequency: Annual

Otto Engine/Type/Test/Limits:

77/143/EEC as amended by 92/55/EEC:
Without catalysts - CO at idle, max. 3.5 % v/v
With 3-way catalysts:
CO at idle manufacturer's limit or 0.5 % v/v max.
CO at idle at minimum 2000 rev/min $\leq$0.3 % v/v, λ = 0.97 to 1.03

Diesel Engine/Type/Test/Limits:

77/143/EEC as amended by 92/55/EEC mandatory from 1 January 1997, except for cars first registered before 1 January 1990, or test in free acceleration with limit:

- maximum measured value from type approval (+1 tolerance)
- or if no measurement from type approval 6 Bacharach maximum

Diesel smoke measurement by Bacharach was discontinued in 1997 and the EU alternative maxima limits are applied:

- Naturally aspirated diesel engines: 2.5 m^{-1}
- Turbo-charged diesel engines: 3.0 m^{-1}

Belgium

All gasoline powered cars more than 4 years old have to be checked annually, or upon change of ownership, at one of 66 state operated test centres. The requirement of 4.5% v/v CO max. at idle must be met by all these cars, including those fitted with catalysts.

Although an opacity limit exists for diesel powered vehicles, no checks are made at the test centres on exhaust emissions from such vehicles.

Denmark

Regulation: In-service emissions testing is part of the roadworthiness test.

Scope: Cars, vans, trucks and buses - Periodic inspection

Frequency: Cars & Vans - Every other year, once vehicle is 4 years old.
Trucks & Buses - Annually after one year.

Gasoline Engine Test/Type/Limits:

Max. 7% v/v CO at idle for vehicles registered before 1 January 1971.
Max. 5.5% v/v CO at idle for vehicles registered between 1 January 1971 and 1 April 1984.
Max. 4.5% v/v CO at idle for non-3-way-catalyst equipped vehicles registered between 1 April 1984 and 1 October 1986.
Max. 3.5% v/v CO at idle for non-3-way-catalyst equipped vehicles registered after 1 October 1986.
Max. 0.5% v/v CO at idle and max. 0.3% v/v CO at 2500 ± 200 rpm and lambda = 1 ± 0.03 at 2500 ± 200 rpm for 3-way-catalyst equipped vehicles.

Diesel Engine Test/Type/Limits:

Max. 2.5 m^{-1} smoke density for naturally aspirated engines.
Max. 3.0 m^{-1} smoke density for turbo-charged engines.

Inspections are carried out by state-employed staff - either at selected workshops or at state-operated test centres. Roadside spot checks are also included in the legislation.

Finland

A regulation for the in-service testing of gasoline cars was introduced, effective from 1 January 1993. Tests can be carried out at the same time as the normal roadworthiness test by an authorized institution, repair shop, or service station. The first test will be conducted 4 years after registration, the second after 6 years, and annually thereafter according to the following schedule. Diesel powered vehicles registered after 1 January 1980 are tested by the smoke opacity method, using the limits given in EU Directive 92/55/EEC.

Table B.1.54 Finnish in-service emissions testing

Vehicle Description	Idle CO % v/v	Idle HC ppm	Idle >2000 rpm CO % v/v	Idle >2000 rpm HC ppm	Lambda >2000 rpm high idle
Registered before 01/01/78	-	-	-	-	-
Registered 01/01/78 - 31/09/86	4.5	1000	-	-	-
Registered after 01/10/86	3.5	600	-	-	-
Low Emission Vehicles	0.5	100	0.3	100	0.97-1.03 (1)

(1) Or car manual values

France

No requirements.

Germany

The following table gives details of German in-service emissions test requirements, according to regulation Abgasuntersuchung AU (Article 47a StVZO), which became effective on 1 December 1993.

Table B.1.55 Germany - In-Service Emissions Test Requirements

Vehicle Type	Gasoline	Gasoline	Diesel	Diesel
	Oxidation catalysts or no catalysts	3-way catalysts	<3.5t	>3.5t
Test Frequency (months)	12	24	24	12
Vehicle Age (months)	12	36	36	12
Type Of Testing				
Visual Check	+	+	+	+
Idle Speed, low	+	+	+	+
Idle Speed, high	-	-	+	+
Spark Timing	+	+ (1)	-	-
Dwell Angle	+	-	-	-
EGR	+	-	-	-
Secondary Air System	+	-	-	-
CO Low Idle	+	+	-	-
CO High Idle	+	+	-	-
Lambda Sensor Circuit	-	+	-	-
Lambda Sensor Output	-	+	-	-
Full Load Stop	-	-	+	+
Opacity Free Acceleration	-	-	+	-

+ Limits as stipulated by the manufacturer and conformity of production limits.

(1) If possible

Greece

From January 1995, an "Automotive Emissions" card is issued annually after the vehicle passes an emissions test. Failure to possess a card renders the vehicle owner liable to a fine.

Ministry Decision No. 50/93 350/4444 requires that diesel vehicles, including passenger cars of up to 3.5 t, must be checked annually. Diesel taxis and trucks above 3.5 t must be checked every six months.

Italy

Regulation: Law No. 615 of 1966 (diesel engines only); no legal requirements for gasoline vehicles. Some local authorities, during air quality non-attainment days, only allow vehicles complying with emissions limits to operate in urban areas.

Scope: Diesel and gasoline vehicles.

Frequency: No nation-wide scheduled tests, but in most cities the local authorities strongly encourage vehicles to be checked annually in authorised workshops. Diesel vehicles may be checked by means of road-side spot-checks for smoke opacity.

Test Type: Smoke opacity under free acceleration (diesel vehicles). CO at idle (gasoline vehicles)

Limits: 65% opacity for urban buses.
70% opacity for all other diesel vehicles.
Manufacturer's manual for CO of catalysts-equipped cars. 4.5% v/v CO and 3.5% v/v CO at idle for non-catalyst cars registered before 1986 and after 1992 respectively.

Penalty for non-compliance:
Fine and withdrawal of vehicle license until the owner resubmits the vehicle and it is found to comply.

Netherlands

Regulation: APK/"*Milieu*" (Environmental) Inspection

Scope: Passenger cars and light-duty spark ignition engined vans (3500 kg max.) aged 3 years or older have to be checked annually and, since 1995, diesel cars, buses and trucks have had to meet a free acceleration smoke opacity requirement. Test work is also carried out to check that vehicles meet type approval limits and manufacturers are notified of the results.

Test Limits: Since 1 September 1991, some cars have to meet the more stringent "Milieu" inspection requirements:

Table B.1.56 "Milieu" Inspection Requirements

Vehicle	Limits
Gasoline and LPG vehicles registered since 1974	Overall idle CO: 4.5% v/v max
Cars with three-way catalysts, registered since 1986	All exhaust gas limits in line with type approval
Other cars (with and without uncontrolled catalysts) and registered since 1980	An idle CO limit per car model and in line with quoted type approval limits
Diesel cars and vans	Smoke opacity under free acceleration

Vehicles failing to meet these requirements have to be adjusted and re-tested. Vehicles which can not achieve the limits are not allowed on the road.

Norway

Emissions tests are included in the normal roadworthiness tests - however, these are not conducted at fixed intervals. Emissions tests are also carried out at roadside controls.

Table B.1.57 In-service Inspection for Gasoline Cars in Norway [1]

Effective Date (car registration)	Test at idle	
	CO (% v/v)	HC (ppm)
before 01/01/74	-	-
after 01/01/74	4.5	-
after 01/10/79	3.5	-
Category L1 after 01/07/91	0.5	100
Category L2 after 01/10/92	1.0	200

(1) Diesel vehicles are inspected for “no excessive smoke” only

Poland

The following requirements are applicable to passenger cars, light duty vehicles, heavy duty vehicles and agricultural vehicles. Compliance is checked during mandatory periodical inspections and also nominally at random roadside checks. The frequency of periodical inspections depends on vehicle category and age, as follows:

- 3 years from first registration, next after 2 years and then annually for passenger cars and light duty vehicles subject to type approval
- every year for passenger cars and light duty vehicles not subject to type approval
- every year for trucks having a maximum mass exceeding 3500 kg
- one year from the first registration and then every six months for buses having more than 15 seats

Vehicles equipped with SI engines

For vehicles first registered before or after 1 October 1986, the equivalent EU regulations apply..

The following regulations apply to vehicles registered on or after 1 July 1995, except for vehicles with engines <700 cc, which were exempt until 31 December 1996:

Table B.1.58 In-Service limits for SI vehicles in Poland

Vehicle Type	Idle Emissions Limits		Fast Idle Emissions Limits (2000-3000 rpm)	
	CO (% v/v)	HC (ppm) [1]	CO (% v/v)	HC (ppm) [1]
all vehicles except heavy duty vehicles (>3500 kg GVW) and motorcycles [2]	0.5	100	0.3	1000
motorcycles	4.5			

(1) as hexane NDIR

(2) For vehicles fitted with a lambda probe, air-fuel equivalence ratio (lambda) measured at 2000-3000 rpm idle speed should be within 0.97-1.03.

Diesel Vehicles

The smoke level measured at free acceleration from low idle speed should not exceed;

naturally aspirated engines 2.5 m^{-1}
turbo-charged engines 3.0 m^{-1}

Portugal

No requirements.

Spain

No requirements.

Sweden

Passenger cars aged 2 years or older (see below) have to be inspected annually by the Swedish Motor Vehicle Inspection Company. The following limits apply:

Table B.1.59 Limits for 3-way catalyst equipped cars

Vehicle	CO % v/v	HC ppm
L1	0.5	100
L2	1.0	200

(1) * First introduced 01/10/90

Limits for 1976-1988 car models

EGR valves are not compulsory but must function if fitted. The annual test CO limit is about 4.5% v/v but the actual limit varies with model and engine. If the car fails there are certain threshold CO levels which will be reported to the vehicle owner but no further remedial action is required. These values vary between vehicle make, model and engine.

Failed vehicles have to be rectified and re-tested within one month. Vehicles which are not re-tested within that month are not allowed to be used on the road. Vehicles must be submitted for the annual test once they are 5 years old or have reached 80 000 km, whichever occurs first. It is expected that this limit will be extended to 160 000 km, equivalent to Californian regulations.

Switzerland

Gasoline Powered Passenger Cars/Other Light Duty Vehicles not Exceeding 3500 kg GVW

Tested biannually at authorized garages. The test comprises:

- Idle speed
- Ignition timing (with and without vacuum advance)
- CO, HC and CO_2 - Limits vary from model to model, reflecting the engine calibration employed for emissions homologation.

The emissions test certificate must be carried on the vehicle. The police conduct random spot checks and if the certificate is not displayed or is out of date the vehicle

owner is liable to a fine. Vehicles failing to pass the test are considered as "*not meeting the legal requirements*" and must be withdrawn from service.

All Vehicles with Diesel Engines

Smoke opacity under full rack acceleration in neutral is measured when the vehicle undergoes a regular check at an official Cantonal test station.

Test interval: 1 year for trucks transporting dangerous goods.
3 years for all other diesel vehicles.

Vehicles failing the test have to be re-submitted within two to three weeks.

United Kingdom

Emissions testing was introduced as part of the existing Department of Transport (DoT) roadworthiness tests conducted annually on cars more than 3 years old. Gaseous emissions standards were first introduced from 1 November 1991 for light duty vehicles. Smoke emissions standards were applied to heavy duty vehicles from 1 September 1992 and for light duty diesel vehicles from 1 February 1994. The more stringent requirements of EU Directive 92/55/EEC were promulgated by an amendment to Regulation 61 of the Road Vehicles Regulations of 1986 and were applied to all gasoline and diesel engined vehicles from 25 September 1995 and to gasoline engined cars with advanced emission control systems from 1 January 1996. Additional inspections of filler caps and pipes were introduced in 1996.

Tests are conducted with the engine warmed-up and at idle and the following limits apply:

Table B.1.60 UK limits for gasoline vehicles

Vehicle Type	Emissions Limit
First used before 01/08/75	no requirement
First used after 01/08/75	CO 4.5% v/v max., HC 0.12% v/v max. at normal idle
First used after 01/08/94 (after 01/08/92 for cars)	CO 3.5% v/v max., HC 0.12% v/v max. at normal idle speed
First used after 01/08/96 (after 01/08/94 for cars)	CO 0.5% v/v max. at normal idle speed and CO 0.3% v/v max., HC 0.02% v/v max. at λ 1$\pm$ 0.03 at >2500 <3000 rev/min (or manufacturers settings for λ and fast idle)

In addition, cars must not emit blue or black smoke after being fully warmed up. Vehicles will fail the complete DoT test even if emissions performance is the only item of failure. A free re-test will be allowed (if the vehicle has failed on emissions only) and provided the vehicle is returned to the same testing station "*within 14 days or so*". Emissions standards will also be the subject of road-side testing. Vehicles which fail to comply will be required to be rectified "*within 14 days or so*".

Table B.1.61 UK limits for diesel vehicles

Vehicle Type:	Emission Limits
Passenger cars and light commercial vehicles (<3500 kg) first used before 01/08/79	No blue or black smoke at idle by visual inspection
All other vehicles	The smoke level measured at free acceleration from low idle speed should not exceed: naturally aspirated engines: 2.5 m^{-1} turbo-charged engines: 3.0 m^{-1}

B.1.6.4. EU On-board diagnostic systems

Introduction

An on-board diagnostic (OBD) system consists of a computer incorporated in a vehicle's electronics for the purpose of detecting operational malfunctions within the engine control system. When malfunctions are detected, a warning light illuminates on the instrument panel and a "trouble" code is stored in the computer memory, identifying the part of the system (i.e. catalyst, oxygen sensor, etc.) in which the fault has occurred. OBD systems are seen as a complement to traditional I/M programmes rather than a substitute. EU Directive 98/69/EC stipulates the requirements and tests required for the OBD systems which have to be fitted to light duty vehicles from 2000. Details will be found in **Part 1**, **Section 1.6.3**.

B.1.6.5. Heavy Duty OBD

EU Directive 1999/96/EC stipulates that, from 1 October 2005, new types of vehicles, and from 1 October 2006, all types of vehicles, shall be equipped with an OBD system or an on-board measurement system (OBM) to monitor in-service exhaust emissions. The EU Commission was to propose provisions to this effect to the European Parliament and the Council by 31 December 2000. Details will be found in **Part 1, Section 1.6.4**.

B.2. OTHER EUROPEAN COUNTRIES, TURKEY AND RUSSIA

B.2.1. VEHICLE EMISSIONS LIMITS

B.2.1.1. The Stockholm Agreement

At a meeting in Sweden in July 1985, a number of countries agreed to adopt the US 1983 standards. The signatories to this agreement were Austria, Canada, Denmark, Finland, Norway, Sweden and Switzerland. These countries also introduced heavy duty limits based on UN ECE R49. These varied from country to country and further details will be found in **Report No. 6/97**.

Of these countries, Denmark was already a member of the EU and Austria, Finland and Sweden joined subsequently. In Amendment 40 to the KDV regulations issued on 24 March 1995, Austria adopted the EU Directives 94/12/EC, 93/59/EEC and 91/542/EEC for passenger cars, light duty and heavy duty vehicles respectively. However their limits for mopeds and motorcycles remained unchanged (see **Table B.2.1**). Finland adopted the requirements of EU Directive 91/441/EEC and 91/542/EC for cars and heavy duty vehicles respectively and later the requirements of EU Directive 93/59/EEC for light duty vehicles. Norway adopted all the relevant EU directives.

B.2.1.2. Austria

Table B.2.1 Austrian Moped and Motorcycle emissions limits, g/km

Vehicle	Effective Date	CO	HC	NOx
Motorcycles (<50 cc>40 km/h):				
2 stroke	from 01/10/91	8.0	7.5	0.1
4 stroke	from 01/10/91	13.0	3.0	0.3
Motorcycles (>50 cc):				
2 stroke	from 01/10/90	8.0	7.5	0.1
4 stroke	from 01/10/90	13.0	3.0	0.3
Mopeds (<50 cc>40 km/h):	from 01/10/88	1.2	1.0	0.2

B.2.1.3. Sweden

Before being admitted to the EU, Sweden introduced even more stringent limits than those specified in the “Stockholm Agreement” for all vehicle classes, as given in **Report No. 6/97**, **Tables A.1.20** and **A.1.21**. These limits have largely been overtaken by the introduction of Euro 3 and Euro 4 limits. Vehicle manufacturers also had to meet conformity guarantees, as in US legislation.

In addition, limits were published in the A 14 Regulation of 18 March 1992 for Low Emitting Vehicles (LEVs). Voluntary adoption was encouraged within the framework of taxes for two environmental categories - Classes C1 and C2, with C1 having the more stringent levels. Tests were carried out according to the ECE 15 + EUDC or US FTP 75 procedures. The limit values are based on 1990 US Clean Air Act Amendment Limits and are given in **Tables B.2.2** and **B.2.3** below, for the US FTP

and ECE procedures respectively. The limits applied to spark-ignition or compression-ignition engines (including gaseous, alcohol-fuelled or hybrid electric vehicles).

Table B.2.2 Low emitting vehicle (LEV) [1] emission standards A14 Regulation (FTP categories and cycle)

Category (Model Year)	Class	Durability (km)	Emissions (g/km)							(g/test)	(mg/km)	Useful Life (yr/km)
			CO	CO@ -7°C	HC	NMHC [4]	NOx	NOx (hwy)	PM [3]	Evap	HCHO [5]	
L1 (1993)	C1	80k	2.1	6.2	0.25	0.08	0.25	0.33	0.05	2.0	9.0	10/ 160 000
		160k	2.6			0.01	0.37		0.06	2.0	11.0	
	C2	80k	2.1		0.25	0.16	0.25	0.33	0.05	2.0	9.0	
		160k	2.6			0.19	0.37		0.06	2.0		
L2 (<2700 kg) (1993)	C1	80k	2.7	7.5		0.10	0.43		0.05	2.0	11.0	10/ 160 000
		160k	3.4		0.50	0.12	0.61	1.2	0.06	2.0	14.0	
	C2	80k	2.7			0.20	0.43		0.05	2.0	11.0	
		160k	3.4		0.50	0.25	0.61	1.2	0.06	2.0		
L3 (>2700 kg) (1994	C1	80k	2.7	7.5		0.10	0.43			2.0	14.0	11/ 200 000
		200k	4.0		0.50	0.14	0.61	1.2	0.06	2.0	17.0	
	C2	80k	2.7			0.25	0.43			2.0	14.0	
		200k	4.0		0.50	0.29	0.61	1.2	0.06	2.0		

Table B.2.3 Low emitting vehicle (LEV) [1] emission standards A14 & A 31 Regulations (FTP categories and cycle)

Class	CO (g/km)	HC+NOx (g/km)		PM (g/km)	Evap (g/test)	Useful Life (yr/km)
MI C2 Gasoline	2.2	0.5		-	2.0	5/80 000
M1 C2 IDI Diesel	1.0	0.7		0.08	-	5/80 000
M1 C2 DI Diesel	1.0	0.9		0.10	-	5/80 000
	CO (g/kWh)	HC (g/kWh)	NOx (g/kWh)	PM (g/kWh)		
HDV C2 (1983) [2]	4.0	1.1	7.0	0.15	-	-

(1) New LDVs approved according to ECE regulations. Other LDVs 11 yr/200 000 km.

(2) New HDV with service life: <200 000 km, 8 yr/200 000 km; 200 000-500 000 km, 8 yr/350 000 km; >500 000 km, 8 yr/500 000 km.

(3) Applies to diesel vehicles only, which also have smoke limits of 3.5 Bosch / 45 Hartridge.

(4) Expressed as NMOG for Class 1, NMHC for Class 2.

(5) For methanol-fuelled vehicles (those designed to operate on more than 50% methanol) only. Also HC/NMOG/NMHC limits refer to “organic equivalents”.

Since 1 April 1996, the three largest cities in Sweden (Stockholm, Gothenburg and Malmö) restricted the types of heavy duty vehicles which could enter their city centres to those conforming to the Euro 2 emissions standards, those which are less than 8 years old and older vehicles retrofitted with equipment to reduce emissions. The retrofit equipment, which has to be approved by Svensk Bilprovning, must be of one of two types depending on the age of the vehicle. The B Type kit applies to 1986 and older vehicles and must reduce particulate emissions and hydrocarbons by 80% and 60% respectively. 1986 and 1987 model year vehicles can alternatively be fitted with Type A systems which reduce particulates

and hydrocarbons by 20% and 60%. All 1980 model year and older vehicles were banned in 1996. In 1997, 1998, 1999, 2000 and 2001 the ban has been further extended to 1981, 1982, 1983/4, 1985/86 and 1987/88 model year vehicles respectively.

B.2.1.4. European Region Countries

Introduction

As of 1 May 2004, ten new Member States enlarged the EU:

- Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia and Slovenia.

Four other countries have applied to become members:

- Bulgaria, Croatia, Turkey and Romania.

Many of these states joined the EU on 1 May 2004 and have adopted the appropriate emissions legislation:

- Passenger Cars and Light Commercial Vehicles - EU Directive 98/69/EC,
- Heavy Duty Vehicle Emissions - EU Directives 1999/96/EC and 2001/27/EC.

Prior to those dates, most East European countries applied some combination of ECE and EU regulations, as shown in **Table B.2.4**.

Table B.2.4 Summary of Vehicle Emissions Legislation in Eastern Europe (Prior to Accession States joining the EU)

Country	Vehicle Type	Effective Date	Emission Limits
Bulgaria	passenger cars & light duty ≤3.5t	1975 1979	ECE R 24.03 ECE R 83.01
	heavy duty >3.5t	1975 1981	ECE R 24.03 ECE R 49.02
	motorcycles	1979	ECE R 40.01
	mopeds	1982	ECE R 47
Commonwealth of Independent States (CIS)	passenger cars & light duty ≤3.5t	1987 1996 1987	ECE R 15.04 ECE R 83.02 ECE R 24.03
	heavy duty >3.5t	1996 1987	ECE R 49.02 ECE R 24.03
	motorcycles	1987	ECE R 40.01
	mopeds	1987	ECE R 47
	see also **Tables B.2.5** to **B.2.8**		
Croatia	passenger cars & light duty ≤3.5t	1976 1985	ECE R 15.04 ECE R 83.02
	heavy duty >3.5t	1985	ECE R 49.02
	motorcycles	1988	ECE R 40.01
	mopeds	1985	ECE R 47
Czech & Slovak Republics	passenger cars & light duty ≤3.5t	1986 1995	ECE R 24.03 ECE R 83.02
	heavy duty >3.5t	1986 1992	ECE R 24.03 ECE R 49.02
	motorcycles	1988	ECE R 40.01
	mopeds	1982	ECE R 47
Hungary (1)	passenger cars & light duty ≤3.5t	1996 1997 2000	ECE R 24.03 ECE R 83.01A ECE R 83.01B/C
	heavy duty >3.5t	1986 1996 1997	ECE R 49 ECE R 24.03 ECE R 49.01
	motorcycles	1988	ECE R 40.01
	mopeds	1996	ECE R 47
Poland	passenger cars & light duty ≤3.5t	1992 1995	ECE R 24.03 ECE R 83.02
	heavy duty >3.5t	1992 1995	ECE R 24.03 ECE R 49.02
	motorcycles	1992	ECE R 40.01
	mopeds	1992	ECE R 47
Romania	passenger cars & light duty ≤3.5t	1996 1996 2000 2002	ECE R 24.03 ECE R 83 ECE R 83.01 ECE R 83.02
	heavy duty >3.5t	1994 1.1.1996 2002	ECE R 49.01 ECE R 24.03 ECE R 49.02B
	motorcycles	1988	ECE R 40.01
	mopeds	1996	ECE R 47
Slovenia	passenger cars & light duty ≤3.5t	1994 1996	ECE R 24.03 ECE R 83.02
	heavy duty >3.5t	1994 1994	ECE R 24.03 ECE R 49.02
	motorcycles	1995	ECE R 40.01
	mopeds	1985	ECE R 47

(1) Diesel engine free acceleration smoke limits:

	Free acceleration from idle	Light absorption coefficient
Naturally aspirated	1000 rpm	3.5 m^{-1}
		1.5
Turbocharged	idle	2.5

B.2.1.5. Russian Federation

Table B.2.5 Russian Federation Exhaust Emission Limits
Regulation OST 37. 001. 054-86. Gasoline cars without catalytic converters

Vehicle Reference Mass (kg)	Exhaust emission limits (g/test) Test Method: ECE 15			
	CO		HC+NOx	
	Type Approval	Conformity of Production	Type Approval	Conformity of Production
<1020	52	62	19.0	23.8
1021-1250	60	72	20.5	25.6
1251-1470	68	82	22.0	27.5
1471-1700	76	91	23.5	29.4
1701-1930	83	100	25.5	31.3
1931-2150	91	109	26.5	33.1
>2150	99	119	28.0	35.0

The limits for off-road vehicles, trucks and buses are stipulated by multiplying the above values by the following factors:
for <2000 kg: 1.25
for >2000 kg: 2.00

Table B.2.6 Russian Federation Exhaust Emission Limits -
Regulation OST 37. 001. 054-86. Gasoline cars with catalytic converters

Engine Cubic Capacity (litres)	Exhaust emission limits (g/test) Test Method: ECE 15					
	CO		HC+NOx		NOx	
	Type Approval	Conformity of Production	Type Approval	Conformity of Production	Type Approval	Conformity of Production
1.4-2.0	30	36	8.0	9.6	-	-
>2.0	25	30	6.5	7.8	3.5	4.2

The limits for off-road vehicles, trucks and buses are stipulated by multiplying the above values by the following factors:
for <2000 kg: 1.25
for >2000 kg: 2.0

Table B.2.7 Russian Federation Exhaust Emission Limits -
Regulation OST 37. 001. 234-81. Diesel engines

Exhaust emission limits (g/bhp.h) Test Method: ECE R49 13-Mode		
CO	HC	NOx
9.5	3.4	14.35

Table B.2.8 Russian Federation Black Smoke Emission Limits - Regulation GOST 17. 2. 01-84. Diesel engines

Nominal Flow (l/s)	Smoke Limits (opacity %)
<42	60
50	56
75	50
100	45
125	41
150	39
175	37
200	35
>200	34

The procedure consists of two stages:

- Full load
- Constant engine speeds between max. speed and 45% of max. speed, but no less than 1000 rpm.

Opacity under free acceleration should not exceed the maximum approved level under steady regimes for naturally aspirated engines, or more than by 10% for turbo-charged engines.

B.2.2. FUEL QUALITY REGULATIONS AND SPECIFICATIONS

B.2.2.1. Introduction

As stated in **Section B.2.1.4**, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia and Slovenia joined the EU on 1 May 2004. Bulgaria, Croatia, Turkey and Romania have also applied for membership. As a consequence, all these countries have adopted, or are in the process of adopting, EN specifications. The following tables therefore chart their progress over the last two decades in aligning their fuel specifications with those of the EU.

B.2.2.2. European Region Gasolines

Table B.2.9 Pre-2000 Eastern European Motor Gasoline Specifications – Hungary & Poland

Property		Hungary	Poland		
			Leaded 94	Leaded 98	Unleaded 95 (1)
RON	min	98.0/95.0/91.0	94.0	98.0	95.0
MON	min	88.0/85.0/82.5	85.0	87.0	85.0
Lead content, g/l	max	0.013	0.05 –0.15	0.05 –0.15	0.013
Sulphur content, % m/m	max	0.05	0.1	0.1	0.1
Gum, g/100ml	max		5	5	5
Copper Corrosion	max		1	1	1
Distillation, °C					
10% v/v evap.	max				
50% v/v evap.	max				
90% v/v evap.	max				
FBP	max		215	215	215
% v/v evap at 70°C		S 15-42 W 20-47	S 15-42 W 20-45	S 15-42 W 20-45	S 15-42 W 20-45
% v/v evap at 100°C		S 40-65 W 42-70			
% v/v evap at 180°C	min	85	85	85	85
RVP @ 37.8 °C, kPa	max	S 45-70 W 60-90	S 45-70 W 50-90	S 45-70 W 60-90	S 45-70 W 60-90
VLI = 10RVP + 7E70	max		S 900 W 1100	S 900 W 1100	S 900 W 1100
Benzene content, % v/v	max	2.0	5.0	5.0	5.0
Aromatics content, % v/v	max				
Oxygenates content, % v/v	max		(2)	(2)	(2)
Density, kg/m^3			725 – 775	720 – 760	720 - 780
Oxidation Stability, min	min		360	360	360
Colour			Yellow	Red	Neutral
PFI/VDC Additives					
Specification		MSZ 11793 ESZ-95			

(1) ULG 98 and VSR grades are also available.

(2) Apply limits set out in EU Directive 85/536/EEC.

- Slovakia has introduced lead and benzene limits of 0.005 g Pb/l and 3.0% v/v respectively, implementation date unknown.

Table B.2.10 Pre-2000 grade structure and lead contents of gasolines in other European Region countries

Country	Unleaded Gasolines	Lead Content (gPb/l)	Leaded Gasolines	Lead Content (gPb/l)
Bulgaria	95	unleaded	96/93/86	0.15
Croatia	95/91	0.013	98	0.40 - 0.60
Cyprus	95	0.013	98/92	0.34-0.40/0.07-0.15
Czech Republic	98/95	0.013	96-97/91-92	0.1 - 0.14
Gibraltar	-	-	98	0.15
Iceland	95/92	0.005	98	0.15
Macedonia	93-95	0.013	94-98/86-89	0.10-0.60/0.07-0.52
Romania	95	unleaded	95/87	0.3/0.6
Slovakia	98/95/91	0.013	91	0.15
Turkey	95	0.013	95/91	0.40/0.15

Table B.2.11 Post-2000 European Region Gasoline Specifications

Country	Belarus	Croatia	Czech Republic (1)	Hungary (2)	Poland (3)	Romania (4)	Slovakia (5)	Slovenia (6)	Ukraine
Standards	GOST 2084-77	EN 228	ČSN EN 228-2001	MSZ-EN 228-2000	PN EN 228-2003	EN 228	STN EN 228-2000	SIST EN 228:2001	GOST 2084-77
MON, min		85	85	85	85	85	85	85	85
RON, min	95	95	95	95	95	95	95	95	95
Density, 15ºC, max	-	725-780	720-775	720-775	720-775	720-775	720-775	720-775	-
Vapour pressure, 37.8ºC, kPa	66.7-93.3	(S) 35-70 (W) 55-90	(S) 45-70 (W) 60-90	(S) 45-60 (W) 60-90	(S) 45-60 (W) 60-90	(S) 45-60 (W) 60-90	(S) 45-70 (W) 60-90	(S) 45-60 (W) 60-90	66.7-93.3
Distillation									
IBP ºC, min	30								
T10 ºC, max	75								75
T50 ºC, max	120								120
T90 ºC, max	190								180
E70, % v/v		(S) 15-45 (W) 15-47	(S) 20-48 (W) 22-50	(S) 20-48 (W) 22-50	(S) 20-48 (W) 22-50	(S) 20-48 (W) 22-50	(S) 20-48 (W) 22-50	(S) 20-48 (W) 22-50	
E100, % v/v		(S) 40-65 (W) 43-70	46-71	46-71	46-71	46-71	46-71	46-71	
E150, % v/v			75	75	75	75	75	75	
FBP ºC, max	(S) 205 (W) 195	215	210	210	210	210	210	210	S 205 W 195
Residue % v/v, max		2	2	2	2	2	2	2	2
VLI (Summer)		950	Class A	Class A	Class A	1000	Class A	Class A	
VLI (Winter)		1150	Class D	Class D		Class D	Class D	Class D	
Pb, mg/l, max	13	13	5	5	5	5	5	5	0.013
S, mg/kg, max	500-1000	1000	150	150 50 (2)	150	150	150	150	1000 500 (7)
P, g/l, max	-		5	0	-		0		-
Benzene, % v/v, max	-	5.0	1.0	1.0	1.0	1.0	1.0	1.0	5.0 (7)
Aromatics, % v/v, max	-		42	42/35 (2)	42	42	42	42	-
Olefins, % v/v, max	-		21/18	21/18	21/18	21/18	21/18	21/18	-
Oxygen, % m/m, max		2.7	2.7	2.7	2.7	2.7	2.7	2.7	
Copper corrosion, 3 h, 50ºC, max	pass	1	1	1	1	1	1	1	pass
Oxidation stability, minutes, min.	360	360	360	360	360	360	360	360	360
Gum, kg/m^3, max	5	5	5	5	5	5	5	5	5
Appearance		clear & bright	clear & bright	clear & bright	clear & bright	clear & bright	clear & bright	clear & bright	

(1) The marketed gasoline qualities in the Czech Republic (RON/MON) are: Normal 91.0/82.0 ; Super 95.0/85.0 ; Super Plus 98.0/88.0. Oxygenates comply with 98/70/EC.

(2) The marketed gasoline qualities in Hungary (RON/MON) are: Normal 91.0/82.5 ; Super 95.0/85.0 ; Super Plus 98.0/88.0. Super Plus gasoline has been marketed to 98/70/EC 2005 specifications with tax incentives from 01.01.2000. Oxygenates comply with 98/70/EC.

(3) The marketed gasoline qualities in Poland (RON/MON) are: Super 95.0/85.0 ; Super Plus 98.0/88.0. During the transient period a mixed version of Classes A and D1 is employed for volatility control: RVP: 45 - 90 kPa and VLI: 1150 (max). Oxygenates comply with 98/70/EC.

(4) Romania started aligning its fuels with Dir 98/70/EEC in 2001 to finish at the latest by 1 January 2003.

(5) The marketed gasoline qualities in Slovakia (RON/MON) are: Normal 91.0/82.5 ; Super 95.0/85.0 ; Super Plus 98.0/87.0. Oxygenates comply with 98/70/EC.

(6) The marketed gasoline qualities in Slovakia (RON/MON) are: Normal 91.0/82.5 ; Super 95.0/85.0 ; Super Plus 98.0/87.0. Oxygenates comply with 98/70/EC.

(7) City gasoline only.

Switzerland - Tax on Fuel Sulphur Content

On 20 September 2002, the Swiss Government proposed a tax penalty on gasoline and diesel fuel containing more than 10 mg/kg sulphur. Fuels below 10 mg/kg would be considered desulphurized and therefore exempt from the new tax. This entered into force on 1 January 2004.

B.2.2.3. European Region Diesel Fuels

Table B.2.12 Pre-2000 European Region Diesel Fuel Specifications

Property		Bulgaria	Hungary 0.01	Hungary 0.05	Poland			Romania
					DL– Summer (1)	DP – Winter (2)	DZ- Winter 2 (3)	
Cetane Number	min				45	45	45	
Cetane Index	min	W 45 S 49	48	48				53 (4)
Density @ 20°C, kg/m^3		820-860	820-860	820-860	810 – 870	810 – 870	810 – 870	850
Sulphur % m/m	max	0.3	0.01	0.05	0.3	0.3	0.3	0.3
Viscosity @ 40°C, mm^2/s					2.8 – 8.0	2.4 – 6.0	2.4 – 6.0	
Distillation °C								
50% v/v rec. at	max				300	290	280	
Recovered at 350°C	min				85	90	95	
Flash Point °C	min				45	45	45	
Ash % m/m	max				0.01	0.01	0.01	
Water & Sediment					none	none	none	
Copper Strip Corrosion @ 50°C for 3 h					pass	pass	pass	
Carbon Residue (10% btms) % m/m	max				0.2	0.2	0.2	
Acidity (mgKOH/100ml)	max				8	8	6	
Pour Point °C	min				-5	-20	-35	
CFPP °C	min		S/W +5/-15	S/W +5/-15	0	-12	-20	
Specification			MSZ 1627	MSZ 1627				

(1) April – October.

(2) November - March.

(3) For temperatures below – 20°C.

(4) Diesel Index, normally equivalent to a Cetane Index of greater than 50.

- Slovakia has introduced a sulphur limit of 0.05% m/m, date of implementation unknown.

Table B.2.13 Post-2000 European Region Diesel Fuel Specifications

Country	Belarus	Bulgaria	Croatia	Czech Republic	Hungary	Poland	Romania	Slovakia	Slovenia	Ukraine
Standard	GOST 305-82		EN 590	ČSN EN 590-2001	MSZ-EN 590-2000	PN EN 590-2002	SR EN 590:1997	STN EN 590-2000	SIST EN 590:2001	GOST 305-82
Cetane number, min	45		49	51	51	51	49	51	51	45
Cetane index, min	-	W 45 S 49	46	46	46	46	46	46	46	-
Sulphur, mg/kg, max	2000	3000	5000	350	350	350	500	350	350	2000
Polyaromatics, % v/v max	-			11	11	11		11	11	-
Density, @ 15°C	820-860 (4)	820-860	820-860	820-845	820-845	820-845	820-860	820-845	820-845	W: 840 max (3) S: 860 max (3)
Viscosity, mm^2/s, 40°C	W: 1.8-6.0 (4) S: 3.0-6.0 (4)		2.0-4.5	2.0-4.5	2.0-4.5	2.0-4.5	2.0-4.5	2.0-4.5	2.0-4.5	W: 1.8-5.0 (3) S: 3.0-6.0 (3)
Distillation										
E250, % v/v			<65	<65	<65	<65	<65	<65	<65	
T85, °C, max										
T50, °C, max	280									280
E350, % v/v, min			85	85	85	85	85	85	85	
T90, °C, max										
T95, °C, max				360	360	360		360	360	
T96, °C, max	360									360
E370, % v/v, min			95				95			
Pour point, °C max	W: -30 S: -10				-	-				W: -35 S: -10
CFPP, °C. max (W)	-5		-15	- 20	- 20	- 20	- 15	- 20	- 15	
CFPP, °C. max (T)			-10 or - 5	- 10		- 10		- 10	- 10	
CFPP, °C. max (S)			5	0	5	0	5	0	0	- 5
Cloud point, °C				- 8	-			-	-	W: -25 S: -5
Flash point, ºC, min	W: 40 S: 62		55	55	55	55	55	55	55	W: 40 S: 62
Carbon residue, 10%, % m/m, max	W. 0.2 S: 0.3		0.3	0.3	0.3	0.3	0.3	0.3	0.3	W: 0.2 S: 0.3
Ash, %(m/m) max	0.008		0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Water , mg/kg max	-		200	200	200	200	200	200	200	-
Impurities, mg/kg, max	-		24	24	24	24	24	24	24	-
Oxidation stability g/m^3, max	-		25	25	25	25	25	25	25	-
Copper corrosion, 3h, 50°C, class	pass		1	1	1	1	1	1	1	pass
Lubricity, µm, max.			460	460	460	460	460	460	460	

B.2.2.4. Turkey Gasolines

Table B.2.14 Turkey Leaded and Unleaded Gasoline Specifications

Property		Limits (1)			Test Methods
		Leaded (2)		Unleaded (3)	
		Regular	Super	Premium	
RON	min	91.0	95.0	95.0	ASTM D 2699
MON	min	80.0	84.0	85.0	ASTM D 2700
Lead (mg Pb/l)	max	1500	1000 – 4000	5	IP 352
Sulphur (mg/kg)	max	1000	1000/50 (4)	500/50 (4)	IP 336
Benzene (% v/v)	max	5.0	5.0	2.5	
Density @ 15°C (kg/m^3)		710 - 740	725 - 760	725 - 780	ASTM D 1298
RVP @ 37.8°C (kPa)		(S) 50 - 70 (W) 60 - 80			
Distillation:					
E70 (% v/v)		(S) 15 - 45 (W) 15-47			
E100 (% v/v)		(S) 40 - 65 (W) 43 - 70			ASTM D86
E180 (% v/v)	min	85			
FBP (°C)	max	215			
Residue (% v/v)	max	2			
VLI (5)					
Summer grade (6)	max	950			
Winter grade (7)	max	1200			
Copper Strip Corrosion (3 h at 50 ^{0}C)	max	1			ASTM D 130
Doctor Test		Negative			IP30
or Mercaptan Sulphur (ppm)	max	15			ASTM D 3227
Oxidation Stability (minutes)	min	360			ASTM D 525
Existent Gum (mg/100 ml)	max	4	4	5	ASTM D 381
Colour			Orange	-	
Appearance			-	Clear & Bright	

(1) These are industry rather than national specifications. Turkey was planning to meet EU Directive 98/70/EEC by January 2005. Lead phase-out is planned for post-2005. However, some refineries were intending to eliminate the production of leaded super gasoline and minimize the use of lead in regular gasoline starting from year 2002.

(2) Introduced July 1999.

(3) Introduced in 2002.

(4) Refinery dependent.

(5) VLI = 10 x RVP + 7x (E70).

(6) 1 April - 31 October (± 15 days).

(7) 1 November -31 March (± 15 days).

B.2.2.5. Russian Federation Gasolines

Table B.2.15 Russia GOST R 51105-97 (Introduced 1 January 1999)

Physico-Chemical and Performance Characteristics

Property [1]		**Normal-80**	**Regular-91**	**Premium-95**	**Super-98**
RON	min	80.0	91.0	95.0	98.0
MON	min	76.0	82.5	85.0	88.0
Lead content, g/l	max	0.010	0.010	0.010	0.010
Manganese content, g/l	max	50	18	-	-
Sulphur content, % m/m	max	0.05	0.05	0.05	0.05
Existent Gum, g/100ml	max	5	5	5	5
Copper Corrosion	max	1	1	1	1
Benzene content, % v/v	max	5.0	5.0	5.0	5.0
Oxygenates content, % v/v	max	(2)	(2)	(2)	(2)
Density, kg/m^3		700 – 750	725 – 780	725 – 780	725 – 780
Oxidation Stability, min	min	360	360	360	360
PFI/VDC Additives		(2)	(2)	(2)	(2)
Specification		OKP 025112 370	OKP 025112 3702	OKP 025112 3703	OKP 025112 3704

(1) GOST Test Methods are quoted in the standard – these are directly equivalent to the appropriate ASTM, ISO and EN methods.

(2) Oxygenates, anti-oxidants and detergents are permitted but the standard does not specify limits or types.

Volatility Characteristics

Property [1]		Class [2]				
		1	2	3	4	5
RVP, kPa	min	35	45	55	60	80
	max	70	80	90	95	100
Distillation, °C:						
IBP	min	35	35	Report	Report	Report
10%	max	75	70	65	60	55
50%	max	120	115	110	105	100
90%	max	190	185	180	170	160
FBP	max	215	215	215	215	215
Residue % v/v	max	2	2	2	2	2
OR						
% v/v evap at 70°C	min/max	10-45	15-45	15-47	15-50	15-50
% v/v evap at 100°C	min/max	35-65	40-70	40-70	40-70	40-70
% v/v evap at 180°C	min	85	85	85	85	85
VLI = 10RVP + 7E70	max	900	1000	1100	1200	1300

(1) GOST Test Methods are quoted in the standard – these are directly equivalent to the appropriate ASTM, ISO and EN methods.

(2) No guidance is provided in the standard regarding the selection of appropriate volatility classes for different climatic regions.

B.2.3. EMISSIONS AND FUEL ECONOMY TEST PROCEDURES

Where such procedures exist, EU or United Nations ECE test protocols have been adopted.

B.2.4. REFERENCE FUELS

The new EU member states have adopted EU reference fuels (see **Section B.1.4**). No information is available for other European region countries, Turkey or Russia.

B.2.5. FUEL CONSUMPTION AND CO_2 REULATIONS

The new EU member states have adopted EU regulations (see **Section B.1.5**). No information is available for other European region countries, Turkey or Russia.

B.2.6. IN-SERVICE EMISSIONS LEGISLATION AND ON-BOARD DIAGNOSTIC SYSTEMS

B.2.6.1. New EU Member States

The new EU member states have adopted EU legislation (see **Section B.1.6**).

B.2.6.2. Other European Region Countries and Turkey

No information is available

B.2.6.3. Russian Federation

The Federation employs the following in-service limits:

Table B.2.16 Gasoline Engines, Regulation GOST 17. 2. 2. 03-87

Idle Speed (rpm)	CO (% v/v)	HC (ppm) ≤4 Cylinders	HC (ppm) >4 Cylinders
Nmin (1)	1.5	1200	3000
Nhigh (2)	2.0	600	1000
Nmin	3.0 (3)	-	-

Nmin: Minimum idle speed, according to manufacturer's manual

Nhigh: Increased idle speed, according to manufacturer's manual

Applies only to police and municipality roadworthiness checks

Table B.2.17 Diesel Engines, Regulation GOST 21393-75

Engine Regime	Smoke Emission Limits (Opacity %) (1)
Idle	15
Free acceleration	40

(1) Smoke opacity is measured in-service under police and municipal roadworthiness checks under no-load conditions (transmission in Neutral)

B.3. US FEDERAL STATES

B.3.1. VEHICLE EMISSIONS LIMITS

B.3.1.1. Introduction - The 1990 US Clean Air Act Amendments (CAAA)

In November 1990, the replacement US Clean Air Act was signed into law. Once the Amendments were approved, the EPA worked with the assistance of the oil and motor industries to develop detailed rules to put the legislation into place. The most important of these were the “Tier 1” exhaust emissions limits for LDVs (Table B.3.1), evaporative emissions procedures and limits, plus the rules for reformulated gasoline.

There was some debate regarding the role of the EPA in establishing the air quality standards for California, with various legislative moves first involving and then omitting the EPA from the formulation of an implementation plan. In the event California went ahead and enforced its own proposals.

The CAA introduced new emissions standards; Tier 1, to be followed by Tier 2 limits from 2004. However, during the 1990s, the twelve eastern states - comprising the Ozone Transport Region (OTR) - adopted some elements of the California legislation. The EPA wanted to avoid the complexity of different emission limits applying in different Federal states and developed a compromise solution known as the National LEV Programme (see **Section B.3.1.5**). This superseded the Tier 1 limits laid down in the CAAA.

B.3.1.2. Tier 1 Emissions Legislation

Light Duty Vehicles (Cars and Trucks below 3750 lb GVW)

There were two sets of standards defined in the CAAA, Tier 1 and Tier 2 (Tier 0 was the legislation in place prior to the Act). Tier 1 was covered by a final regulation, published 5 June 1991 and was introduced progressively from 1994. Starting in 1996, vehicles had to be certified up to 100 000 miles, or to the higher "*useful life*" limits. Current emissions test procedures are described in **Section B.3.3**.

Table B.3.1 Tier 1 US Light Duty Vehicle Emissions Regulations

Vehicle		CO g/mile	NMHC g/mile	NOx g/mile	PM g/mile	Evap. g/test
US Tier 1 [1]	**Gasoline**	3.4 (4.2)[2]	0.25 (0.31)[4]	0.4 (0.6)	-	[3]
	Diesel	3.4 (4.2)[2]	0.25 (0.31)[4]	1.00 (1.25)	0.08 (0.10)	-

(1) limits are for an intermediate life of 5 yr or 50 000 miles with those for full useful life of 10 yr or 100 000 miles in parentheses.

(2) A CO standard of 10 g/mile was specified at 20ºF, commencing in 1994. However, if despite the "reformulated gasoline" programme six or more cities remained out of compliance with CO air quality targets by 1996, the more stringent limit of 3.4 g/mile was to be phased in over three yr, starting in 2001. This was overtaken by the introduction of the National LEV programme – see **Section B.1.3.5**.

(3) See **Section B.3.1.3**.

(4) There is also a THC limit of 0.41 g/mile.

- In-use (recall) standards are also specified which must be met under randomised testing of in-service cars by the EPA. If the limits are not met an "*emissions recall*" may be triggered where the manufacturer has to recall and rectify any emissions defects.

The EPA submitted its Tier 2 Report to Congress in July 1998. The study examined the question of the need for a further reduction in emissions from light-duty motor vehicles in order to attain, or maintain, the National Ambient Air Quality Standards (NAAQS). The Agency concluded that more stringent vehicle standards were needed to meet the ozone and particulate air quality standards. The Tier 2 limits are described in detail in **Part 1**, **Section 3.1**.

Light Duty Trucks

Tier 1 emissions limits were developed for light duty trucks and progressively introduced (**Table B.3.2**). Those for light light-duty trucks were introduced in 1996, except for particulates limits for methanol- and diesel-fuelled compression ignition engines, where 80% of sales were required to conform by 1996 and all sales by 1997. For heavy light-duty trucks, except cold start CO, 50% of sales were expected to conform to all requirements, by 1996 and 100% by 1997. The implementation of cold start CO for these vehicles was required to be completed by 1996.

Table B.3.2 Tier 1 Federal Light Duty Truck emissions legislation [1]

Vehicle	Category	Tier	CO (g/mile)	THC [2] (g/mile)	NMHC [2] (g/mile)	NOx (g/mile)	PM (g/mile)
Light LDT	lvw (lb)						
gasoline & methanol	0-3750 3751-5750	Tier 1 Tier 1	3.4 (4.2) 4.4 (5.5)	(0.8) (0.8)	0.25 (0.31) 0.32 (0.40)	0.4 (0.6) 0.7 (0.97)	0.08 (0.1) 0.08 (0.1)
diesel	0-3750 3751-5750	Tier 1 Tier 1	3.4 (4.2) 4.4 (5.5)	(0.8) (0.8)	0.25 (0.31) 0.32 (0.40)	1.0 (1.25) (0.97)	0.08 (0.1) 0.08 (0.1)
Heavy LDT	lvw/alvw (lb)						
gasoline, methanol & diesel	3751-5750 >5750	Tier 1 Tier 1	4.4 (6.4) 5.0 (7.3)	(0.8) (0.8)	0.32 (0.46) 0.39 (0.56)	0.7 (0.98) 1.1 (1.53)	(0.10) 0.12)

(1) Limits are intermediate life (5 yr or 50 000 miles whichever occurs first) with full life 10 yr or 100 000 miles for Tier 1 in parentheses.

(2) THC and NMHC are OMHCE and OMNMHCE (in g carbon) respectively for methanol-fuelled engines and the full life for THC and OHMCE is 12 yr or 120 000 miles.

Supplemental FTP Emissions Limits for Light Duty Vehicles and Trucks

The EPA introduced revisions to the FTP for measuring tailpipe emissions to better represent actual driving conditions, including the use of air conditioning systems (Final Rule: 22 October 1997). The new Supplemental Federal Test Procedure (SFTP) includes two new test driving cycles, the US06, representing aggressive and microtransient driving and the SC03, representing driving immediately following vehicle start-up, air conditioning operation and micro-transient driving. Dynamometers with significantly higher power absorption characteristics were required for the new US06 test. Furthermore, manufacturers are required to show that their test results conform to those which would be obtained using an environmental chamber to reproduce the high-temperature ambient conditions which require the use of air conditioning. Further details of the test procedures will be found in **Section B.3.3.1**.

Apart from any modifications arising from the use of new dynamometers, there are no changes to the existing regulations for Tier 1 emissions based on the FTP 75 procedures. However the new procedures will require the CAFE standards to be re-addressed and there are significant new rulings relating to the SFTP.

EPA finalised a "composite" compliance calculation for NMHC + NOx that weights results from the conventional FTP with results from the SFTP. In the composite SFTP calculation, emissions from the FTP are weighted at 35 percent, emissions from the SC03 at 37 percent, and from the US06 emissions at 28 percent. If an engine family or vehicle configuration is not available with air conditioning, the air conditioning test is not run and emissions from the FTP are weighted at 72 percent and US06 emissions at 28% (note that the air conditioning test is required for any vehicle available with air conditioning, even if the installation rate is projected to be less than 33%). For gasoline vehicles, the standards for the SFTP composite NMHC + NOx emissions are the same as the combined NMHC and NOx standards applicable under the conventional FTP.

Unlike NMHC + NOx, a composite CO standard was not set based upon the weighted average of the individual CO standards over the various cycles. Due to the additional allowance in the US06 CO standard for commanded enrichment (required in some engine models to reduce peak engine and catalyst temperatures), the final rule sets separate CO standards for the US06 and SC03 cycles. A

composite CO standard is allowed, at the manufacturers' option, which is set at the level of the CO standard applicable under the conventional FTP.

Standards for light-duty diesel vehicles and light-duty diesel trucks in the LDT1 (≤6000 lb GVWR ≤3750 lb LVW) category are different from those for gasoline-powered vehicles in those categories. The supplemental FTP for diesel LDVs and LDT1s does not include the SC03 cycle, because sufficient test data was not available at the time to create an appropriate air conditioning standard for these diesel vehicles. In addition, the NMHC + NOx standard is higher for diesel LDVs and LDT1s because of the inherently higher NOx emissions associated with diesel engines. This is similar to EPA's treatment of conventional FTP Tier 1 standards for diesel LDVs and LDT1s, which are less stringent for NOx emissions. Diesel LDVs and LDT1s will have to comply with the same US06 standards (or optional composite standards) for CO as gasoline-fuelled LDVs and LDT1s. The composite SFTP NMHC + NOx and CO standards will be weighted at 72% for the conventional FTP cycle and 28% for the US06 cycle. Due to the absence of relevant test data on which to base a decision, no supplemental standards are being promulgated for other classes of light-duty diesel trucks, and no supplemental standards or test procedures are being promulgated for diesel particulate emissions.

The SFTP standards do not apply to vehicles tested at high altitude nor to vehicles operating on alternative fuels, but do apply to flexible-fuelled and dual-fuelled vehicles operating on gasoline or diesel fuel.

The composite figures, discussed above, apply to the current Tier 1 standards. However, for vehicles certified under alternative standards, such as the National LEV Programme (see **Section B.1.3.5**), the contribution of the conventional FTP standard to the Composite NMHC + NOx and optional Composite CO standards will have to be adjusted proportionately.

The EPA ruling on the additional limits by the SFTP, and the corresponding implementation schedules, are given in **Tables B.3.3** and **B.3.4** below. Manufacturers have the option of taking sales figures for LDV and Light LDT separately or in combination for the purposes of calculating implementation schedules. Production figures may be substituted in lieu of sales figures for all categories of vehicles at the discretion of the EPA.

Table B.3.3 Supplemental FTP Emissions Limits for Light Duty Vehicles and Trucks [1]

Vehicle	Category	NMHC + NOx Composite (g/mile) [3]	CO (g/mile)		
			A/C Test	US06	Composite Option [3]
LDV					
gasoline		0.65 (0.91)	3.0 (3.7)	9.0 (11.1)	3.4 (4.2)
diesel		1.48 (2.07)	na (na)	9.0 (11.1)	3.4 (4.2)
Light LDT [2]	lvw (lb)				
gasoline	0-3750 3751-5750	0.65 (0.91) 1.02 (1.37)	3.0 (3.7) 3.9 (4.9)	9.0 (11.1) 11.6 (14.6)	3.4 (4.2) 4.4 (5.5)
diesel	0-3750 3751-5750	1.48 (2.07) na (na)	na (na) na (na)	9.0 (11.1) na (na)	3.4 (4.2) na (na)
Heavy LDT [1]	alvw (lb)				
gasoline	3751-5750 >5750	1.02 (1.44) 1.49 (2.09)	3.9 (5.6) 4.4 (6.4)	11.6 (16.9) 13.2 (19.3)	4.4 (6.4) 5.0 (7.3)
diesel	3751-5750 >5750	na (na) na (na)	na (na) na (na)	na (na) na (na)	na (na) na (na)

(1) Limits are for intermediate life with full life limits in parentheses.

(2) Refer to the Glossary for vehicle classifications.

(3) Composite standards apply to current Tier 1 limits, and will need to be adjusted for the FTP standard as follows;
New SFTP standard = Old SFTP standard - (Tier 1 FTP standard - new FTP standard).

(4) The SFTP standards do not apply to alternative fuels but do apply to gasoline and diesel operation of flexible- and dual-fuelled vehicles.

(5) The standards do not apply to vehicles tested at high altitude.

Table B.3.4 Implementation Schedule for SFTP limits [1]

Light Duty Vehicles and Light LDT [2]		Heavy light duty trucks [3]	
Model Year	**Percentage**	**Model Year**	**Percentage**
2000	40	2002	40
2001	80	2003	80
2002	100	2004	100

(1) With the enactment of the National LEV programme, the SFTP phase-in will be changed to match the CARB Implementation Schedule. CARB's SFTP standards would also apply.

(2) Small volume manufacturers are exempt until 2002 when 100% of vehicles must comply.

(3) Small volume manufacturers are exempt until 2004 when 100% of vehicles must comply.

Clean Fuel Fleet Programme for Light Duty Trucks

The Clean Air Act Amendments (1990) required the establishment of a Clean Fuel Fleet Program (CFFP) in states with ozone and CO non-attainment areas. For those states, fleet owners, with 10 or more vehicles capable of centrally refuelling, had to purchase some new vehicles meeting Clean-Fuel Fleet Vehicle (CFFV) exhaust emissions standards, with effect from 1998. A credit programme allows fleet owners to claim credits from early purchases of CFFVs, or bank credits to demonstrate compliance at a later date, or trade them to another fleet. In addition, this rule established provisions for a new sub-group of CFFVs, known as inherently low-emission vehicles (ILEVs). This programme, which is voluntary for both the vehicle manufacturers and the fleet industry, grants exemptions to vehicles in this group in recognition of their superior emission characteristics.

The relevant emissions standards are given in **Table B.3.5**.

Table B.3.5 Federal Clean Fuel Standards for Light Duty Trucks

Effective Date	Vehicle Class (3,4)	Durability Mileage	CO (g/mile)	NMOG (g/mile)	NOx (g/mile)	PM (1) (g/mile)	HCHO (g/mile)
Phase I (5) from 1996 MY	<3750 lb lvw	50 000	3.4	0.125	0.4	-	0.015
	<6000 lb gvw	100 000	4.2	0.156	0.6	0.08	0.018
	>3750 lb lvw	50 000	4.4	0.160	0.7	-	0.018
	<5750 lb lvw <6000 lb gvw	100 000	5.5	0.200	0.9	0.08	0.023
Phase I (5) from1998 MY	<3750 lb lvw	50 000	3.4	0.125	0.4 (2)	-	0.015
	>6000 lb gvw	120 000	5.0	0.180	0.6	0.08	0.022
	>3750 lb lvw	50 000	4.4	0.160	0.7 (2)	-	0.018
	<5750 lb lvw	120 000	6.4	0.230	1.0	0.10	0.027
	>5750 lb lvw	50 000	5.0	0.195	1.1 (2)	-	0.022
	<8500 lb gvw	120 000	7.3	0.280	1.5	0.12	0.032
Phase II (6) from2001 MY	<3750 lb lvw	50 000	3.4	0.075	0.2	-	0.015
	<6000 lb gvw	100 000	4.2	0.090	0.3	0.08	0.018
	>3750 lb lvw	50 000	4.4	0.100	0.4	-	0.018
	<5750 lb lvw <6000 lb gvw	100 000	5.5	0.130	0.5	0.08	0.023

(1) Diesel-fuelled vehicles only.

(2) Not applicable to diesel-fuelled vehicles.

(3) lvw = loaded vehicle weight or test weight = curb weight + 300 lb, gvw (gvwr) = gross vehicle weight rating.

(4) Tier 1 light duty truck classifications:

Classification		lvw (lb)	gvwr (lb)
Light duty trucks	LLDT	-	<6000
	LDT1	<3750	<6000
	LDT2	>3750	<6000
Heavy light duty trucks	HLDT	-	>6000

(5) TLEV/Tier 1 standard

(6) LEV standard

B.3.1.3. Refuelling, Evaporative and Low Temperature Emissions

Refuelling Emissions

A report published by The National Highway Traffic Safety Administrator (NHTSA) in September 1991 concluded that on-board refuelling controls are significantly less safe than the alternative Stage II vapour recovery systems. As a result, the EPA decided not to issue a rule requiring large carbon canisters to be fitted to vehicles. However, this decision was overturned by a Federal Court ruling that the EPA must comply with the Clean Air Act, which explicitly states that the EPA shall promulgate regulations requiring on-board controls. As a result the EPA issued a final rule on 24 January 1994. The rule requires on-board refuelling emissions controls for passenger cars and light trucks (e.g. pickups, mini-vans and most delivery and utility vehicles). It will not require on-board control of refuelling emissions for heavy duty vehicles and trucks over 8500 lb GVW. The rule covers 97% of new vehicles and 94% of refuelling emissions. It requires a limit of 0.20 g HC (g carbon for methanol vehicles) per US gallon (0.053 g/litre) of fuel dispensed. The schedule for fitting large carbon canisters is given in **Table B.3.6**.

For passenger cars the controls were phased in over three model years with 40%, 80% and 100% of new car production being required to meet the standard in model years 1998, 1999 and 2000, respectively. Comparable proportions of light trucks will require on-board controls over three-year periods, 2001-2003 (GVW <6000 lb) and 2004-2006 (GVW 6000-8500 lb).

The rule establishes a refuelling emission standard of 0.20 grams hydrocarbons per US gal of dispensed fuel and is expected to yield a 95% reduction over current uncontrolled levels.

Table B.3.6 Implementation schedule for large carbon canisters

Light Duty Vehicles		Light light-duty Trucks		Heavy light duty Trucks	
1998	40%	2001	40%	2004	40%
1999	80%	2002	80%	2005	80%
2000	100%	2003	100%	2006	100%

The EPA rule has had some effect on the provision of refuelling vapour recovery systems on gasoline pumps at service stations (Stage II systems). As required by the Clean Air Act, it was still necessary to implement the Stage II provisions in serious, severe and extreme ozone non-attainment areas in order to control refuelling emissions until on-board controls were widely used in the vehicle population. Moderate ozone non-attainment areas are, however, relieved of the Act's stipulation to implement Stage II, although many of these areas may still need Stage II in order to satisfy other air quality standards.

Evaporative Emissions

The EPA issued regulations, effective from 23 April 1993, specifying revised procedures and limits for evaporative emissions, with implementation phased-in over the 1996 to 1999 model years. The regulations apply to light- and heavy-duty vehicles and heavy-duty engines fuelled with gasoline, methanol or gasoline/methanol mixtures.

The EPA also specified that, from 1 January 1996, the dispensing rates from gasoline and methanol pumps may not exceed 10 US gallons (37.9 litres) per minute. Facilities with throughputs below 10 000 gallons per month were given a further 2 years to comply. This requirement is consistent with the dispensing rates specified in the new test measuring spillage during refuelling.

The old test procedure, which had changed little since its introduction, measured emissions from fuel evaporation during parking (diurnal emissions) and immediately following a drive (hot soak emissions). The new procedures, described in detail in **Section B.3.3.6**, consist of vehicle preconditioning (including an initial loading of the carbon canister with fuel vapour), exhaust emission testing, a running loss test and three diurnal emissions cycles. Fuel spillage during refuelling (spit-back) is also measured. A supplemental procedure omitting the running loss test but involving two diurnal cycles following the emissions cycles is included. This procedure ensures that all the emissions resulting from purging the evaporative canister are measured during the emission and diurnal cycles and do not escape during the running loss test. Because of its increased severity, the limits specified for this test are more relaxed than those for the three-diurnal sequence. The supplemental

procedure can also be used in conjunction with the test procedures devised by the CARB.

The procedures for heavy duty vehicles are similar except that the driving sequence for the running loss test consists of three consecutive Urban Dynamometer Driving Schedule (UDDS) cycles, which reflect the different driving pattern experienced in-service. The testing of heavy-duty engines, without the vehicle chassis or body, requires that the test engine be equipped with a loaded evaporative canister and will be expected to demonstrate a sufficient level of purge during engine testing.

The EPA has pointed out that it has powers to deny certification upon determination that a particular control system design constitutes a defeat device, i.e. an auxiliary emission control device that reduces the effectiveness of the system under conditions which may reasonably be expected to be encountered in normal vehicle operations. The limits are given in **Table B.3.7**.

Table B.3.7 US Federal evaporative emissions requirements for all vehicles from 1996 (3)

Implement-ation Schedule (1) % prodn.	Vehicle GVW lb	Durability Mileage	3-Diurnal Hot Soak g/test	Supple-mentary 2-Diurnal g/test	Running Loss g/mile	Spit-back g liquid /test
1996 20%	<6000 (4)	(2)	2.0	2.5	0.05	1.0
1997 40%	>6000 <8500	120 000	2.5	3.0	0.05	1.0
1998 90%	>8500 <14000	120 000	3.0	3.5	0.05	1.0
1999 100%	>14000	120 000	4.0	4.5	0.05	-

- Limits for methanol-fuelled vehicles in g/carbon per test or mile.

(1) vehicles per year do not have to comply until the 1999 model year.

(2) Durability mileage: LDV 2 yr or 24 000 miles if device cost less than USD 200, 8 yr or 80 000 if deemed “specified major emission components”, light-duty trucks <3750 lb, 10 yr or 100 000 miles, >3750 lb; 120 000 miles.

(3) Also vehicles 6001-8500 lb with fuel tank capacity <30 US gal

Cold Temperature CO Emissions for Light Duty Vehicles and Trucks

The Clean Air Act Amendments specify a CO standard at 20°F (-7°C) of 10 g/mile for light duty vehicles and light light-duty trucks and of 12.5 g/mile for heavy light duty trucks. The phase-in of this standard started in 1994 and was completed in 1996.

B.3.1.4. Alternative Fuels

As described in **Section B.3.2.3**, the Clean Air Act Amendments include legislation on fuel composition and emissions performance, as well as vehicle emission limits. The original proposal called for a major shift to the use of “clean alternative fuels”, i.e. methanol, ethanol, CNG, LPG and hydrogen. However, as the debate progressed the emphasis shifted from alternatives to reformulated fuels, i.e. conventional gasoline whose composition was modified to reduce exhaust emissions.

Therefore, contrary to the original proposals, the final version of the Clean Air Act Amendments contained no mandate for the introduction of alternative fuels. Instead

it described performance criteria for "Clean alternative fuels" which may include:

> *"methanol and ethanol (and mixtures thereof), reformulated gasoline, natural gas, LPG, electricity and any other fuel which permits vehicles to attain legislated emission standards."*

Since the standards set in the CAAA are achievable by conventional vehicles it is likely that "*conventional*" gasoline and diesel will qualify as clean fuels under certain specific circumstances.

The Amendments do make provision for the Clean Fuels programme described earlier. This programme mandates emission standards for these vehicles which are the same as those specified in California's Low Emission Vehicle (LEV) programme. This part of the CAAA also specified a pilot programme for the introduction of lower emitting vehicles in California, beginning in 1996. Under this programme, 150 000 clean fuel vehicles were to be produced for sale in California in 1996 and this figure rose to 300 000 in 1999. These vehicles were initially required to meet Transitional Low Emission Vehicle (TLEV) standards. These limits remained in force until 2000 when the LEV standards outlined above came into operation.

The EPA have developed a voluntary vehicle emissions classification, called the Inherently Low Emission Vehicle (ILEV) as part of the Clean Fuel Fleet Programme regulation to provide comparatively attractive emissions benefits through relatively low evaporative emissions. Vehicles likely to meet the ILEV requirement are dedicated LPG, methanol- and ethanol-fuelled vehicles and electric vehicles, although manufacturers have no current plans to introduce M100 or E100 vehicles.

Table B.3.8 US Emissions Limits for "Clean Alternative Fuels" Programme

Programme	Effective Date	Equivalent Standard	CO g/mile	NMHC g/mile	NOx g/mile	HCHO g/mile
Fleet Refuelled	1998	LEV	3.4	0.075	0.2	0.015
California Pilot Programme	1996	TLEV	3.4	0.125	0.4	0.015
	2000	LEV	3.4	0.075	0.2	0.015

Energy Policy Act (EPo Act)

The Energy Policy Act was originally conceived to reduce the dependence of the US on imported petroleum stocks and is primarily designed to displace a proportion of petroleum derived fuels irrespective of the vehicle's emissions performance. The Act does not require alternative fuel vehicles to meet specific standards and therefore some Alternative Fuel Vehicles (AFV) may not necessarily meet clean fuel emission standards. The vehicle manufacturers have been actively supporting the Federal Fleet Conversion Task Force and the Clean Cities Initiative to develop an AFV market.

Under the Act, the Department of Energy issued a final rule on 28 February 1995 applying to companies that produce alternative fuels and which operate in metropolitan areas with more than 250 000 inhabitants in 1980 with fleets of at least 20 light duty vehicles. The rule required that at least 30% of the 1997 model year vehicles purchased by these companies should run on the alternative fuel they produced. The rule applies to electricity, ethanol, hydrogen, methanol, natural gas, neat biodiesel (a new addition to the list of alternative fuels) and other substitutes for petroleum-based fuels. Marketable credits are allowed on such motor vehicles

purchased beyond the legal requirement. State government fleets in the area must purchase at least 10% of their 1997 model year vehicles to run on alternative fuels.

B.3.1.5. The National LEV Programme

Introduction – State Autonomy and the Ozone Transport Region

The Clean Air Act reaffirmed the authority of individual states to adopt more stringent emission standards if they wish to do so. However, they were only permitted to adopt the standards set by California. This restriction was imposed in order to prevent motor manufacturers having to produce individual models for each state. Instead they only need to produce two models - one complying with Federal standards and one complying with Californian requirements.

The Ozone Transport Commission (OTC) (comprising the District of Columbia and the twelve eastern states of Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont and Virginia), was created by the Clean Air Act Amendments to coordinate the regional development of plans to control ground level ozone. In February 1993 it submitted a proposal to apply the California LEV limits to the Region. The EPA eventually adopted this proposal on 19 December 1994 and issued its Final Rule effective from 15 February 1995. However, this rule was overturned by the Court of Appeal on 11 March 1997. This decision allowed, but did not require, the OTC states to adopt Californian low emissions vehicles (LEVs). At the same time the EPA put forward an alternative National LEV Program (see below). New York State and Massachusetts adopted the California programme in 1996, to include whatever LEV programme was adopted.

National LEV Program

The EPA determined that a National LEV programme would result in emissions reductions in the OTR that are equivalent to or greater than the emissions reductions that would be achieved through OTC state-by-state adoption of the Californian LEV programme. Thus it established the regulatory framework for a voluntary National LEV programme in its final rule, effective 5 August 1997. Under the National LEV programme, motor manufacturers have the option of agreeing to comply with more stringent tailpipe emissions standards than the Tier 1 legislation. Manufacturers were committed to the programme and the standards were enforceable in the same way as other federal motor vehicle emissions control requirements.

The National LEV programme included a set of exhaust emissions standards for new light-duty vehicles (LDVs) and light-duty trucks (LDTs) at or below 6000 lb gross vehicle weight rating (GVWR) (light, light-duty trucks, or LLDTs). The programme included a manufacturer fleet average standard for non-methane organic gas (NMOG) that was applicable in the OTC States beginning in Model Year (MY) 1997 and applicable nation-wide (except California) beginning in MY 2001.

The final rule established separate sets of emission standards for LDVs and for LLDTs - the HLDT category continues to be certified to the applicable Tier 1 standards. All emission tests are run on a Californian Phase 2 reformulated gasoline. There are five vehicle emission categories for vehicles under the voluntary National LEV programme, ranging in stringency from the current federal Tier 1 vehicles to ZEVs. The Tier 1 standards have already been codified in the

federal regulations with a phase-in schedule that required 100% of model year 1996 LDVs and LLDTs to meet the Tier 1 standards. The TLEV, LEV, ULEV and ZEV certification standards for LDVs and LLDTs up to 3750 lb LVW are shown in **Table B.3.9** and those for LLDTs from 3750 to 5750 lb LVW are shown in **Table B.3.10**. The particulate standards adopted specifically for National LEV apply only to diesel vehicles. Non-diesel vehicles will be subject to the federal Tier 1 PM standards.

Table B.3.9 National LEV Intermediate and Full Useful Life Standards for LDVs and LLDTs to 3750 lb LVW

Vehicle Emission Category	Useful Life (miles)	NMOG (g/mile)	CO (g/mile)	NOx (g/mile)	HCHO (g/mile)	PM (1) (g/mile)
TLEV		0.125	3.4	0.4	0.015	-
LEV	50 000	0.075	3.4	0.2	0.015	-
ULEV		0.040	1.7	0.2	0.008	-
TLEV		0.156	4.2	0.6	0.018	0.08
LEV	100 000	0.090	4.2	0.3	0.018	0.08
ULEV		0.055	2.1	0.3	0.011	0.04

(1) Diesels only.

Table B.3.10 National LEV Intermediate and Full Useful Life Standards for LLDTs From 3751 lb LVW to 5750 lb

Vehicle Emission Category	Useful Life (miles)	NMOG (g/mile)	CO (g/mile)	NOx (g/mile)	HCHO (g/mile)	PM (1) (g/mile)
TLEV		0.160	4.4	0.7	0.018	-
LEV	50 000	0.100	4.4	0.4	0.018	-
ULEV		0.050	2.2	0.4	0.009	-
TLEV		0.200	5.5	0.9	0.023	0.10
LEV	100 000	0.130	5.5	0.5	0.023	0.10
ULEV		0.070	2.8	0.5	0.013	0.05

(1) Diesels only.

The voluntary standards also included two-tiered NMOG standards for flexible-fuel and dual-fuel vehicles, based on California's approach for these vehicle types. Flexible- and dual-fuel vehicles had to be certified to the applicable standards for both the alternative fuel and gasoline. When certifying on an alternative fuel, these vehicles had to meet the intermediate and full useful life emission standards for TLEVs, LEVs or ULEVs laid out above.

The National LEV programme explicitly adopted California's intermediate in-use standards, which are slightly less stringent than the certification standards. These standards, which apply to in-use testing for a period of model years following introduction of the certification standards, are set at less stringent levels than certification limits. This was to allow manufacturers to gain in-use experience with vehicles certified to LEV or ULEV standards. In-use limit values for LDVs and LLDTs to 3750 lb LVW are shown in **Table B.3.11** and those applicable to LLDTs from 3751 to 5750 lb LVW are shown in **Table B.3.12**. As indicated in the tables, compliance with in-use standards beyond the intermediate useful life was not required for LEVs and ULEVs until after model year 1998.

Table B.3.11 National LEV In-Use Standards for LDVs and LLDTs to 3750 lb LVW

Vehicle Emission Category	Model Year	Useful Life (miles)	NMOG (g/mile)	CO (g/mile)	NOx (g/mile)	HCHO (g/mile)
LEV	1997-1999	50 000	0.100	3.4	0.3	0.015
	1999	100 000	0.125	4.2	0.4	0.018
ULEV	1997-1998	50 000	0.058	2.6	0.3	0.012
	1999-2000	50 000	0.055	2.1	0.3	0.012
	2001-2002	50 000	0.055	2.1	0.3	0.008
	1999-2002	100 000	0.075	3.4	0.4	0.011

Table B.3.12 National LEV In-Use Standards for LLDTs from 3751 lb LVW to 5750 lb LVW

Vehicle Emission Category	Model Year	Useful Life (miles)	NMOG (g/mile)	CO (g/mile)	NOx (g/mile)	HCHO (g/mile)
LEV	1997-1998	50 000	0.128	4.4	0.5	0.018
	1999	50 000	0.130	4.4	0.5	0.018
	1999	100 000	0.160	5.5	0.7	0.018
ULEV	1997-1998	50 000	0.075	3.3	0.5	0.014
	1999-2002	50 000	0.070	2.8	0.5	0.014
	1999-2002	100 000	0.100	4.4	0.7	0.014

Under the National LEV programme, manufacturers were required to meet an increasingly stringent fleet average NMOG standard shown in **Table B.3.13**. The NMOG standards are equivalent to the sale of 40% TLEVs in MY 1997-MY 1998, 40% TLEVs and 30% LEVs in MY 1999, 40% TLEVs and 60% LEVs in MY 2000, and 100% LEVs in MY 2001.

An important part of the National LEV rulemaking was the set of provisions allowing manufacturers to use a market-based approach to meet the fleet average NMOG requirements through averaging, banking, and trading NMOG credits and debits. Both this overall approach and most of the specifics of programme implementation were modelled on California's trading programme. The few differences between the National LEV and California requirements are mainly due to the need to have separate compliance determinations in the OTC States and the 37 States, or are driven by EPA's legal authority.

Table B.3.13 EPA fleet average NMOG (g/mile) schedule

Vehicle Category	Fleet Average NMOG (g/mile)				
	1997	1998	1999	2000	2001
LDV & LLDT lvw ≤3750 lb	0.20	0.20	0.148	0.095	0.075
LLDT lvw >3750 lb	0.256	0.256	0.190	0.124	0.100

B.3.1.6. Tier 2 Emission Emissions Legislation

The EPA are phasing in the Tier 2 standards for LDVs/LLDTs over a four year period beginning in 2004 and a delayed two year phase-in, beginning in 2008 for HLDTs. Thus different Tier 2 phase-in schedules have been established for two different groups of vehicles. In addition, two different sets of interim standards for 2004 and later model year vehicles not yet phased-in to the Tier 2 standards have also been developed. The Tier 2 Standards are comprehensively described in **Part 1**, **Section 3.1.1**.

B.3.1.7. Heavy Duty Vehicles

Introduction

The following regulations apply to Trucks and Buses greater than 3750 lb gross vehicle weight (GVW).

1998 Standards

Reductions in NOx and diesel particulates were implemented from 1990 to 1995. These required the use of three-way catalysts for heavy duty gasoline engines and major advances in diesel engine technology. Full details of the limit values up to 1991 will be found in **Report No. 6/97** and **Table B.3.25** outlines the standards in force since 1998. The current test method is the US HD Transient cycle (see **Section B.3.3.2**).

Table B.3.14 1998 Federal Heavy Duty Vehicle emissions limits

Effective Date	Vehicle Type	GVW (lb)	CO (1) (g/bhp.h)	HC (2) (g/bhp.h)	NOx (g/bhp.h)	PM (g/bhp.h)
1998	gasoline	≤14 000 >14 000	14.4 37.1	1.1 1.9	4.0 4.0	- -
	diesel		15.5	1.3	4.0	0.1 (0.05)(4)

(1) Idle CO limit of 0.5% for gasoline fuelled engines with exhaust after-treatment and all methanol fuelled engines.

(2) OMHCE for methanol fuelled S.I. and diesel engines.

(3) Figure in parentheses for urban buses for in-use testing.

(4) Figure in parentheses for urban buses, 0.07 g/bhp.h for in-use testing.

(5) Durability in Years or Miles (whichever comes sooner):

Engine/Pollutant	hp range (approx.)	Years	Miles
Gasoline	-	8	110 000
Light HD	70 – 170	8	110 000
Medium HD diesel	170 –250	8	185 000
Heavy HD diesel	Over 250	8	290 000
Heavy HD diesel urban bus PM	-	10	290 000

2004 Diesel Engine/Vehicle Standards

A new Final Rule on emissions from "Highway Heavy Duty Engines" was published in the Federal Register on 21 October 1997 (Volume 62, Number 203). In this action, the EPA adopted a new emission standard and related provisions for diesel heavy duty engines (HDEs) intended for highway operation, beginning with MY 2004. Details will be found in **Part 1**, **Section 3.1.2.1**.

B.3.1.8. Current Motor Cycle Emissions Standards

Current and future emissions limits are described in **Part 1**, **Section 3.1.3**.

B.3.1.9. Non-Road Diesel Emissions Standards

The standards are described in **Part 1**, **Section 3.1.4**.

B.3.1.10. Non-Road Large Spark Ignition Engines Exhaust Emissions

Please refer to **Part 1**, **Section 3.1.5**.

B.3.1.11. Non-Road Recreational Engines Exhaust Emissions Standards

The standards for smaller recreational engines are not due to be implemented until 2006 and are therefore described in **Part 1**, **Section 3.1.6**.

B.3.2. FUEL QUALITY REGULATIONS AND SPECIFICATIONS

B.3.2.1. ASTM D4814-94 Gasoline Specification

A new specification was issued in 1988 to cover gasoline and its blends with oxygenates such as alcohols and ethers. This specification, which was further revised in 1993 and 1994, is not a legal requirement except in a few states which have adopted it as such. It can consequently be overruled by US Federal legislation on volatility. The specification still contains reference to the lead content and recommended octane level of leaded gasolines. With regard to volatility, six vapour pressure/distillation classes and five vapour lock protection classes are specified. Octane quality is not specifically controlled by the ASTM specification, being left to "*commercial practice*". However, EPA regulations do require a grade with a minimum antiknock index [(RON + MON)/2] of 87 to be sold (see **Table B.3.15**).

Table B.3.15 US National Specifications for Automotive Spark Ignition Engine Fuel (ASTM D4814-94d)

Volatility (1)

Vapour pressure/ distillation class	Reid vapour pressure kPa max. (2,3)	Distillation temperature, °C at % v/v evaporated (2)						Vapour/liquid ratio (4)		Vapour lock
		10% v/v °C max.	50% v/v °C min	50% v/v °C max.	90% v/v °C max.	End point °C max.	Residue % v/v	Test temperature	V/L max.	Protection class
AA	54	70	77	121	190	225	2	-	-	-
A	62	70	77	121	190	225	2	60	20	1
B	69	65	77	118	190	225	2	56	20	2
C	79	60	77	116	185	225	2	51	20	3
D	93	55	77	113	185	225	2	47	20	4
E	103	50	77	110	185	225	2	41	20	5

(1) Six vapour pressure/distillation classes and five vapour lock protection classes are specified. The appropriate fuel volatility is specified by a designation that uses a letter from each of the two tabulations according to the region and season of sale.

(2) If Federal legislation restricts RVP to a level lower than specified in the standard, distillation limits shall be consistent with corresponding RVP limits as above.

(3) Dry test methods must be used for gasoline/alcohol blends

(4) Version of test D 2533 using mercury must be used for oxygenate blends

Octane Quality (1)

Antiknock Index [(RON + MON)/2]	Application
	Leaded Fuel
88	For most vehicles that were designed to run on leaded fuel
	Unleaded Fuel
87	Designed to meet antiknock requirements of most 1971 and later model vehicles
89, 91 and above	Satisfies vehicles with higher antiknock requirements

(1) Octane quality is not specifically controlled by the ASTM specification, being left to "commercial practice". However, EPA regulations do require a grade with a minimum antiknock index [(RON + MON)/2] of 87 to be sold. The ASTM specification lists current antiknock Indices in Current Practice (i.e. grades) as follows:

- As required by EPA (Reg. 40 CFR part 80), reductions in octane for altitude are allowed
- Unleaded gasoline with an antiknock index of 87 should also have a minimum MON of 82
- Permissible reductions in antiknock index for altitude and seasonal variation are given in tables in the specification

Other Specification Criteria

Copper Strip Corrosion (max)	Existent Gum (mg/100ml) max	Sulphur Content (% m/m) max.		Oxidation Stability (mins.) min	Water Tolerance (1)
		Unleaded	Leaded		
No.1	5	0.10	0.15	240	(1)

(1) Maximum phase separation temperatures are specified by region and by month.

Lead Content

Leaded gasoline sales were banned from January 1995, the same date that reformulated gasoline had to be sold in specified areas which did not meet ambient ozone targets.

Grade	Lead Content (g/US gal) max	Lead Content (g/l) max
Leaded	4.2	1.1
Unleaded (1)	0.05	0.013

(1) In addition, phosphorous is limited in unleaded gasoline to 0.005 g/US gal (0.0013 g/l)

Volatility

From 1 January 1995, RVP has been restricted in those areas where legislation requires “reformulated gasolines” to 8.1 psi (55.8 kPa) and 7.2 psi (49.6 kPa) respectively. A permanent waiver of 1 psi (7 kPa) is allowed for ethanol blends. From 1996 an even lower limit of 7.0 psi (48.2 kPa) has been required in California for “Phase 2 reformulated gasolines”.

Sulphur Content

Standard gasoline sulphur content is specified at max. 0.10% m/m according to ASTM D4814-94 (see **Table B.3.15**). In addition, supplies of conventional gasolines are not allowed to exceed their 1990 sulphur values by more than 25% to comply with the so-called "anti-dumping" rule of the Clean Air Act. Federal US Phase II reformulated gasoline is required not to exceed a refiner's 1990 average sulphur content (statutory baseline of 338 mg/kg - see **Section B.3.2.3**).

Benzene Content

In the USA benzene content was limited to 1% v/v maximum (or 0.95% v/v period average, with a 1.3% v/v absolute maximum) from 1 January 1995 by implementation of the regulations requiring "*reformulated*" gasoline (see **Section B.3.2.3**). Total aromatics are indirectly controlled by the requirement to demonstrate a 15% reduction in the emissions of "air toxics".

B.3.2.2. Tier 2 Gasoline Sulphur Standards

The US EPA announced its final ruling on Tier 2 Motor Vehicle emissions standards and gasoline sulphur requirements (Federal Register; Volume 65, No. 28 of 10/02/00). Details will be found in **Part 1**, **Section 3.2.2**.

B.3.2.3. Reformulated Gasolines

Introduction

Section 107(d) of the Clean Air Act, (as amended in 1990) required States to identify all areas that do not meet the national ambient air quality standards (NAAQS) for ozone, and directed EPA to designate these areas as ozone non-attainment areas. Section 181 of the Act required EPA to classify each area as a marginal, moderate, serious, severe or extreme ozone non-attainment area.

Mandated RFG Programme Areas

The Act mandated the sale of reformulated gasoline ("RFG") in the nine worst ozone non-attainment areas beginning January 1, 1995. EPA determined the nine covered areas to be the metropolitan areas of Baltimore, Chicago, Hartford, Houston, Los Angeles, Milwaukee, New York City, Philadelphia, and San Diego.

Any ozone non-attainment area that is reclassified as severe becomes a mandated RFG programme area. Inclusion in the RFG programme occurs one year following the date of reclassification. For example, Sacramento was reclassified from serious to severe on 1 June, 1995 and became a mandatory RFG area effective 1June, 1996. The complexities of the programme are described more comprehensively in the **Appendix to Part 1**, **Section A.3.2.3**.

B.3.2.4. Oxygenates, and Oxygenated Gasolines

The use of new components in unleaded gasoline must be approved by the EPA, who must ensure that they will not adversely affect emission control systems.

In the case of oxygenates, the EPA has ruled that aliphatic alcohols and glycols, ethers and poly-ethers may be added to the fuel, provided that the amount of oxygen in the finished fuel does not exceed 2.7% m/m. However, note should be taken of new limits set out in the Clean Air Act Amendments. Methanol is excluded from this approval.

This is known as the "*substantially* similar" ruling, as these components are considered to be substantially similar to fuels in widespread use before the requirement for EPA approval. This EPA ruling originates from July 1981, when the oxygen content limit was set at 2.0% m/m max. In February 1991, in response to a request from the Oxygenated Fuel Association (OFA), EPA revised the ruling to increase the maximum oxygen limit to 2.7% m/m.

One section of the Clean Air Act calls for cities which do not meet ambient air CO standards in winter to use gasoline containing oxygenates to give 2.7% m/m oxygen.

This has applied during the four winter months (November-February) since 1992. In a few cities this requirement may be applied for a longer period.

B.3.2.5. Deposit Control Additives

Clean Air Act Amendments Requirement

The 1990 CAAA required that “effective 1 January 1995, all gasolines in the US must contain additives to prevent the accumulation of deposits in engines and fuel supply systems”. The Act provided no definition of additives or deposits and no guidance as to which parts of the fuel system were to be considered. The final rule was to be promulgated by 15 November 1992 and adopted before 15 October 1994. In practice a NPRM proposing requirements was not issued by EPA until December 1993. The requirements are described in the **Appendix to Part 1**, **Section A.3.2.5**.

B.3.2.6. ASTM D975-94 Specification for Diesel Fuel

ASTM D975-94 covers specifications for two grades of 0.05% m/m automotive gas oil (see **Table B.3.16**).

Table B.3.16 US National Specifications for Automotive Diesel Fuels (ASTM D975-94)

Grade	No.1-D (1)	No.2-D (2)
Flash Point °C	38 min	52 min
Cloud Point °C	(3)	(3)
Water & Sediment % v/v	0.05 max.	0.05 max.
Ramsbottom Carbon on 10% residue % m/m	0.15 max.	0.35 max.
Ash % m/m	0.01 max.	0.01 max.
Distillation 90% v/v °C	288 max. (4)	282-338 (4)
Viscosity Kinematic @ 40°C mm^2/s	1.3-2.4 (4)	1.9-4.1 (4)
Sulphur Content % m/m	0.05 max.	0.05 max.
Copper Strip Corrosion	No.3 max.	No.3 max.
Cetane Number	40 min. (5)	40 min. (5)
1) Cetane Index or	40 min.	40 min.
2) Aromatics Content % v/v	35 max.	35 max.

(1) Volatile distillate fuel oil for engines requiring frequent speed and load changes.

(2) Distillate fuel oil of lower volatility for engines in industrial and heavy mobile service.

(3) It is unrealistic to specify low-temperature properties that will ensure satisfactory operation on a broad basis. Satisfactory operation should be achieved in most cases if the cloud point (or wax appearance point) is specified at 6ºC above the tenth percentile minimum ambient temperature for the area in which the fuel will be used. Appropriate low temperature operability properties should be agreed upon between the fuel supplier and purchaser for the intended use and expected ambient temperatures.

(4) When cloud point less than -12ºC is specified, the minimum viscosity shall be 1.7 mm^2/s and the 90% point shall be waived.

(5) Low atmospheric temperatures as well as engine operation at high attitudes may require use of fuels with higher cetane ratings.

- To meet special operating conditions, modifications of individual limiting requirements may be agreed upon between purchaser, seller and manufacturer.

B.3.2.7. EPA Diesel Fuel Standards (Legislated Quality Requirements)

A sulphur limit of 500 mg/kg was adopted by the EPA and became effective on 1 October 1993. In addition, highway diesel fuel must have a minimum cetane index (ASTM D976-80) of 40, or a maximum aromatic content of 35% v/v. Other fuel property specifications must correspond to ASTM D975. Further reductions in sulphur content to 15 mg/kg are in place and details will be found in **Part 1**, **Section 3.2.7**.

B.3.2.8. Alternative Fuels

Contrary to the original proposals, the final version of the Clean Air Act Amendments contain no mandate for the introduction of alternative fuels. Instead it describes performance criteria for *"clean alternative fuels*" which may include *"methanol and ethanol (and mixtures thereof), reformulated gasoline, natural gas, LPG, electricity and any other fuel which permits vehicles to attain legislated emission standards".*

B.3.2.9. US Federal Energy Policy Act of 2005

The act is described in detail in **Part 1**, **Section 3.2.5**.

B.3.3. EMISSIONS AND FUEL ECONOMY TEST PROCEDURES

B.3.3.1. Light Duty Exhaust Emission and Fuel Economy Test Procedures

The procedures are comprehensively laid out in the **Appendix to Part 1**, **Section A.3.3.1**.

B.3.3.2. Heavy Duty Exhaust Emission Test Procedures

The US transient test was introduced as an option for certification of heavy duty vehicles in 1984. In 1985, it became mandatory, replacing the previous steady-state test. The reasons for moving to a transient cycle were to make the test more representative of on-highway conditions and to improve repeatability. The test is described in the **Appendix to Part 1**, **Section A.3.3.3**.

B.3.3.3. Test Procedures for Highway and Non-road Engines – Proposed Rules

On 10 September, 2004, the EPA published a Notice of Proposed Rulemaking (Federal Register/Vol. 69, No. 175). This proposed regulation aims to revise and harmonize test procedures from the various EPA programmes for controlling engine emissions. It will not address emission standards, nor is it intended to change expected emission reductions. Rather, it proposes to amend the regulations, which contain laboratory specifications for equipment and test fuels, instructions for preparing engines and running tests, calculations for determining final emission levels from measured values, and instructions for running emission tests using portable measurement devices outside the laboratory. These regulations currently apply to land-based non-road diesel engines, land-based non-road spark-ignition engines over 19 kilowatts, and recreational vehicles. These proposed revisions will update the regulations to deal more effectively with the more stringent standards recently promulgated by EPA and will also clarify and better define certain elements of the required test procedures. In particular, the proposed amendments will better specify the procedures applicable to field testing. The proposals are described in more detail in the **Appendix to Part 1**, **Section A.3.3.4**.

B.3.3.4. Non-Road Large Spark ignition Engine Emissions Test Procedures

For 2004 through 2006 model years, the EPA specify the same steady-state duty cycles adopted by California ARB. For variable-speed engines, this involves the

testing based on the ISO C2 duty cycle. A separate duty cycle applies to the large number of Large SI engine providing power for constant-speed applications. Constant-speed testing is based on the ISO D2 duty cycle and this same test applies to constant-speed, non-road diesel engines. Emission values measured on the D2 duty cycle are treated the same as values from the C2 duty cycle; the same numerical standards apply to both cycles. The tests are described in the **Appendix to Part 1**, **Section A.3.3.5**.

B.3.3.5. Motorcycle, Off-highway Motorcycle, ATV and Snowmobile Emissions Test Procedures

Details of the procedures will be found in the **Appendix to Part 1**, **Sections A.3.3.2** and **A.3.3.6**.

B.3.3.6. Evaporative Emissions Test Procedures

The current EPA procedure was phased in over the period 1996-1999 and is described in the **Appendix to Part 1**, **Section A.3.3.7**.

B.3.3.7. Permeation Emissions Test Procedure

The test procedures for determining permeation emissions from fuel tanks and hoses on recreational vehicles are described in the **Appendix to Part 1**, **Section A.3.3.8**.

B.3.3.8. Inspection and Maintenance Procedure - US IM 240

The IM 240 procedure is described in the **Appendix to Part 1**, **Section A.3.3.9**.

B.3.4. REFERENCE FUELS

Table B.3.17 Certification Gasoline Specification

Fuel Property	Limits	Test Method
Octane (Research)	93 (min)	D2699-88, D2700-88
Octane (R+M)/2		D2699-88, D2700-88
Sensitivity	7.5 (min)	D2699-88, D2700-88
Lead	0.05 g/US gal (max); no lead added	D3237
Distillation Range °F:		D86
IBP (1)	75-95	
10% point	120-135	
50% point	200-230	
90% point	300-325	
EP, maximum	415	
Residue		
Sulphur	0.10% m/m	
Phosphorous	0.005 g/US gal (max)	D3231
RVP (2, 3)	8.7-9.2 psi	D323
Olefins	10% v/v (max)	D1319
Total Aromatic Hydrocarbons	35% v/v (max)	

- Unleaded gasoline representative of commercial gasoline which will be generally available through retail outlets shall be used in service accumulation.

(1) For testing at altitudes above 4000 ft (1219 m) the specified range is 75-105°F.

(2) For testing which is unrelated to evaporative emissions control, the specified range is 8.0-9.2 psi.

(3) For testing at altitudes above 4000 ft (1219 m) the specified range is 7.6-8.0 psi.

Table B.3.18 Certification Diesel Fuel Specification

Fuel Property	Limit	Test Method
Natural Cetane Number	42-50	D 613-86
Distillation Range °F		D 86
IBP	340-400	
10% point	400-460	
50% point	470-540	
90% point	560-630	
EP	610-690	
API Gravity	32-37	D 287-82
Total Sulphur	0.03-0.05% m/m	D 2622
Additives	(1)	
Total Aromatic Hydrocarbons	27% v/v (min)	D 1319
Flashpoint	130 °F (max)	D 93-80
Viscosity @ 40°F	2.0 - 3.2	D 445-83

- Diesel fuel representative of commercial diesel fuel which will be generally available through retail outlets shall be used in service accumulation.

(1) The following non-metallic additives are allowed: cetane improver, metal deactivator, anti-oxidant, dehazer, anti-rust, pour depressant, dye, dispersant and biocide.

Table B.3.19 Certification Alcohol Fuels and Mixtures of Petroleum and Alcohol Fuels Specifications for Flexible Fuel Vehicles

US Federal regulations do not specify an ethanol fuel. The US Federal specification for methanol fuel simply calls for a product which is representative of commercially available methanol fuel, containing at least 50% methanol by volume. For flexible fuel vehicles, the US Federal Regulations simply call for a flexible fuel to comprise an appropriate petroleum product and methanol representative of the fuel expected to be found in use

Table B.3.20 Certification Natural Gas Fuel Specification

Specification	Limits (% mole/mole)
Methane	89.0 (min)
Ethane	4.5 (max)
C_3 and higher hydrocarbon content	2.3 (max)
C_6 and higher hydrocarbon content	0.6 (max)
Oxygen	0.5 (max)
Inert gases (CO_2 + N_2)	4.0 (max)

(1) For mileage accumulation purposes the US Federal regulations require the use of commercially available natural gas which will generally be available throughout retail outlets.

Table B.3.21 Certification Liquefied Petroleum Gas Fuel Specifications

US Federal regulations simply call for the use of commercially available LPG.

Large SI Engines - Reference Fuels for Emission Testing

For gasoline-fuelled Large SI engines, the EPA are adopting the specifications established for testing gasoline fuelled highway vehicles and engines. This includes the revised specification to cap sulphur levels at 80 mg/kg (65 FR 6698, 10 February, 2000). These fuel specifications apply for both exhaust and evaporative emissions.

For LPG, the EPA is adopting the same specifications established by California ARB. For natural gas, specifications similar to those adopted by California ARB will be used.

Unlike California ARB, the fuel specifications only apply to testing for emission measurements, not to service accumulation. Service accumulation between emission tests may involve certification fuel or any commercially available fuel of the appropriate type. Similarly, manufacturers are allowed to choose between certification fuel and any commercial fuel for in-use measurements to show compliance with field-testing emission standards.

B.3.5. FUEL CONSUMPTION AND CO_2 REGULATIONS

B.3.5.1. CAFE Standards

The Energy Policy and Conservation Act, passed in December 1975, and amended by the Motor Vehicle Information and Cost Saving Act, requires each vehicle manufacturer to determine sales weighted average fuel consumption figures for all passenger cars and for all light duty trucks produced by them. Electric cars or hybrid vehicles may be included in the fleet average calculations and a credit is given for flexible fuelled vehicles.

The standards are based on the combined City/Highway fuel figures and are known as the CAFE (Corporate Average Fuel Economy) standards. The limits, which have remained unaltered since 1991, are 27.5 miles/US gal for cars and 11.65 miles/US gal for light duty trucks. The penalty for non-compliance has been raised from USD 5.0 to USD 5.5 per mile per US gallon for each vehicle exceeding the above limits.

Table B.3.22 US Fuel Consumption Standards in litres/100 km (miles/US gal)

Model year	Passenger cars	Light trucks[1] Combined	Light trucks[1,2] (2WD)	Light trucks[1,2] (4WD)
1978	13.07 (18.0)	-	-	-
1979	12.38 (19.0)	13.68 (17.2)	13.68 (17.2)	14.89 (15.8)
1980	11.76 (20.0)	16.8 (14.0)[3]	14.70 (16.0)	16.80 (14.0)[2]
1981	10.69 (22.0)	16.22 (14.5)[3]	14.08 (16.7)[4]	15.68 (15.0)[2]
1982	9.80 (24.0)	13.45 (17.5)	13.07 (18.0)[2]	14.70 (16.0)
1983	9.05 (26.0)	12.38 (19.0)	12.07 (19.5)	13.45 (17.5)
1984	8.71 (27.0)	11.76 (20.0)	11.59 (20.3)	12.72 (18.5)
1985	8.55 (27.5)	12.07 (19.5)[5]	11.94 (19.7)[5]	12.45 (18.9)[5]
1986	9.05 (26.0)	11.76 (20.0)	11.47 (20.5)	12.06 (19.5)
1987	9.05 (26.0)	11.47 (20.5)	11.20 (21.0)	12.06 (19.5)
1988	9.05 (26.0)	11.47 (20.5)	11.20 (21.0)	12.06 (19.5)
1989	8.88 (26.5)	11.47 (20.5)	10.94 (21.5)	12.38 (19.0)
1990	8.55 (27.5)	11.76 (20.0)	11.47 (20.5)	12.38 (19.0)
1991	8.55 (27.5)	11.65 (20.2)	11.37 (20.7)	12.32 (19.1)

(1) Light trucks defined as less than 6000 lb GVW in 1979, less than 8500 lb 1980 - 91.

(2) Separate 2WD/4WD standards or combined light truck standard may be used 1982-1991.

(3) Relaxation granted for 1980-81 trucks with engines not based on passenger cars.

(4) Revised mid-year to 18.0 mpg (13.02 l/100 km).

(5) Revised in October 1984 to 21.6 mpg for 2WD, 19.0 mpg for 4WD and 21.0 mpg combined.

(6) Maximum fuel consumption before attracting “Gas Guzzler” Car Tax:

Year	1980	1981	1982	1983	1984	1985	1986 on
Miles/US gal	15.0	17.0	18.5	19.0	19.5	21.0.	22.5

(7) “Gas Guzzler” Car Tax (1991 and later)

Miles/US gal	0.00-12.5	12.5-13.5	13.5-14.5	14.5-15.5	15.5-16.5	16.5-17.5
Tax (USD)	7700	6400	5400	4500	3700	3000
Miles/US gal	17.5-18.5	18.5-19.5	19.5-20.5	20.5-21.5	21.5-22.5	22.5 & over
Tax (USD)	2600	2100	1700	1300	1000	0

The introduction of revised dynamometer specifications accompanying the introduction of the new SFTP emissions testing procedures means that the provisions of the Act will have to be amended to take into account the different load characteristics of the dynamometers.

B.3.6. IN-SERVICE EMISSIONS LEGISLATION AND ON-BOARD DIAGNOSTIC SYSTEMS

B.3.6.1. In-Use Surveillance Testing: Non-Routine Testing

There are two aspects to US in-service emissions testing. The first involves surveillance testing to ensure compliance with certification durability requirements (i.e. conformity with the 50 000 or 100 000 mile limits). The second extends the rigour of inspection and maintenance programmes. The requirements are summarised below and dealt with more fully in the **Appendix to Part 1**, **Section A.3.6**.

B.3.6.2. In-Use Surveillance Testing: Continuous Vehicle Surveillance

From model year 1992, defects on certain emission-related components/systems of in-use vehicles have to be reported for a period of 5 years after the end of that model year. A report has to be filed once a maximum of 25 defects have occurred on an individual part. The report includes a specification of the defective component(s), a description of the failure and details of the corrective action taken. Based upon this report, the EPA may decide upon a model recall.

B.3.6.3. Inspection and Maintenance Testing - Summary of State Programmes Before the Clean Air Act 1990 Amendment

Nearly every state had formulated its own inspection and maintenance programme by the end of 1986. The type and frequency of testing and the means of enforcement were left to the discretion of each state, subject to EPA's approval that the necessary performance criteria would be met.

About 65% of the programmes were performed by licensed local private garages or dealerships. Any vehicle which failed the inspection text was normally repaired at the same facility and re-inspected. The rest of the programmes involved testing at specialized facilities run by the state, or contractors, and were capable of handling large numbers of vehicles. Vehicles which failed had to be repaired elsewhere and returned to the test site for re-inspection. About three-quarters of the programmes limited the amount which owners had to pay to repair vehicles which did not comply. However, these ceilings did not normally apply to vehicles where the control systems had been tampered with. Most states required annual testing, although some, including California, specified biennial tests. About half the states required compliance with the I&M requirements as a prerequisite for vehicle registration renewal. Most of the others required a sticker certifying compliance to be displayed on the windscreen, non-compliance resulting in a fine.

Enhanced Inspection and Maintenance Testing was introduced with the Clean Air Act Amendments and is therefore covered in the **Appendix to Part 1**, **Section A.3.6.3**.

B.3.6.4. On-board diagnostic systems

A final Federal rule was established which required manufacturers to install on-board diagnostic (OBD) systems on light-duty vehicles and light-duty trucks beginning with the 1994 model year. The thresholds as defined in the FTP for OBD

system identification of emissions-related malfunction or deterioration are tabulated in the **Appendix to Part 1**, **Section A.3.6.4**.

B.3.6.5. Heavy Duty Smoke Tests

On 3 April 1997, the Environmental Protection Agency (EPA) recommended the use of the SAE J1667 procedure for state-operated in-use testing programs for highway heavy-duty diesel vehicles (HDDV). The SAE J1667 is a snap acceleration test under idle conditions, using engine inertia for loading, and is specifically designed for identifying excessive smoke emissions. Since it is a stationary vehicle test, the SAE J1667 can be conducted either at the roadside or in a test facility.

B.4. CALIFORNIA

B.4.1. VEHICLE EMISSION LIMITS

B.4.1.1. Light Duty Vehicles (1994 Standards)

California has always set more stringent emission limits than the rest of the US, and established a plan for the progressive reduction of vehicle emissions designed to enable the state to achieve national air quality standards by the year 2010. This plan involved the progressive introduction of so-called Transitional Low Emission Vehicles (TLEV), Low Emission Vehicles (LEV), Ultra-Low Emission Vehicles (ULEV) and Zero Emission Vehicles (ZEV). ZEVs are defined as vehicles which have no exhaust or evaporative emissions of any pollutant. These vehicles, except ZEVs, can use gasoline, diesel fuel or any alternative fuel and include dual-fuelled and flexible-fuelled vehicles. The California low-emission vehicle (LEV) regulations are administered by the California Air Resources Board (ARB) and apply to passenger cars, light duty trucks and medium duty vehicles. They are contained in various sections of chapter 1 (Motor Vehicle Pollution Control Devices), division 3 (Air Resources Board), title 13, California Code of Regulations (CCR).

The LEV exhaust emission standards were originally adopted in a 1990-1991 rulemaking, and generally became applicable in the 1994 model year. The LEV programme also includes requirements for the introduction of zero-emission vehicles (ZEVs).

Following a 5 November 1998 hearing, the ARB adopted the California “LEV II” regulations, which generally become applicable with the 2004 model year (although earlier certification to the LEV II standards is permitted). The LEV II regulations were formally adopted 5 August 1999 and became operative 27 November 1999. The original LEV standards are now referred to as the “LEV I” standards.

The standards for the various categories of LEV I are defined in **Table B.4.1**.

Table B.4.1 Californian 1994 Standards for Low Emissions Light Duty Vehicles - Gasoline, Diesel and Dual/Flexible-Fuelled Vehicles operating on Alternative Fuels

Category (1)	Emissions (g/mile) (2)									
	CO		NMOG (3) (4)		NOx		HCHO (5)		PM (6)	
Tier 1 gasoline	3.4	(4.2)(2)	0.25	(0.31)	0.4	(0.6)	0.015	(-)	-	(-)
Tier 1 diesel	-	(4.2)	-	(0.31)	-	(1.0)	0.015	(-)	-	(0.08)
TLEV	3.4	(4.2)	0.125	(0.156)	0.4	(0.6)	0.015	(0.018)	-	(0.08)
LEV	3.4	(4.2)	0.075	(0.090)	0.2	(0.3)	0.015	(0.018)	-	(0.08)
ULEV	1.7	(2.1)	0.04	(0.055)	0.2	(0.3)	0.008	(0.011)	-	(0.04)
ZEV	0.0		0.0		0.0		0.0		0.0	
EZEV (7)	(0.17)		(0.004)		(0.02)		-		(0.004)	

(1) Passenger cars and derivatives for 12 persons or less and light duty trucks with loaded vehicle weight 0-3 750 lb

(2) Limits for 50 000 miles with 100 000 miles in parentheses

(3) NMOG emission limits for dual and flexible fuelled vehicles operating on gasoline, TLEV 0.125 (0.156), LEV 0.075 (0.090), ULEV 0.040 (0.055) g/mile.

(4) The NMOG levels of alternative fuelled vehicles are adjusted using a Reactivity Adjustment Factor (RAF) to reflect the ozone-forming potential of the particular NMOG produced.

(5) HCHO = Formaldehyde (methanol and flexible fuelled vehicles only)

(6) Diesels only

(7) Compliance limits, FTP 75 cycle plus evaporative emissions, to be verified by in-use testing.

Manufacturers, selling more than a total of 3000 passenger cars, light duty trucks and medium duty vehicles were permitted to manufacture any combination of vehicles as long as sales-weighted emissions did not exceed a fleet average standard. This standard was defined in terms of non-methane organic gases (NMOG) emissions for the high emission, Tier 1, TLEV, LEV and ULEV vehicles comprising the fleet. Manufacturers were also able to accrue marketable credits for complying with or improving on the standards.

Furthermore, it was required that by 1998 ZEVs must account for 2% of manufacturers sales, this figure progressively rising to 10% in 2003. More recently this requirement has been relaxed, the obligation to begin selling any ZEVs being put back to 2003. This relaxation was however subject to Memoranda of Agreement between the CARB and the motor manufacturers to the effect that the required air quality improvements must still be achieved without the ZEVs and that the sale of cleaner cars nation-wide must begin with the 2001 model year, i.e. two years before they were required by federal law. In addition the CARB require a partnership agreement between itself and industry to continue with the development of advanced battery technology.

Table B.4.2 Original implementation schedule for Fleet Average NMOG and ZEVs for light duty vehicles

	1996	1997	1998	1999	2000	2001	2002	2003
NMOG (g/mile)	0.225	0.202	0.157	0.113	0.073	0.070	0.068	0.062
ZEV (%)			2	2	2	5	5	10

(1) Fleet average NMOG = ($NMOG_{nonHEV}$ + $NMOG_{HEV}$)/ total number of vehicles sold, where $NMOG_{nonHEV} = \sum_{Tier\ 1,\ TLEV,\ LEV,\ ULEV}$ (number of vehicles sold in each class x class factor), the class factors being, Tier 1 0.25, TLEV 0.125, LEV 0.075, ULEV 0.040 and where $NMOG_{HEV}$ is similarly calculated for the three classes of hybrid electric vehicle (HEV). The NMOG emissions are RAF adjusted.

(2) Fleet average NMOG for manufactures <3000 vehicle/annum is 0.075 g/mile starting 2000 model year

It was also been proposed by the CARB that any hybrid electric vehicle (HEV) which did not emit more pollutants per unit energy than would be emitted by a electric generating plant in the South Coast Air Basin region, should be classified as an equivalent zero emission vehicle (EZEV) and be given full ZEV credits in calculating the manufacturers fleet average. The evaporative emissions used in the calculations include those arising from storage and transportation of the fuel in addition to those emitted during driving and refuelling.

California also ruled that from 1994 "*major gasoline suppliers*", i.e. those companies having a refinery within California, which have a capacity greater than 50 000 barrels/day, and who own or lease more than 25 retail stations in the South Coast region, would be required to make available alternative fuels at retail outlets. However, the application of this rule was subject to the availability of a reasonable number of suitable vehicles.

B.4.1.2. Light Duty Trucks (1994 Standards)

Emissions limits and introduction schedules were applied to light duty trucks in a similar way to those for light duty vehicles, except that there was no requirement for ZEVs (see **Tables B.4.3** and **B.4.4**).

Table B.4.3 Californian standards for low emissions light duty trucks; gasoline, diesel and dual and flexible fuelled vehicles operating on alternative fuel

Category (1)	Emissions (g/mile) (2)									
	CO		NMOG (3)		NOx		HCHO (4)		PM (5)	
Tier 1 gasoline	4.4	(5.5)(2)	0.32	(0.40)	0.7	(0.97)	0.018	(-)	-	(-)
Tier 1 diesel	-	(5.5)	-	(0.40)	-	(1.5)	0.018	(-)	-	(0.08)
TLEV	4.4	(5.5)	0.160	(0.200)	0.7	(0.9)	0.018	(0.023)	-	(0.08)
LEV	4.4	(5.5)	0.100	(0.130)	0.4	(0.5)	0.018	(0.023)	-	(0.08)
ULEV	2.2	(2.8)	0.050	(0.070)	0.4	(0.5)	0.009	(0.013)	-	(0.04)
ZEV	0.0		0.0		0.0		0.0		0.0	

(1) Loaded weight 3750 - 5750 lb Light duty vehicle limits apply to LDT ≤3 750 lb

(2) Limits for 50 000 miles with 100 000 miles in parentheses

(3) NMOG emission limits for dual and flexible fuelled vehicles operating on gasoline, TLEV 0.32 (0.40), LEV 0.160 (0.200), ULEV 0.100 (0.130) g/mile.

(4) HCHO = Formaldehyde (methanol and flexible fuelled vehicles only)

(5) Diesels only

Table B.4.4 Implementation schedule for Fleet Average NMOG for light duty trucks

	Fleet Average NMOG (g/mile)							
	1996	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
NMOG (g/mile)	0.287	0.260	0.205	0.150	0.099	0.098	0.095	0.093

- Calculation of Fleet Average NMOG as for light duty vehicles.
- Manufacturers selling ≤3000 vehicles/annum exempt until 2000. For 2000 and subsequent model years NMOG requirement is 0.100 g/mile

B.4.1.3. Medium Duty Trucks (1994 Standards)

Emissions limits and introduction schedules were applied to medium duty trucks in a similar way to those for light duty trucks. At the request of the natural gas industry, a new vehicle category, the Super Ultra Low Emission Vehicle (SULEV) is under consideration which could be used to obtain emissions credits. The limits according to loaded weight categories are given in **Table B.4.5** and **B.4.6** for all these categories. The CARB are proposing to relax the limits for ULEV by increasing the CO limits to those equal to current LEV values and by increasing the 120 000 mile NOx emissions limits by 0.1 g/mile. The CARB are also proposing different standards and introduction schedules for engine-certified as distinct from vehicle-certified LEV, ULEV and SULEV.

Table B.4.5 Californian standards for low emissions medium duty trucks

Category	Emission Limits (g/mile) [1]					
	Test Weight (lb)	CO	NMOG [2]	NOx [3])	HCHO [4]	PM [5]
Tier 1	0 - 3750	3.4 (5.0)	0.25 (0.36)	0.4 (0.55)	0.015 (--)	-- (0.08)
	3751 - 5750	4.4 (6.4)	0.32 (0.46)	0.7 (0.98)	0.018 (--)	-- (0.10)
	5751 - 3500	5.0 (7.3)	0.39 (0.56)	1.1 (1.53)	0.022 (--)	-- (0.12)
	8501 - 10 000	5.5 (8.1)	0.46 (0.66)	1.3 (1.81)	0.028 (--)	-- (0.12)
	10 001 - 14 000	7.0 (10.3)	0.60 (0.86)	2.0 (2.77)	0.036 (--)	-- (0.12)
LEV	0 - 1750	3.4 (5.0)	0.125 (0.180)	0.4 (0.6)	0.015 (0.022)	-- (0.08)
	3751 - 5750	4.4 (6.4)	0.160 (0.230)	0.4 (0.6)	0.018 (0.027)	-- (0.10)
	5751 - 8500	5.0 (7.3)	0.195 (0.280)	0.9 (0.9)	0.022 (0.032)	-- (0.12)
	8501 - 10 000	5.5 (8.1)	0.230 (0.330)	0.7 (1.0)	0.028 (0.040)	-- (0.12)
	10 001 - 14 000	7.0 (10.3)	0.300 (0.430)	1.0 (1.5)	0.036 (0.052)	-- (0.12)
ULEV	0 - 3750	1.7 (2.5)	0.075 (0.107)	0.2 (0.3)	0.008 (0.012)	-- (0.04)
	3751 - 5750	2.4 (6.4)	0.100 (0.143)	0.4 (0.6)	0.009 (0.013)	-- (0.05)
	5751 - 8500	5.0 (7.3)	0.117 (0.167)	0.6 (0.9)	0.011 (0.016)	-- (0.06)
	8501 - 10 000	5.5 (8.1)	0.138 (0.197)	0.7 (1.0)	0.014 (0.021)	-- (0.06)
	10 001 - 14 000	7.0 (10.3)	0.180 (0.257)	1.0 (1.4)	0.018 (0.026)	-- (0.06)
SULEV	3751 - 5750	2.2 (3.2)	0.05 (0.072)	0.2 (0.3)	0.018 (0.027)	-- (0.05)
	5751 - 8500	2.5 (3.7)	0.059 (0.084)	0.3 (0.45)	0.022 (0.032)	-- (0.06)
	8501 - 10 000	2.8 (4.1)	0.069 (0.10)	0.35 (0.5)	0.028 (0.040)	-- (0.06)
	10 001 - 14 000	3.5 (5.2)	0.09 (0.13)	0.5 (0.7)	0.036 (0.052)	-- (0.06)

(1) Limits for 50 000 miles with 120 000 miles in parentheses

(2) NMHC for Tier 1 limits, ONMHE for alcohol fuelled vehicles. NMOG emission limits for dual and flexible fuelled vehicles operating on gasoline, LEV same as Tier 1 NMHC standards and ULEV same as LEV NMOG standards

(3) For dual and flexible fuelled vehicles, NOx emissions measured on the Federal Highway Fuel Economy test cycle must not be greater than 2.0 times the standard.

(4) HCHO = Formaldehyde (methanol and flexible fuelled vehicles only)

(5) Diesels only

Table B.4.6 Implementation schedule for Fleet Average NMOG for medium duty trucks

Vehicle Category	Percentage of MDV Fleet Delivered for Sale			
	2000	2001	2002	2003
LEV	75	95	90	85
ULEV	2	5	10	15
Proposed LEV	75	80	70	60
ULEV	2	20	30	40

Manufacturers selling ≤3000 vehicles/annum are exempt until 2001 model year when all fleet must be the 100% LEV

B.4.1.4. Light and Medium Duty Vehicles (2001/2006 Standards)

Table B.4.7 Exhaust Emission Standards: New 2001 - 2003 Model Year Tier 1 Vehicles, TLEV Passenger Cars and Light Duty Trucks; 2001 - 2006 Model Year LEV and ULEV Passenger Cars and Light Duty Trucks

Vehicle Description			Emission Limits (g/mile); (mg/mile for HCHO)				
Type	**Durability Mileage**	**Emission Category**	**NMOG (1)**	**CO**	**NOx**	**HCHO**	**PM (2) (3)**
All PCs; LDTs (0 - 3750 lb LVW)	50 000	Tier 1	0.25	3.4	0.4	n/a	0.08
		TLEV	0.125	3.4	0.4	15	n/a
		LEV	0.075	3.4	0.2	15	n/a
		ULEV	0.040	1.7	0.2	8	n/a
	100 000	Tier 1	0.31	4.2	0.6	n/a	n/a
		Tier 1 - diesel option	0.31	4.2	1.0	n/a	n/a
		TLEV	0.156	4.2	0.6	18	0.08
		LEV	0.090	4.2	0.3	18	0.08
		ULEV	0.055	2.1	0.3	11	0.04
LDTs (3751 - 5750 lb LVW)	50 000	Tier 1	0.32	4.4	0.7	n/a	0.08
		TLEV	0.160	4.4	0.7	18	n/a
		LEV	0.100	4.4	0.4	18	n/a
		ULEV	0.050	2.2	0.4	9	n/a
	100 000	Tier 1	0.40	5.5	0.97	n/a	n/a
		TLEV	0.200	5.5	0.9	23	0.10
		LEV	0.130	5.5	0.5	23	0.10
		ULEV	0.070	2.8	0.5	13	0.05

(1) For Tier 1 vehicles, NMOG = NMHC.

(2) Diesel vehicles only.

(3) Particulate standards are determined on a 50 000 mile basis for Tier 1 passenger cars and light duty trucks, on a 100 000 mile basis for all other passenger cars and light duty trucks and on a 120 000 mile basis for medium duty vehicles.

Table B.4.8 Exhaust Emission Standards: 2001-2003 Model Year Tier 1 Medium Duty Vehicles; and 2001-2006 Model Year LEV I, LEV, ULEV and SULEV Medium Duty Vehicles

Vehicle Description			Emission Limits (g/mile); (mg/mile for HCHO)				
Type (Weight lb ALVW)	Durability Mileage	Emission Category	NMOG (1)	CO	NOx	HCHO	PM (2) (3)
MDVs (3751 - 5750)	50 000	Tier 1	0.32	4.4	0.7	18	n/a
		LEV	0.16	4.4	0.4	18	n/a
		ULEV	0.10	4.4	0.4	9	n/a
		SULEV	0.05	2.2	0.2	4	n/a
	120 000	Tier 1	0.46	6.4	0.98	n/a	0.1
		LEV	0.23	6.4	0.6	27	0.1
		ULEV	0.143	6.4	0.6	13	0.05
		SULEV	0.072	3.2	0.3	13	0.05
MDVs (5751 - 8500)	50 000	Tier 1	0.39	5	1.1	22	n/a
		LEV	0.195	5	0.6	22	n/a
		ULEV	0.117	5	0.6	11	n/a
		SULEV	0.059	2.5	0.3	6	n/a
	120 000	Tier 1	0.56	7.3	1.53	n/a	0.12
		LEV	0.28	7.3	0.9	32	0.12
		ULEV	0.167	7.3	0.9	16	0.06
		SULEV	0.084	3.7	0.45	8	0.06
MDVs (8501 - 10 000)	50 000	Tier 1	0.46	5.5	1.3	28	n/a
		LEV	0.23	5.5	0.7	28	n/a
		ULEV	0.138	5.5	0.7	14	n/a
		SULEV	0.069	2.8	0.35	7	n/a
	120 000	Tier 1	0.66	8.1	1.81	n/a	0.12
		LEV	0.33	8.1	1	40	0.12
		ULEV	0.197	8.1	1	21	0.06
		SULEV	0.10	4.1	0.5	10	0.06
MDVs (10 001 - 14 000)	50 000	Tier 1	0.60	7	2	36	n/a
		LEV	0.30	7	1	36	n/a
		ULEV	0.18	7	1	18	n/a
		SULEV	0.09	3.5	0.5	9	n/a
	120 000	Tier 1	0.86	10.3	2.77	n/a	n/a
		LEV	0.43	10.3	1.5	52	0.12
		ULEV	0.197	10.3	1.5	26	0.06
		SULEV	0.13	5.2	0.7	13	0.06

(1) For Tier 1 vehicles, NMOG = NMHC.

(2) Diesel vehicles only.

(3) Particulate standards are determined on a 50 000 mile basis for Tier 1 passenger cars and light duty trucks, on a 100 000 mile basis for all other passenger cars and light duty trucks and on a 120 000 mile basis for medium duty vehicles.

Table B.4.9 SFTP Exhaust Emission Standards for 2001 through 2003 Model-Year Tier 1 and TLEV Passenger Cars and Light Duty Trucks

Vehicle Description				Emission Limits (g/mile)			
Vehicle Type	Loaded Weight (lb)	Durability Mileage	Fuel Type	NMHC + NOx Composite	CO		
					A/C Test	US06 Test	Composite Option
PC	All	50 000	Gasoline	0.65	3.0	9.0	3.4
			Diesel	1.48	n/a	9.0	3.4
		100 000	Gasoline	0.91	3.7	11.1	4.2
			Diesel	2.07	n/a	11.1	4.2
LDT	0 - 3750	50 000	Gasoline	0.65	3.0	9.0	3.4
			Diesel	1.48	n/a	9.0	3.4
		100 000	Gasoline	0.91	3.7	11.1	4.2
			Diesel	2.07	n/a	11.1	4.2
LDT	3751 - 5750	50 000	Gasoline	1.02	3.9	11.6	4.4
			Diesel	n/a	n/a	n/a	n/a
		100 000	Gasoline	1.37	4.9	14.6	5.5
			Diesel	n/a	n/a	n/a	n/a

Table B.4.10 SFTP Exhaust Emission Standards for LEVs, ULEVs, and SULEVs in the Passenger Car, Light Duty Truck, and Medium Duty Vehicle Classes [1]

Vehicle Description [2]		Emission Limits (g/mile)			
Vehicle Type [2]	Weight (lb)	US06 Test [3]		A/C Test [3]	
		NMHC + NOx	CO	NMHC + NOx	CO
PC	All	0.14	8.0	0.20	2.7
LDT	0 - 3750 (LVW)	0.14	8.0	0.20	2.7
LDT	3751 - 5750 (LVW)	0.25	10.5	0.27	3.5
MDV	3751 - 5750 (ALVW)	0.40	10.5	0.31	3.5
MDV	5751 - 8500 (ALVW)	0.60	11.8	0.44	4.0

(1) The standards represent the maximum SFTP exhaust emissions at 4000 miles for new 2001 and subsequent model LEVs, ULEVs, and SULEVs in the passenger car and light duty truck class, and new 2003 and subsequent model year LEV, ULEV and SULEV medium duty vehicles less than 8500 lb gross vehicle weight rating:

(2) The following definitions apply for purposes of this SFTP standards table only:
LDT is any motor vehicle rated at 6000 lb gross vehicle weight or less, which is designed primarily for purposes of transportation of property or is a derivative of such a vehicle, or is available with special features enabling off-street or off-highway operation and use.
MDV is any motor vehicle having a manufacturer's gross vehicle weight rating greater than 6000 lb and less than 14 001 lb, except passenger cars.

(3) For certification purposes, testing shall be conducted at 4000 miles ±250 miles or at the mileage determined by the manufacturer for emission-data vehicles.

B.4.1.5. Light and Medium Duty Vehicles (LEV II Standards – 2004 and Subsequent Model Years)

Following a 5 November 1998 hearing, the ARB adopted the California "LEV II" regulations, which generally become applicable with the 2004 model year (although earlier certification to the LEV II standards was permitted). The LEV II rulemaking also included the adoption of "CAP 2000" amendments which establish new motor vehicle certification and in-use test. These are applicable to 2001 and subsequent model motor vehicles. The LEV II regulations were formally adopted 5 August 1999 and became operative 27 November 1999. The original LEV standards are now referred to as the "LEV I" standards. These are reported in **Part 1**, **Section 4.1**.

B.4.1.6. Exhaust Emissions Standards - Light and Medium Duty Vehicles - Background Information and Additional Details

The LEV I Regulations

The LEV I standards include all of the California exhaust emission standards for 1981 through 2003 model-year passenger cars, light duty trucks and medium duty vehicles. The key portions of the LEV I programme are:

- Formaldehyde exhaust emission standards for 1993-2003 model methanol-fuelled passenger cars, light duty trucks and medium duty vehicles. Formaldehyde exhaust emission standards for 1992-2006 model LEV I TLEVs, LEVs, ULEVs and SULEVs in the passenger car, light duty truck, and medium duty vehicle classes.
- The non-LEV so-called "Tier 1" standards for 1995 through 2003 model passenger cars and light duty trucks, plus those for medium duty vehicles.
- The "LEV I" TLEV, LEV and ULEV standards for passenger cars and light duty trucks plus the "LEV I" LEV, ULEV and SULEV standards for medium duty vehicles.
- The fleet average NMOG requirements for the 2001-2003 model years. The fleet average NMOG mechanism requires manufacturers to introduce an incrementally cleaner mix of Tier 1, TLEV, LEV, ULEV and ZEV vehicles each year.

In addition, one section contains the Supplemental Federal Test Procedure (SFTP) standards which apply to both LEV I and LEV II vehicles.

All 2001 and subsequent model passenger cars, light duty trucks and medium duty vehicles certified to the LEV I or LEV II standards will be subject to the CAP 2000 certification procedures.

The ZEV Regulation

The LEV I regulations also included standards for ZEVs, and requirements that specified percentages of 1998 and subsequent model passenger cars and light duty trucks with a loaded vehicle weight of 0-3750 lbs. be certified as ZEVs. The LEV II rulemaking added provisions pertaining to partial ZEV credits. At a 25 January 2001 hearing, the ARB approved major amendments to the ZEV requirements which significantly reduced the number of full function ZEVs that were required in the initial years of the programme starting with MY 2003. In March 2003 the regulations were further amended, delaying the programme until 2005 at the earliest.

B.4.1.7. Exhaust Emissions Standards - Light and Medium Duty Vehicles: Subsidiary Legislation

This section provides details of NMOG limits, 50°F exhaust emission and cold temperature CO standards. It also describes other requirements, including emission credits, implementation schedules and in-use compliance standards.

Table B.4.11 50°F Exhaust Emission Standards

Limits for Vehicles Certified to the LEV I Standards								
Vehicle Weight Class (lb)	Emission Limits by Vehicle Category (g/mile)							
	TLEV		LEV		ULEV		SULEV	
	NMOG	HCHO	NMOG	HCHO	NMOG	HCHO	NMOG	HCHO
PCs; LDTs 0 - 3750 LVW	0.25	0.030	0.150	0.030	0.080	0.016	n/a	n/a
LDTs 3751 - 5750 LVW	0.312	0.036	0.180	0.036	0.110	0.018	n/a	n/a
MDVs 3751 - 5750 TW	n/a	n/a	0.320	0.036	0.200	0.018	0.100	0.008
MDVs 5751 - 8500 TW	n/a	n/a	0.390	0.064	0.234	0.032	0.118	0.016
MDVs 8501 - 10 000 TW	n/a	n/a	0.460	0.080	0.276	0.042	0.138	0.020
MDVs 10 001 - 14 000 TW	n/a	n/a	0.600	0.072	0.360	0.036	0.180	0.018

- All light- and medium duty TLEVs, LEVs, ULEVs and SULEVs must demonstrate compliance with the above exhaust emission standards for NMOG and formaldehyde measured on the FTP (40 CFR, Part 86, Subpart B) conducted at a nominal test temperature of 50°F. The NMOG mass emission result shall be multiplied by the applicable reactivity adjustment factor, if any, prior to comparing to the applicable adjusted 50 000 mile certification standards detailed above. Emissions of CO and NOx measured at 50°F shall not exceed the standards applicable to vehicles of the same emission category and vehicle type subject to a cold soak and emission test at 68 to 86°F. Natural gas and diesel-fuelled vehicles are exempt from the 50°F test requirements.

Table B.4.12 2001 and Subsequent Model Year Cold Temperature Carbon Monoxide Exhaust Emissions Standards for Passenger Cars, Light Duty Trucks, and Medium Duty Vehicles

Vehicle Type & Weight Class (lb)	CO (g/mile)
All PCs, LDTs 0 - 3750 LVW	10.0
LDTs, 3751 - 5750 LVW LDTs 3751 LVW - 8500 GVW LEV I and Tier 1 MDVs, 0 - 8500 ALVW	12.5

- These standards are applicable to vehicles tested in accordance with 40 CFR Part 86 Subpart C at a nominal temperature of 20°F (-7°C). Natural gas vehicles, diesel-fuelled vehicles, and medium duty vehicles with a gross vehicle weight rating greater than 8500 lb are exempt from these standards.

Table B.4.13 Other Requirements and Emission Credits (1)

Requirement/Credit	Details
Highway NOx Standard	The maximum emissions of oxides of nitrogen measured on the Federal Highway Fuel Economy Test (HWFET; 40 CFR 600 Subpart B) shall not be greater than 1.33 times the applicable PC and LDT standards or 2.0 times the applicable MDV standards. Both the projected emissions and the HWFET standard shall be rounded in accordance with ASTM E29-67 to the nearest 0.1 g/mile (or 0.01 g/mile for vehicles certified to the 0.05 or 0.02 g/mile NOx standards) before being compared.
Requirements for Vehicles Certified to the Optional 150 000 Mile Standards	A vehicle that is certified to the 150 000 mile standards shall generate additional NMOG fleet average credit, or additional vehicle equivalent credits, provided that the manufacturer extends the warranty on high-priced parts to 8 yr or 100 000 miles, whichever occurs first, and agrees to extend the limit on high mileage in-use testing to 150 000 miles. A manufacturer that certifies to the 150 000 mile SULEV standards shall also generate a partial ZEV allocation.
Optional LEV NOx Standard	A manufacturer may certify up to 4% of its light duty truck fleet from 3751 lb LVW - 8500 lb GVW with a maximum base payload of 2500 lb or more, to the LEV, option 1, standard based on projected sales of trucks in this category. Passenger cars and light duty trucks 0 - 3750 lb LVW are not eligible for this option.
NMOG Credit for Vehicles with Zero-Evaporative Emissions	In determining compliance of a vehicle with the applicable exhaust NMOG standard, a gram per mile NMOG factor, based on available data, shall be subtracted from the reactivity-adjusted NMOG exhaust emission results for any vehicle that has been certified to the "zero" evaporative emission standard set forth in title 13, CCR, section 1976(b)(1)(E). This credit shall not apply to a SULEV that generates a partial ZEV allowance.
NMOG Credit for Direct Ozone Reduction Technology	A manufacturer that certifies vehicles equipped with direct ozone reduction technologies shall be eligible to receive NMOG credits that can be applied to the NMOG exhaust emissions of the vehicle when determining compliance with the standard. In order to receive credit, the manufacturer must submit the following information for each vehicle model, including, but not limited to: a demonstration of the airflow rate through the direct ozone reduction device and the ozone-reducing efficiency of the device over the range of speeds encountered in the SFTP test cycle; an evaluation of the durability of the device for the full useful life of the vehicle; and a description of the on-board diagnostic strategy for monitoring the performance of the device in-use. Using the above information, the value of the NMOG credit will be based on the calculated change in the one-hour peak ozone level using an approved airshed model.
NOx Credits for Pre-2004 MDVs Certified to the LEV I LEV or ULEV Standards	Prior to the 2004 model year, a manufacturer may earn a 0.02 g/mile per vehicle NOx credit for MDVs between 6000-8500 lb GVW certified to the LEV I LEV or ULEV standards for PCs and LDTs. The manufacturer may apply the credit on a per vehicle basis to the NOx emissions of LDTs between 6000-8500 lb GVW certified to the PC/LDT LEV or ULEV standards for the 2004 to 2008 model years.

(1) A complex system for calculating NMOG credits and debits has been proposed. Interested readers should refer to the original document for details.

Table B.4.14 Fleet Average NMOG Phase-In Requirements for Passenger Cars and Light Duty Trucks - Volume Production [1]

Model Year	Fleet Average NMOG (g/mile) (50 000 mile Durability Vehicle Basis) [Weight Classes in lb] [2] [3]		Model Year	Fleet Average NMOG (g/mile) (50 000 mile Durability Vehicle Basis) [Weight Classes in lb] [2] [3]	
	All PCs; LDTs 0 - 3750 LVW	LDTs 3751 LVW - 8500 GVW		All PCs; LDTs 0 - 3750 LVW	LDTs 3751 LVW - 8500 GVW
2001	0.070	0.098	2006	0.046	0.062
2002	0.068	0.095	2007	0.043	0.055
2003	0.062	0.093	2008	0.040	0.050
2004	0.053	0.085	2009	0.038	0.047
2005	0.049	0.076	2010+	0.035	0.043

(1) Different limits apply to small manufacturers - See Note 4.

(2) Each manufacturer's fleet average NMOG value for the total number of PCs and LDTs produced and delivered for sale in California shall be calculated as follows:
$\sum$ [Number of vehicles in a test group x applicable emission standard] + $\sum$ [Number of hybrid electric vehicles in a test group x HEV NMOG factor] = Total Number of Vehicles Produced, including ZEVs and HEVs
The applicable emission standards to be used in the above equation are as follows:

Model Year	Emission Category	Emission Standard Value [Weight Classes in lb)	
		All PCs; LDTs 0 - 3750 LVW	LDTs 3751 - 5750 LVW
2001 and subsequent (AB 965 vehicles only)	Tier 1	0.25	0.3
2001 - 2003	Tier 1	0.25	0.3
2001 - 2006 model year vehicles certified to the "LEV I" standards (For TLEVs, 2001 - 2003 model years only)	TLEVs	0.125	0.160
	LEVs	0.075	0.100
	ULEVs	0.040	0.050
Model Year	**Emission Category**	**All PCs; LDTs 0-3750 LVW**	**LDTs 3751 LVW - 8500 GVW**
2001 and subsequent model year vehicles certified to the "LEV II" standards	LEVs	0.075	0.075
	ULEVs	0.040	0.040
	SULEVs	0.01	0.01
2001 and subsequent model year vehicles certified to the optional 150 000 mile "LEV II" standards for PCs and LDTs	LEVs	0.06	0.06
	ULEVs	0.03	0.03
	SULEVs	0.0085	0.0085

(3) The HEV NMOG factor for light duty vehicles is calculated as follows:
LEV HEV Contribution Factor = 0.075 - [(Zero-emission VMT Factor) x 0.035]
ULEV HEV Contribution Factor = 0.040 - [(Zero-emission VMT Factor) x 0.030]
where Zero-emission VMT Factor for HEVs is determined in accordance with Section C.3 of the "California Exhaust Emission Standards and Test Procedures for 2003 and Subsequent Model Zero-Emission Vehicles, and 2001 and Subsequent Model Hybrid Electric Vehicles, in the Passenger Cars, Light Duty Trucks and Medium Duty Vehicles Classes," as incorporated by reference in section 1962(e), title 13, CCR.

(4) Requirements for Small Volume Manufacturers.
(a) In 2001 through 2003 model years, a small volume manufacturer shall not exceed a fleet average NMOG value of 0.075 g/mile for PCs and LDTs from 0-3750 lb LVW or 0.100 g/mile for LDTs from 3751-5750 lb In 2004 and subsequent model years, a small volume manufacturer shall not exceed a fleet average NMOG value of 0.075 for PCs and LDTs from 0-3750 lb LVW or 0.075 for LDTs from 3751 lb LVW - 8500 lb.

(b) If a manufacturer's average California sales exceeds 4500 units of new PCs, LDTs, MDVs and heavy duty engines based on the average number of vehicles sold for the three previous consecutive model years, the manufacturer shall no longer be treated as a small volume manufacturer and shall comply with the fleet average requirements applicable to larger manufacturers beginning with the fourth model year after the last of the three consecutive model years.
(c) If a manufacturer's average California sales falls below 4500 units of new PCs, LDTs, MDVs and heavy duty engines based on the average number of vehicles sold for the three previous consecutive model years, the manufacturer shall be treated as a small volume manufacturer and shall be subject to the requirements for small volume manufacturers beginning with the next model year.

Table B.4.15 Fleet Average NMOG Medium Duty Vehicle Phase-In Requirements

Model Year	Vehicles Certified to These Proposals (%)		Vehicles Certified to title 13 CCR Section 1956.8(g) or (h) (%)		
	LEV	ULEV	Tier 1	LEV	ULEV
2001	80	20	100	0	0
2002	70	30	0	100	0
2003	60	40	0	100	0
2004 +	40	60	0	0	100

- Beginning with the 2004 model year, a manufacturer shall phase-in at least one test group per model year to the MDV LEV II standards.
- For the 2001 and subsequent model years, each manufacturer's MDV fleet shall be defined as the total number of California-certified MDVs produced and delivered for sale in California. The percentages shall be applied to the manufacturers' total production of California-certified medium duty vehicles delivered for sale in California.
- **Requirements for Small Volume Manufacturers:** In 2001 and subsequent model years, a small volume manufacturer shall certify, produce, and deliver for sale in California LEVs in a quantity equivalent to 100% of its MDV fleet.

Table B.4.16 Implementation Schedules for SFTP Emission Standards - PCs and of LDTs Certified to Tier 1 and TLEV (1)

Model Year	Percentage of PC and LDT Fleet
2001	25
2002	50
2003	85
2004 and subsequent	100

(1) Excluding small volume manufacturers.

- For the purposes of the implementation schedule, each manufacturer's PC and LDT fleet shall be defined as the total projected number of Tier 1 and TLEV PCs and LDTs from 0-5750 lb LVW sold in California. As an option, a manufacturer may elect to have its total PC and LDT fleet defined, for the purposes of this implementation schedule only, as the total projected number of the manufacturer's PCs and LDTs, other than zero-emission vehicles, certified and sold in California.

Table B.4.17 Implementation Schedules for SFTP Emission Standards - PCs and of LDTs Certified to LEV, ULEV and SULEV (1)

Model Year	Percentage	
	PC, LDT	MDV
2001	25	NA
2002	50	NA
2003	85	25
2004	100	50
2005 and subsequent	100	100

(1) Excluding small volume manufacturers.

- A manufacturer may use an "Alternative or Equivalent Phase-in Schedule" to comply with the phase-in requirements. An "Alternative Phase-in" is one that achieves at least equivalent emission reductions by the end of the last model year of the scheduled phase-in. Model-year emission reductions shall be calculated by multiplying the percent of vehicles (based on the manufacturer's projected California sales volume of the applicable vehicle fleet) meeting the new requirements per model year by the number of model years implemented prior to and including the last model year of the scheduled phase-in. The "cumulative total" is the summation of the model year emission reductions (e.g., a four model year 25/50/85/100% phase-in schedule would be calculated as: (25% $\times$ 4 yr) + (50% $\times$ 3 yr) + (85% $\times$ 2 yr) + (100% $\times$ 1 year) = 520). Any alternative phase-in that results in an equal or larger cumulative total than the required cumulative total by the end of the last model year of the scheduled phase-in shall be considered acceptable under the following conditions: 1) all vehicles subject to the phase-in shall comply with the respective requirements in the last model year of the required phase-in schedule and 2) if a manufacturer uses the optional phase-in percentage determination, the cumulative total of model year emission reductions as determined only for PCs and LDTs certified must also be equal to or larger than the required cumulative total by end of the 2004 model year. A manufacturer shall be allowed to include vehicles introduced before the first model year of the scheduled phase-in (e.g., in the previous example, 10% introduced one year before the scheduled phase-in begins would be calculated as: (10% $\times$ 5 yr) and added to the cumulative total).
- For the purposes of the implementation schedule, each manufacturer's PC and LDT fleet shall be defined as the total projected number of low-emission, ultra-low-emission and super-ultra-low-emission PCs and LDTs from 0-5750 lb loaded vehicle weight sold in California. Each manufacturer's MDV fleet shall be defined as the total projected number of low-emission, ultra-low-emission, and super-ultra-low-emission MDVs less than 8501 lb gross vehicle weight rating sold in California.

Table B.4.18 Intermediate In-Use Compliance Standards for MDVs: 3751-14 000 lb ALVW

Vehicle Description			Intermediate In-Use Compliance Standards by Weight Class (lb) (1) (g/mile)							
			3751 - 5750		5751 - 8500		8501 - 10 000		10 001 - 14 000	
Emission Category	Model Year	Durability Mileage	NMOG	NOx	NMOG	NOx	NMOG	NOx	NMOG	NOx
ULEV	2002	50 000	0.128	--	0.156	--	0.184	--	0.240	--
	2002	120 000	0.160	--	0.195	--	0.230	--	0.300	--
SULEV	prior to 2002	50 000	0.072	0.3	0.084	0.45	0.100	0.5	0.130	0.7
	2002	120 000	0.100	0.4	0.117	0.6	0.138	0.65	0.180	1.0

(1) Dashes mean that the standards in **Table B.4.7** apply.

- The standards include fuel-flexible, bi-fuel and dual-fuel vehicles when operating on an available fuel other than gasoline and apply for the specified model years only. In-use compliance with standards beyond 50 000 miles shall be waived through the model year for SULEVs.

Table B.4.19 Intermediate In-Use Compliance Standards for Model Year 2001 Fuel-Flexible, Bi-Fuel and Dual-Fuel Medium Duty SULEVs Operating on Gasoline

Test Weight (lb)	Vehicle Emission Category	Limit (g/mile)
3751 - 5750	SULEV	0.128
5751 - 8500	SULEV	0.156
8501 - 10 000	SULEV	0.184
10 001 - 14 000	SULEV	0.240

- Compliance with the standards beyond 50 000 miles will be waived for the 2001 model year for SULEVs.

Reactivity Adjustment Factors

A reactivity adjustment factor is the ratio of the specific reactivity of a low-emission vehicle designed to operate on a fuel other than conventional gasoline (including a fuel-flexible, bi-fuel or dual-fuel vehicle when operating on any fuel other than conventional gasoline) compared to the NMOG baseline specific reactivity of vehicles in the same vehicle emission category operating on conventional gasoline.

Table B.4.20 Reactivity Adjustment Factors Applicable Through the 2003 Model Year

Fuel (1)	Light Duty Vehicles 0-6000 lb GVW			Medium Duty Vehicles 6001- 14 000 lb GVW	
	TLEV	LEV	ULEV	LEV	ULEV
	Baseline Specific Reactivity (grams ozone / gram NMOG)				
Conventional gasoline	3.42	3.13	3.13	3.13	3.13
	Reactivity Adjustment Factors				
Phase 2 RFG	0.98	0.94	0.94	0.94	0.94
M85	0.41	0.41	0.41	0.41	0.41
Natural gas	1.0	0.43	0.43	0.43	0.43
LPG	1.0	0.50	0.50	0.50	0.50
	Methane Reactivity Adjustment Factors				
Natural gas	0.0043	0.0047	0.0047	0.0047	0.0047

(1) Details of the fuel specifications will be found in **Section B.4.4**.

Determination of Specific Reactivity

The following procedure is used to establish reactivity adjustment factors for exhaust emissions of non-methane organic gases (NMOG) for the purpose of certifying a vehicle of specific emission category and fuel for sale in California. A representative speciated NMOG exhaust emission profile for light and medium duty low-emission vehicles is established according to the following conditions:

(i) Speciated NMOG profiles are obtained from a statistically valid number of vehicles in each vehicle emission category and fuel type. The maximum incremental reactivities to be used are provided in the "California Non-Methane Organic Gas Test Procedures," Part II, section A.100.5.4.

(ii) The speciated NMOG profiles identify and quantify, in units of grams / mile or milligrams / mile, all compounds above the specified laboratory limit of detection as measured in accordance with the procedures specified in the "California Non-Methane Organic Gas Test Procedures."

The "grams ozone per mile" value of each organic compound identified in the speciated profile are determined by multiplying the "grams per mile NMOG" emission value of each compound by the applicable maximum incremental reactivity value as specified in the "California Non-Methane Organic Gas Test Procedures."

The "total grams ozone per mile" of NMOG exhaust emissions from each vehicle emission category and fuel type is the sum of all the organic compounds values calculated in the preceding paragraph. The specific reactivity of each vehicle emission category and fuel type is then determined by dividing the "total grams ozone per mile" value by the "total grams per mile of NMOG emissions."

B.4.1.8. Evaporative Emissions

The California evaporative emissions test is given in the **Appendix to Part 1**, **Section A.4.3.8**. The SHED emission limit of 2 g/test has been replaced by limits including diurnal, hot soak and running losses according to the schedule given in **Tables B.4.21** and **B.4.22** below. All diesel vehicles and CNG fuelled HDV are exempt. The California limits were similar to the Federal limits but the implementation schedule was quicker. From the 1996 model year, evaporative leaks as small as the equivalent of a 1 mm diameter orifice must be detected and the detection limit was reduced to 0.5 mm diameter from the 2000 model year. For medium duty vehicles (6000-8500 lb GVW) the Federal refuelling emission legislation was also applied in California.

Table B.4.21 Evaporative Emissions Limits - Hot Soak/72 Hour Diurnal Test

Vehicle Type	Model Year	Hydrocarbons (1)	
		Three-Day Diurnal +Hot Soak (grams/test) Useful Life (2)	Running Loss (grams/mile) Useful Life (2)
Passenger cars	1995 - 2005	2.0	0.05
Light Duty Trucks		2.0	0.05
Medium duty vehicles (6001 - 8500 lbs. GVWR):			
with fuel tanks < 30 gallons		2.0	0.05
with fuel tanks > 30 gallons		2.5	0.05
(8501-14 000 lbs. GVWR) (3)		3.0	0.05
Hybrid electric passenger cars	1993 - 2005	2.0	0.05
Hybrid electric light duty trucks		2.0	0.05
Hybrid electric medium duty vehicles		2.0	0.05

(1) Organic Material Hydrocarbon Equivalent for alcohol-fuelled vehicles.

(2) For purposes of this paragraph, “useful life” shall have the same meaning as provided in Title 13, California Code of Regulations.

(3) For the 1995 through 2005 model years, the evaporative emission standards for incomplete vehicles in this weight range shall be 2.0 grams/test and compliance with the evaporative emission standards shall be based on the test procedures specified in paragraph 4.g. of the “California Evaporative Emission Standards and Test Procedures for 1978 and Subsequent Model Motor Vehicles.”

Table B.4.22 Evaporative Emissions Limits - Hot Soak/48 Hour Diurnal Test

Vehicle Type	Model Year	Hydrocarbons[1] Two-Day Diurnal + Hot Soak (g/test) Useful Life [2]
Passenger cars	1996 - 2005 [3]	2.5
Light Duty Trucks		2.5
Medium duty vehicles (6001 - 8500 lbs. GVWR)		
with fuel tanks < 30 gallons		2.5
with fuel tanks > 30 gallons		3.0
(8501 - 14 000 lbs. GVWR)		3.5
Hybrid electric passenger cars		2.5
Hybrid electric light duty trucks		2.5
Hybrid electric medium duty vehicles		2.5

(1) Organic Material Hydrocarbon Equivalent for alcohol-fuelled vehicles.

(2) For purposes of this paragraph, "useful life" shall have the same meaning as provided in Title 13, California Code of Regulations

(3) The two-day diurnal plus hot soak evaporative emission standards (hereinafter "supplemental standards") shall be phased-in beginning with the 1996 model year. Those vehicles certified under the running loss and useful life standards for the 1996 through 2005 model years must also be certified under the supplemental standards.

B.4.1.9. Cold Start CO Emissions for Light Duty Vehicles, Light and Medium Duty Trucks

All 1996 and subsequent model year vehicles, with the exception of natural gas, diesel fuelled, hybrid electric and zero emission vehicles, must meet a cold CO limit when tested over the full FTP 75 cycle at a nominal start and test temperature of 20°F (-7°C). The limit is 10 g/mile for light duty vehicles and medium duty trucks with a test weight <3 750 lb. For other light and medium duty trucks the limit is 12.5 g/mile. The standard applies to the intermediate life of 50 000 miles.

B.4.1.10. Hybrid Electric and Zero Emissions Vehicles - Exhaust Emission Standards

The standards are described in **Part 1**, **Section 4.1.5**.

B.4.1.11. Heavy Duty Vehicles

The CARB was required by the US Senate to adopt low-emission standards for transit buses. Limits of 4.0 and 0.05 g/bhp.h for NOx and particulates respectively were approved in June 1993 and adopted in 1996. Credits were allowed for NOx levels of 2.5 g/bhp.h NOx and above in 0.5 g/bhp.h increments, which could be sold to stationary sources under a mobile source credit programme developed by several Californian air districts. Each engine manufacturer was allowed to apply for an exemption for up to 10% of its output, if it could be demonstrated that not all of its engine models would meet the 1996 standards. Furthermore, low aromatic and low sulphur diesel fuels were allowed for certification testing for the 1996 and 1997 model years.

Table B.4.23 Exhaust Emission Standards for Heavy Duty Diesel-Cycle Engines

Vehicle Category	Model Year	CO [1] (g/bhp.h)	NMHC [2] (g/bhp.h)	THC [2] (g/bhp.h)	NOx [3] (g/bhp.h)	PM [4] (g/bhp.h)
Diesel	1995 - 1997	15.5	1.2	1.3	5.0	0.10
	from 1998	15.5	1.2	1.3	4.0	0.10
	from 2004	15.5	1.2	1.3	2.4	0.10
Urban Buses	from 1996	15.5	1.2	1.3	4.0	0.05 (0.07)[5]

(1) An idle limit of 0.5 %v CO applies to engines using exhaust after-treatment.

(2) NMHC are optional for all engines except methanol fuelled engines. For methanol engines THC limit is for OMHCE. A 0.05 g/bhp.h max limit for HCHO applies to methanol engines from 1996.

(3) Optional certification in 0.5 g/bhp.h NOx intervals below the limit allowed for the purpose of obtaining emissions credits. Useful life for NOx is 10 years for 1998 model year and later.

(4) Diesel engine smoke opacity limits of 20 % in acceleration mode, 15 % in lugging mode and 50 % peak.

(5) In-use test value.

Table B.4.24 Exhaust Emission Standards for Heavy Duty Otto-Cycle Engines

Model Year	Emissions (g/bhp-hr)			
	Total HC or OMHCE [1]	Optional NMHC [1]	CO [2]	NOx
1995 - 1997	1.9 [3]	1.7 [3]	37.1 [3]	5.0
1998 - 2003 [4]	1.9 [3]	1.7 [3]	37.1 [3]	4.0
	1.9 [3]	1.7 [3]	37.1 [3]	1.5 to 0.5 [5]
	(NMHC + NOx)		CO	
2004 [4]	2.4 g/bhp-hr; or 2.5 with 0.5 g/bhp-hr cap on NMHC		37.1	

(1) The total or optional non-methane hydrocarbon standards apply to petroleum-, natural-gas- and liquefied-petroleum-gas- engines and methanol-fuelled engines beginning in 2004. The Organic Material Hydrocarbon Equivalent, or OMHCE, standards apply to 1987 through 2003 methanol-fuelled engines. Formaldehyde exhaust emissions from new 1993 and subsequent model methanol-fuelled Otto-cycle engines shall not exceed 0.05 g/bhp-hr.

(2) Prior to the 2002 model year, carbon monoxide emissions from engines utilizing exhaust after treatment technology shall also not exceed 0.5% of the exhaust gas flow at kerb idle.

(3) These standards are applicable to Otto-cycle engines intended for use in all heavy duty vehicles.

(4) A manufacturer may request to certify to Option 1 or Option 2 federal NMHC + NOx standards.

(5) These are optional standards and apply to all heavy duty engines intended for use only in vehicles with a gross vehicle weight rating greater than 14 000 lbs. A manufacturer may elect to certify to an optional standard between the values, inclusive, by 0.5 grams per brake horsepower-hour increments.

Table B.4.25 HD Evaporative Emissions Limits

Vehicle Type	Model Year	Hydrocarbons [1]		
		Three-Day Diurnal +Hot Soak (grams/test) Useful Life [2]	Running Loss (grams/mile) Useful Life [2]	Two-Day Diurnal + Hot Soak (g/test) Useful Life [2]
Heavy Duty vehicles (over 14 000 lbs. GVWR)	1995 - 2005	2.0	0.05	-
	1996 - 2005	-	-	4.5
	Post 2004	1.0	0.05	1.25

(1) Organic Material Hydrocarbon Equivalent for alcohol-fuelled vehicles.

(2) For purposes of this table, "useful life" shall have the same meaning as provided in Title 13, California Code of Regulations.

All transit buses have been equipped with positive crankcase ventilation (PCV) systems beginning since 1996 model year. PCV systems are required on all heavy-duty vehicles except for turbo-charged diesel engines.

B.4.1.12. Exhaust Emission Standards - 1985 and Subsequent Model Heavy Duty Urban Bus Engines and Vehicles

Section 1956.1 of Title 13 of the California Code of Regulations was amended in 2005. Exhaust emissions from new 1985 - 2003 and subsequent model heavy-duty diesel cycle urban bus engines are shown below. Limits for more modern vehicles are tabulated in **Part 1**, **Section 4.1.7**.

Table B.4.26 Urban Bus Engine Emissions Limits (1985 – 2003)

Model Year	HC [1] (g/bhp.h)	Optional NMHC (g/bhp.h)	CO (g/bhp.h)	NOx (g/bhp.h)	PM (g/bhp.h)
1985 - 1986	1.3	-	15.5	5.1	-
1987 [2]	1.3	-	15.5	5.1	-
1988 – 1990	1.3	1.2	15.5	6.0	0.60
1991 – 1993 [3]	1.3	1.2	15.5	5.0	0.10
1994 – 1995 [3]	1.3	1.2	15.5	5.0 [4]	0.07
1996 – 2003 [5], [6]	1.3	1.2	15.5	4.0	0.05 [7], [8]

(1) Organic Material Hydrocarbon Equivalent [OMHCE] for methanol-fuelled buses

(2) A manufacturer may certify to the 1988 emission standards one year early as an option

(3) Emissions from methanol-, natural-gas- and LPG-fuelled urban bus engines may be included in the averaging programme for petroleum-fuelled engines other than urban bus engines.

(4) Or optional 3.5 g/bhp.h to 0.5 g/bhp.h NOx

(5) For 1996 and 1997 only, a manufacturer may apply to the Executive Officer for an exemption from the 4.0 g/bhp.h NOx standard, not to exceed 10% of the average of the manufacturer's total urban bus sales in California for the three preceding model years, upon providing technical justification and sales data for each exemption applied for.

(6) 1998 through 2003 model year engines may generate averaging, banking, and trading credits in accordance with the requirements for averaging, banking and trading programmes set forth in "California Exhaust Emission Standards and Test Procedures for 1985 and Subsequent Model Heavy Duty Diesel Engines and Vehicles". Manufacturers may choose to certify 1998 through 2002 model year bus engines produced before 1 October, 2002, to an optional NOx emissions standard between 0.5 g/bhp.h and 2.5 g/bhp.h. A manufacturer may certify to any standard between the values of 2.5

g/bhp.h and 0.5 g/bhp.h, by 0.5 g/bhp.h increments. Manufacturers may not use engines certified to this optional NOx standard for any averaging, banking, or trading programme.

(7) 0.07 PM g/bhp.h in-use

(8) October 1, 2002, PM standard - For diesel-fuelled, dual-fuel, and bi-fuel bus engines except for heavy-duty pilot ignition engines, the PM standard shall be 0.01 g/bhp.h (0.01 PM g/bhp.h in-use) for 2002 and subsequent model year engines produced beginning 1 October, 2002. Manufacturers may choose to meet this standard with an aftertreatment system that reduces PM to 0.01 g/bhp.h.

B.4.1.13. Fleet Rule for Transit Agencies

Section 2023.1 of Title 13 of the California Code of Regulations was amended in 2005. The objective of the regulation is to encourage transit agencies that operate urban bus fleets to purchase or lease lower emission alternative-fuel buses, while also providing flexibility to such fleet operators to determine their optimal fleet mix in consideration of such factors as air quality benefits, service availability, cost, efficiency, safety, and convenience. Two paths to compliance with this fleet rule are available: the alternative-fuel path and the diesel path. The rule is described in the **Appendix to Part 1**, **Section A.4.1.8**.

B.4.1.14. California – Refuse Collection Vehicle Emissions Regulations

A final regulation order entitled “Diesel Particulate Matter Control Measure for On-road Heavy-duty Diesel-fuelled Residential and Commercial Solid Waste Collection Vehicles” was adopted in 2004 within Chapter 1, Division 3, Title 13, of the California Code of Regulations. Details will be found in the **Appendix to Part 1**, **Section A.4.1.9**.

B.4.1.15. Motor Cycle Emissions Standards

Current and future emissions limits are shown in **Part 1**, **Section 4.9** and background information will be found in the **Appendix to Part 1**, **Section A.4.1.10**.

B.4.1.16. Non-road Diesel Emissions Standards

On 28 January 2001 CARB adopted identical standards to those published for the Federal States (see **Section B.3.1.9**).

B.4.1.17. Emission Standards for 2001 and Later Model Year Non-road Large Spark-Ignition Engines

On 28 January 2001 CARB adopted identical standards to those published for the Federal States (see **Part 1**, **Section 3.1.5**). Before then, manufacturers had to comply with the following exhaust emissions from new off-highway recreational vehicles and engines that are “sold, leased, used, or introduced into commerce” in California:

Table B.4.27 California 1997 and Later Model Year Off-Road Recreational Vehicles and Engines Exhaust Emission Standards

Vehicle & Model Year	Emission Limits (g/km)			
	HC	NOx	CO	PM (1)
Off-Road Motorcycles and All-Terrain Vehicles with engines greater than 90 cc; 1977 and later	1.2 (2)	-	15.0	-
Off-Road Motorcycles and All-Terrain Vehicles with engines less than 90 cc; 1979 and later	1.2 (2)	-	15.0	-
All-Terrain Vehicles option; 1997 and later	All-Terrain Vehicle Shall comply with exhaust emission standards equivalent to the off-road motorcycle and all-terrain vehicle standard using the 1995 and later Utility and Lawn and Garden Equipment Engines standards			
Golf Carts in Federal Ozone Non-Attainment Areas; 1997 and later	0	0	0	0

(1) Applicable to diesel and two-stroke spark ignited engines only.

(2) Compliance with the 1.2 gram per kilometre HC standard to be applied as a “corporate average”

B.4.2. FUEL QUALITY REGULATIONS AND SPECIFICATIONS

B.4.2.1. Phase 2 & Phase 3 Reformulated Gasoline

In California, "*Phase 1*" requirements for reformulated gasoline were introduced for some areas from January 1992. Sales of leaded gasoline were banned and summer RVP was limited to 7.8 psi/53.8 kPa max. Deposit control additives were also required (to meet the BMW test limits).

The Californian Air Resources Board (CARB) subsequently adopted more rigorous "*Phase 2*" requirements to replace the previous grade at retail outlets by June 1996. The specification included stringent limits on distillation, olefins and sulphur contents. These are described in detail in **Part 1**, **Section 4.2.1**.

California Change-Over from MTBE to Ethanol

During 2003, supply constraints arose in the distribution system when MTBE was replaced by ethanol in gasoline.

Refiners produce a base unfinished reformulated gasoline mixture to which the ethanol is added. This base material is referred to as reformulated gasoline blendstock for oxygenate blending, or RBOB. In the case of California, the material is called CARBOB, since it meets more stringent emission standards than Federal RBOB. Ethanol is transported and stored separately from other petroleum products because of its affinity for water in the gasoline distribution system, and the ethanol is only blended into CARBOB as the material is loaded onto trucks to be delivered to retail gasoline stations. CARBOB is also a separate product from MTBE-blended RFG. Terminals have a limited number of tanks and are generally unable to accommodate additional gasoline formulations that must be kept segregated. The result was that terminals that switched to ethanol-blended gasoline were, in some instances, no longer be able to supply filling stations that still required MTBE-blended gasoline, reducing supply system flexibility.

The switch from MTBE to ethanol affected California supply in three ways. The change to ethanol reduced the volume of gasoline California refiners could produce. The reduction occurred because:

- only about half the volume of ethanol is used to replace the MTBE removed, and
- because other light components must be removed to meet summer specifications, (because ethanol has a higher blending vapour pressure than MTBE).

The result was that for 8 months of the year refiners' gasoline production was reduced by over 10 percent, which had to be replaced with supply from outside of the State. This loss of production capability gave rise to the second supply impact of the switch to ethanol, which is California's need to import both more and different blending components for gasoline production. MTBE, which was largely shipped from outside the State, must be replaced with one-half the quantity of ethanol, which similarly comes from outside California. In addition, the other half of the MTBE volume lost, and the light ends removed when ethanol is added, must be replaced with high-quality components that will meet the rigorous California gasoline specifications. More CARBOB could also be imported, but in the past only a very few refiners around the world could produce the California-quality gasoline. The net result was that the change pushes California, which has been mostly self-sufficient in meeting its gasoline needs, to require greater volumes of high-quality imports. Since supply is limited, this requirement put upward pressure on California's gasoline prices.

The third impact of the change-over to ethanol was that the switch in early 2003 was only partial, with a still significant fraction of California gasoline being made with MTBE. This had both positive and negative aspects for the California market. On the positive side, it reduced the volume loss from California refiners and the need for imports. On the negative side, it created a market with two types of gasoline that had to be kept separated, which produced complications within the California distribution and logistics system.

California has two major geographically separate gasoline markets. The first is the northern California market with five major refineries in the San Francisco Bay area, which also supply product to northern Nevada. Two refineries in Bakersfield satisfy local demand and also move product north by pipeline. In the south, six refineries located in the Los Angeles area provide product to southern California, Las Vegas, and Arizona. When the shift to ethanol occurred, three refineries in northern California still produced MTBE-blended gasoline, and only one in the south continued to use MTBE. The southern refinery using MTBE was smaller than any one of the three northern refineries using the ether. On the market side, the independent marketers historically looked to the refiners that had not switched to ethanol-blended gasoline for most of their supply. Given the non-fungibility of the two fuels, retailers could not easily switch back and forth between MTBE- and ethanol-blended gasolines.

Further changes took place in 2004. While the logistics system remain constrained, several factors eased many of the problems, including the return to virtually one gasoline. EPA's decision allowing the elimination of the requirement for an oxygenate in summertime Arizona Cleaner Burning Gasoline (CBG) may have made it easier for the California refining industry to supply CBG. This is because it reduced the constraints on gasoline blending and may facilitate imports from abroad

to serve Arizona. However, other factors worked against smooth supply. These included:

- Total gasoline production capability was reduced because all refineries were producing CARBOB.
- More material had to be brought in from outside the State.
- MTBE bans in New York and Connecticut created demand for high-quality, summer-grade gasolines, similar to CARBOB, in the second quarter of 2004. This increased competition for the same type of gasoline and components required by California.

B.4.2.2. Diesel Fuel Compositional Specification

See the **Appendix to Part 1**, **Section A.4.2.2**.

B.4.2.3. Alternative Fuels

California has specifications for a range of alternatives and these are tabulated the **Appendix to Part 1**, **Section A.4.2.3**.

B.4.3. EMISSIONS AND FUEL ECONOMY TEST PROCEDURES

US Federal procedures are generally used, but a number of specific tests are also employed and these are described in the **Appendix to Part 1**, **Section A.4.3**.

B.4.4. REFERENCE FUELS

California has proposed alternative specifications for reference fuels to those generally employed by the US EPA and these are tabulated in **Part 1**, **Section 4.4**.

B.4.5. FUEL CONSUMPTION AND CO_2 REGULATIONS

See **Part 1**, **Section 3.5** for details of the US Federal regulations

B.4.6. IN-SERVICE EMISSIONS LEGISLATION AND ON-BOARD DIAGNOSTIC SYSTEMS

B.4.6.1. In-Use Surveillance Testing: Non-Routine Testing

There are two aspects to US and Californian in-service emissions testing. The first involves surveillance testing to ensure compliance with certification durability requirements (i.e. conformity with the 50 000 or 100 000 mile limits). The second extends the rigour of existing inspection and maintenance programmes.

Random FTP-75 checks of in-use vehicles will be carried out by the administrator at mileages below 50/75 000 miles. Additionally, in California, an evaporative emissions test will be conducted, depending on the manufacturers certification procedure. (EPA Surveillance Test Programmes/Title 13 CCR, Section 2136 - 2140).

B.4.6.2. In-Use Surveillance Testing: Continuous Vehicle Surveillance

From model year 1990, defects on specified emissions-related components and systems of in-use vehicles have to be reported for a period of 5/10 years, or 50 000/100 000 miles, depending on the warranty period (Title 13, CCR). The reporting procedure consists of three steps, where each step requires more and more detailed information. The reporting requirements also ask for information with regard to the number of defects, analysis of those defects and the effects on exhaust emissions. CARB will decide upon a recall, based upon the second and third report stages.

B.4.6.3. Heavy Duty Smoke Tests

In April 1991 CARB introduced a new smoke law for road-side checks and enforcement began in November 1991. The inspection consists of a "*snap-idle*" test, employing a full flow, end-of-line opacity meter (SAE J1243, May 1988). Three accelerations to full governed speed are to be conducted - each acceleration should take approximately 5 to 7 seconds. The following limit values apply:

- Pre-1991 engines: 55% opacity (maximum)
- 1991 and newer engines: 40% opacity (maximum)

B.4.6.4. Inspection and Maintenance Testing

Introduction

Readers should refer to the summary of State Programmes before the Clean Air Act 1990 Amendment for earlier information. (See **Section B.3.6.3**). The Smog Check Programme is administered by the Bureau of Automotive Repair (BAR), which is a part of the California Department of Consumer Affairs (DCA). The Air Resources Board (ARB), by contrast, is a part of the California Environmental Protection Agency. Details of current programmes will be found in the **Appendix to Part 1**, **Section A.4.6.1**.

B.4.6.5. On-board diagnostic systems

Whereas the EPA's enforcement strategy is based on in-use testing as a means of achieving the aim of reducing emissions from cars in use, the CARB approach is to place the emphasis on pre-production vehicle testing and on specifying the standard of the OBD system itself.

The original OBD regulation specified monitoring requirements for the oxygen sensor, EGR system and other emissions-related components. In July 1990 the CARB adopted the so-called OBD II regulations. These required 1994 and subsequent model passenger cars, light-duty trucks and medium-duty vehicles and engines, to be fitted with on-board diagnostic systems to monitor catalyst efficiency, engine misfire, evaporative system integrity, secondary air injection, and chlorofluorocarbon (CFC) containment. These requirements were amended in 1991, 1993 and more extensively in 1995. The amendments allow manufacturers to take advantage of advances in technology in meeting the requirements and to allow more time to address the problems associated with low emissions vehicles, and vehicles with engines using diesel fuel, alternative fuels or with lean-burn

combustion systems. More information on the OBD II requirements will also be found in the **Appendix to Part 1**, **Section A.4.6.2**.

B.4.6.6. Truck Idling Rules

A new Regulation, referred to as section 2485, was adopted on 31 January 2005. This regulation is included within Chapter 10 - Mobile Source Operational Controls, Article 1 - Motor Vehicles, Division 3. Air Resources Board, title 13, California Code of Regulations. Its purpose is to reduce public exposure to diesel particulate matter and other air contaminants by limiting the idling of diesel-fuelled commercial motor vehicles. It applies to diesel-fuelled commercial motor vehicles that operate in the State of California with gross vehicle weight ratings of greater than 10,000 pounds that are or must be licensed for operation on highways. This specifically includes both Californian and non-Californian based vehicles. Further details will be found in the **Appendix to Part 1**, **Section A.4.6.4**.

B.5. CANADA

B.5.1. VEHICLE EMISSIONS LIMITS

The current limits for vehicles of all types are set out in the **Appendix to Part 1**, **Section A.5.1.1**.

B.5.1.1. 1997 Regulations

On 23 October 1995, following recommendations from its Task Force on Cleaner Vehicles and Fuels, the Council of Ministers of the Environment (CCME) published amendments to the Motor Vehicle Safety Regulations which came into effect on 1 September 1997. These amendments fulfilled previous government commitments, including the Canada/US Agreement on Air Quality, the CCME's Management Plan for NOx and VOCs and an international agreement on NOx controls.

The amendments were designed to harmonise Canadian emissions standards with the US Federal standards and, in addition to gasoline and diesel-fuelled vehicles, cover vehicles operating on alternative fuels and motorcycles. The new standards were the same as the US Federal Tier 1 standards. Light-duty vehicles (except diesels) were also required to meet the 10 g/mile CO standard at -7°C. In addition, the NOx emissions requirement for heavy-duty vehicles was reduced from 5 to 4 g/bhp.h. The motorcycle limits of 5 g/km HC and 12 g/km CO were the same as those already accepted under a Memorandum of Understanding with the US for imports. Evaporative emissions limits were progressively introduced from the 1998 model year and now apply to all vehicles. Refuelling emissions regulations were adopted and the requirements for OBD systems also apply.

British Columbia

Local regulations in British Columbia required that vehicle warranties covered the emission control equipment beginning with the 1997 model year. The requirement for catalytic converters was a life of 8 years or 120 000 km. British Columbia also applied US Federal emission standards for passenger cars and light duty trucks for the 1998 to 2000 model years. Furthermore, these vehicles had to meet the California LEV exhaust emission standards from the 2001 model year.

B.5.1.2. Light Duty Vehicles and Light Duty Trucks – 2001/2003 Legislation

On 11 June 2001, the Minister of the Environment, motor vehicle manufacturers, the Canadian Vehicle Manufacturers' Association, and the Association of International Automobile Manufacturers of Canada signed a voluntary Memorandum of Understanding. This set out the general terms and conditions of emissions standards for the 2001, 2002, and 2003 model years applicable to light duty vehicles (passenger cars) and light duty trucks (e.g. vans, pick-up trucks, sport-utility vehicles, etc.).

For the 2001, 2002 and 2003 model years the parties agreed that new light duty vehicles and light duty trucks sold or offered for sale in Canada by the motor vehicle manufacturers would be equipped with the same emissions control and monitoring

equipment as the equivalent US Federal models, designed to meet applicable US Federal emission standards.

B.5.2. FUEL QUALITY REGULATIONS AND SPECIFICATIONS

B.5.2.1. Gasoline Standards

Gasoline regulations and standards are recorded in **Section 5** of both **Part 1** and the **Appendix to Part 1**.

B.5.2.2. Diesel Fuel Standards

Diesel fuel regulations and standards are recorded in **Section 5** of both **Part 1** and the **Appendix to Part 1**.

Sulphur

Environment Canada introduced a regulation requiring 500 mg/kg maximum sulphur content for all Canadian diesel fuel used for on-road applications. Canada Gazette II was issued on 19 February, 1997 as the final regulation, with an implementation date of 1 January 1998.

British Columbia Diesel Fuel Regulations

In 1994 British Columbia adopted a regulation requiring low sulphur diesel fuel (500 mg/kg) in the Lower Fraser Valley and, as of 1 April 1995, throughout the entire province.

B.5.2.3. Unleaded Automotive Gasoline (CAN/CGSB-3.5-2004)

This standard applies to four grades of gasoline to which no lead or phosphorus compounds have been added. They are intended for use in spark ignition engines under a wide range of climatic conditions. Gasoline specified in this standard may contain methyl tertiary butyl ether (MTBE) or other aliphatic ethers. Provincial and federal regulations control some parameters included in this standard. Where such regulations establish more restrictive limits than those given in this standard, the regulated limits shall apply.

The standard was published in November 2004, and amended in August 2005. It supersedes CAN/CGSB-3.5-99. See the **Appendix to Part 1**, **Section A.5.2.2**.

B.5.2.4. Oxygenated Unleaded Automotive Gasoline Containing Ethanol (CAN/CGSB3.511-93)

Scope

This standard applies to four grades of oxygenated gasoline to which no lead or phosphorus compounds have been added and in which the oxygenate consists essentially of ethanol. They are intended for use in spark ignition engines under a wide range of climatic conditions.

The standard was originally published in September 1993 and superseded CANKGSB-3.5 11-M90. It has been amended five times, the last update being published in December 1997. Details will be found in the **Appendix to Part 1**, **Section A.5.2.3**.

B.5.2.5. Automotive Low-Sulphur Diesel Fuel Standard (CAN/CGSB-3.517-2000)

Scope

The supply of low-sulphur diesel fuel (less than 500 mg/kg) to on-road (also called on-highway) vehicles was required as of January1, 1998. The supply of ultra low-sulphur diesel fuel (less than 15 mg/kg) to on-road vehicles is required by mid 2006.

The standard was first published in December 2000 and has subsequently been amended twice. It was last updated in September 2004 and details will be found in **Part 1**, **Section 5.2.5**.

B.5.2.6. Regular Sulphur Diesel Fuel Standard (CAN/CGSB-3.6-2000)

Scope

This standard applies to two types of diesel fuel, Type A and Type B, that are suitable for use in high-speed diesel engines. Both types may be used in off-road diesel-powered equipment. Type A is intended for use when ambient temperatures require better low temperature properties than those exhibited by Type B.

The standard was first published in December 2000 and supersedes CAN/CGSB-3.6-M90. It has been amended twice, the last revision being issued in September 2004. The standard will be found in **Part 1**, **Section 5.2.6**.

B.5.2.7. Automotive Low-Sulphur Biodiesel Fuel Standard (CAN/CGSB-3.520-2005)

Scope

This standard applies to two types of automotive low-sulphur (LS) diesel fuel containing low levels of biodiesel esters, Type A-LS, Bx and Type B-LS, Bx. Bx represents biodiesel fuel containing x percent by volume of biodiesel ester component in the range of 1.0 to 5%. Fuel to this standard is intended for use in high-speed diesel engines that require low-sulphur diesel fuel to meet emission control regulations and high-speed diesel-powered equipment.

The standard was first published in April 2005 and is tabulated in **Part 1**, **Section 5.2.7**.

B.5.2.8. Future Automotive Fuel Standards

On 19 February 2001, the Environment Minister made public the details of a ten year Plan of Action for cleaner vehicles, engines and fuels as an integral part of the Government of Canada's Clean Air Strategy. Environment Canada plans to continue its approach of generally aligning Canadian environmental fuel

requirements with those of the US, while taking into consideration environmental standards developed by the European Union. The Action Plan is described in greater detail in the **Appendix to Part 1**, **Section A.5.2.8**.

B.5.3. EMISSIONS AND FUEL ECONOMY TEST PROCEDURES

Canada has adopted US Federal procedures.

B.5.4. REFERENCE FUELS

As Canadian emissions standards are harmonised with the US Federal standards, similar certification fuels are employed.

B.5.5. FUEL ECONOMY AND CO_2 REGULATIONS

An agreement on climate change action was signed by the Government of Canada and the Canadian automobile industry on 5 April 2005. This is described in **Part 1**, **Section 5.5**

B.5.6. IN-SERVICE EMISSIONS LEGISLATION AND ON-BOARD DIAGNOSTIC SYSTEMS

These Regulations apply to vehicles and engines that are manufactured in Canada, or imported into Canada, on or after January 1, 2004. They are described in **Part 1, Section 5.6**.

B.6. CENTRAL & SOUTH AMERICA

B.6.1. VEHICLE EMISSIONS LIMITS

A number of countries in South America have introduced emissions limits based generally on US or EU regulations. These are tabulated in the **Appendix to Part 1**, **Section A.6.1**.

B.6.2. FUEL QUALITY REGULATIONS AND SPECIFICATIONS

B.6.2.1. Argentina Gasoline Specifications

Table B.6.28 Gasoline Specifications (pre-2003): Argentina

Property			Grade	
			Regular	Prem.
Octane				
	Research	min	83	93
Volatility				
	Distillation			
	10% (°C)	max	70	70
	End point (°C)	max	225	225
Composition				
	Lead (g/l)	max	(1)	(1)
	Aromatics content (% v/v)	max	45	45
	Benzene content (% v/v)	max	4.0	4.0
	Oxygen (% m/m)	max	2.7	2.7

(1) Lead content (g/l, max): leaded = 0.20; unleaded = 0.013.

The following specifications came into effect in 2003 and further changes are planned between 2006 and 2009.

Table B.6.29 Gasoline Specifications (Post-2003): Argentina

Property		Regular	Premium
RON	mín	83	93
MON	mín	75	84
Distillation:			
10% (°C)	max	70	70
FBP (°C)	max	225	225
RVP (kPa)			
(Regional and seasonal variations)			
A		35-70	35-70
B		45-80	45-80
C		55-90	55-90
Benzene (% v/v)	max	2.5	2.5
Aromatics (% v/v)	max	45	45
Lead (g/l)	max	0.013	0.013
Oxygen (% m/m) (1)	max	2.7	2.7
Sulphur (mg/kg)	max	600	350
MTBE (% v/v)	max	15	15
Ethanol (% v/v) (2)	max	5	5
Isopropyl alcohol (% v/v) (2)	max	5	5
Tertiary butyl alcohol (2)	max	7	7
Isobutyl alcohol (2)	max	7	7

(1) Maximum permitted oxygen concentration if displayed at the dispensing pump: 3.7% m/m.

(2) If displayed at the dispensing pump, the following maximum concentrations of individual alcohols (up to the 3.7% m/m oxygen limit) are permitted:

Alcohol	% v/v
Ethanol	12
Isopropyl alcohol	10
Tertiary butyl alcohol	7
Isobutyl alcohol	10

B.6.2.2. Chile Gasoline Specifications

Table B.6.30 Leaded Gasoline Specification (Withdrawn): Chile

Property		Limits wef 01/09/02
RON		93.0
Aromatics	% v/v (max)	30.0 (1)
Benzene	% v/v (max)	2.0 (1)
Oxygen	% m/m	Report
RVP (S/W)	psi (max)	7.5/10.0
Olefins	% v/v (max)	20.0 (1)
Lead	g/l (max)	0.4
Sulphur	% m/m (max)	0.1 (1)

B.6.2.3. Chile Diesel Fuel Specifications

Table B.6.31 Diesel Fuel Specifications - Chile

Properties		Metropolitan	Regional	Metropolitan	Metropolitan	Regional
		Diesel A1 (1990s/2000+) (1)	Diesel B	Diesel A1	July 2004	July 2004
Sulphur (mg/kg)	max	500	3000	300	50	2000
Cetane index	min	48		48		
Cetane number	min	50	45	50		46
Flash point (ºC)	min	52	52	52		
90% distillation (ºC)		282 - 338	282 - 357	282 - 338		282 - 350
Aromatics (% v/v)	max	35		35		35
Polycyclic aromatic hydrocarbons (% v/v)	max	10		10	5	
Nitrogen (mg/kg)	max	170		170		300
Viscosity (mm^2/s)		1.9 - 4.1	1.9 - 5.5	1.9 - 4.1		
Carbon residue (10% distillation residue):						
Conradson	max	0.20	0.34	0.20		
Ramsbottom	max	0.21	0.35	0.21		
Ash (% m/m)	max	0.01	0.01	0.01		
Density @ 15°C, kg/m^3		830 - 850	830 - 870 (2)	830 - 850		850 ± 20
Water and sediment (% m/m)	max	0.1	0.1	0.1		
Copper strip corrosion	max	2	2	2		

(1) Prior to 01/04/2000, the cetane number was 48 and sulphur content was 1500 mg/kg. This fell to 1000 mg/kg on that date. On 01/04/2002, the sulphur was further reduced to 500 mg/kg and the cetane number increased to 50. No comparable data for Diesel B are available.

(2) For regions XI and XII the minimum density is 815 kg/m^3.

See the **Appendix to Part 1** for the proposed 2005 specification.

B.6.2.4. Peru Diesel Fuel Specifications

Table B.6.32 Diesel Fuel Specifications - Peru

Properties		Pre 2004	
		Diesel No 1	**Diesel No 2**
Sulphur content (mg/kg)	max	3000	10000
Cetane index	min	-	-
Cetane number	min	40	45
Flash point (ºC)	min	43	52
Distillation:			
90% distillation (ºC)	max or range	288	357
95% distillation (ºC)	max	-	-
Recovered @ 250ºC (% v/v)	max	-	-
Recovered @ 350ºC (% v/v)	max	-	85
Colour	max	2	3
Viscosity (mm^2/s)		1.4 - 2.5	1.3 - 2.4
Ramsbottom carbon residue (on 10% distillation residue)	max	0.15	0.35
Ash (% m/m)	max	0.01	0.02
Water and sediment (% v/v)	max	0.05	0.1
Copper strip corrosion (3 h @ 50°C)	max	3	3
Particulate contamination (mg/l)	max	-	-
Pour point (ºC)	max	- 12	4

B.6.3. EMISSIONS AND FUEL ECONOMY TEST PROCEDURES

CONCAWE have no information on emissions and fuel economy test procedures for the region.

B.6.4. REFERENCE FUELS

See the **Appendix to Part 1, Section A.6.4**.

B.6.5. FUEL CONSUMPTION AND CO_2 REGULATIONS

CONCAWE are unaware of any current fuel consumption and CO_2 regulations in the region.

B.6.6. IN-SERVICE EMISSIONS LEGISLATION AND ON-BOARD DIAGNOSTIC SYSTEMS

See the **Appendix to Part 1, Section A.6.6**.

B.7. JAPAN

B.7.1. VEHICLE EMISSION LIMITS

B.7.1.1. Introduction

Emissions legislation in Japan is complex with a wide variety of limits and test cycles. Current legislation dates from December 1989 when the Central Council for Environmental Pollution Control (CCEPC) recommended new emission limits with both short-term and long-term targets. Their aim was to set up stringent standards which were technologically feasible, and, in due course, to apply the same standards for both gasoline and diesel fuelled vehicles. Based on this proposal, the Ministry of Transport (MOT) revised the emission regulations in May 1991 to incorporate the short-term limits.

Legislation, proposed by a joint MOT/MITI/EA study, further reducing NOx in urban areas was adopted in December 1992 and took effect in December 1993. It controlled the population of older vehicles and imposed even tougher emission limits on new vehicles.

Existing requirements are given in the following tables. Prior legislation is given in **Report No. 6/97**, **Tables A.1.53** and **A.1.54**. On 21 November 1997, the Central Environment Council issued a report entitled “Future policy for motor vehicle exhaust emissions reduction (Second Report)”.

B.7.1.2. 1975 – 1999 Emission Limits

Gasoline and LPG Vehicles

Table B.7.1 Japanese exhaust emission limits - Gasoline and LPG Vehicles

Vehicle Category			Test Mode (1)	Emission Species		Regulation Year	Regulation Maximum Value (2)	Regulation Average Value (2)	Notes
Gasoline /LPG vehicles	Passenger cars	4-stroke and 2-stroke	10·15M (g/km)	CO		1975	2.70	2.10	
				HC		1975	0.39	0.25	
				NOx		1978	0.48	0.25	(3)
			11M (g/test)	CO		1975	85.0	60.0	
				HC		1975	9.50	7.00	
				NOx		1978	6.00	4.40	
	Trucks and buses	4-stroke mini-size	10·15M (g/km)	CO		1998	8.42	6.50	
				HC		1998	0.39	0.25	
				NOx		1998	0.48	0.25	
			11M (g/test)	CO		1998	104	76	
				HC		1998	9.50	7.00	
				NOx		1998	6.00	4.40	
		LD (GVW≤1.7t)	10·15M (g/km)	CO		1988	2.70	2.10	
				HC		1988	0.39	0.25	
				NOx		1988	0.48	0.25	
			11M (g/test)	CO		1988	85.0	60.0	
				HC		1988	9.50	7.00	
				NOx		1988	6.00	4.40	
		MD (1.7t<GVW≤2.5t)	10·15M (g/km)	CO		1998	8.42	6.50	
				HC		1998	0.39	0.25	
				NOx		1994	0.63	0.40	
			11M (g/test)	CO		1998	104	76	
				HC		1998	9.50	7.00	
				NOx		1994	6.60	5.00	
		HD (2.5t<GVW)	G13M (g/kWh)	CO		1998	68.0	51.0	
				HC		1998	2.29	1.80	
				NOx		1995	5.90	4.50	
				HC		1994	3.80	2.90	(4)
				NOx	DI	1997, 1998, 1999	5.80	4.50	
					IDI		5.80	4.50	
				PM			0.49	0.25	
2-wheeled motor vehicles		4-stroke	2-wheel motor vehicles (g/km)	CO		1998, 1999	20.0	13.0	
				HC			2.93	2.00	
				NOx			0.51	0.30	(5)
		2-stroke		CO			14.4	8.00	
				HC			5.26	3.00	
				NOx			0.14	0.10	

(1) 10·15-mode (10·15M) represents a typical driving pattern in urban areas. 11-mode (11 M) is typical driving pattern of cold-started vehicle travelling from the suburbs to the urban centre.

(2) Both maximum and mean limits are stipulated - the mean limits shown here apply to production ≥2000 units/y and are to be met as a type approval limit and as a production average. The maximum limits apply for production of <2000 units/y and generally as an individual limit in series production.

(3) 2-stroke vehicles are not currently in production.

(4) CO limits on LPG-fuelled vehicles: 105 g/kWh max., 76 g/kWh average.

(5) Enforcement year

(i) Motorcycle type I, mini-size two-wheel motor vehicle: 1998

(ii) Motorcycle type II, two-wheel motor vehicle: 1999

- Maximum permitted age for vehicles in urban areas:

Vehicle Type	Age (Years)
Passenger cars	10
Commercial vehicles <5t	8
Heavy trucks	9
Buses	12

Evaporative Emissions

Current test limits are to be retained but the existing Carbon Trap method of determination has been replaced by a new procedure employing a SHED. A "mid-summer" diurnal test is incorporated. The new procedure was introduced between 2000 and 2002, depending on vehicle model.

Diesel Vehicles

Table B.7.2 Japanese exhaust emission limits - Diesel Vehicles

Vehicle Category			Test Mode [1]	Emission Species		Regulation			Notes
						Year	Maximum Value [2]	Average Value [2]	
Diesel vehicles	Passenger cars	All	10·15M (g/km)	HC		1998	2.29	1.80	
				NOx		1995	5.90	4.50	
				CO		1986	2.70	2.10	
				HC		1986	0.62	0.40	
				NOx	Small	1997	0.55	0.40	[3]
					Medium	1998	0.55	0.40	
				PM	Small	1997	0.14	0.08	
					Medium	1998	0.14	0.08	
	Trucks and buses	LD (GVW≤1.7t)	10·15M (g/km)	CO		1988	2.70	2.10	
				HC		1988	0.62	0.40	
				NOx		1997	0.55	0.40	
				PM		1997	0.14	0.08	
		MD (1.7t<GVW≤2.5t)	10·15M (g/km)	CO		1993	2.70	2.10	
				HC		1993	0.62	0.40	
				NOx		[4]^	0.97	0.70	
				PM		[4]^	0.18	0.09	
		HD (2.5t<GVW)	D13M (g/kWh)	CO		1994	9.20	7.40	GVW≤3.5t, 1997
				HC		1994	3.80	2.90	
				NOx	DI	1997, 1998, 1999	5.80	4.50	3.5t<GVW≤12t, 1998
					IDI		5.80	4.50	
				PM			0.49	0.25	12t<GVW, 1999

(1) 10·15-mode (10·15M) represents a typical driving pattern in urban areas. 11-mode (11 M) is typical driving pattern of cold-started vehicle travelling from the suburbs to the urban centre.

(2) Both maximum and mean limits are stipulated - the mean limits shown here apply to production ≥2000 units/y and are to be met as a type approval limit and as a production average. The maximum limits apply for production of <2000 units/y and generally as an individual limit in series production.

(3) For diesel vehicles, "small-size" are vehicles with an equivalent inertia weight (EIW) of 1.25t (vehicle weight of 1.265t) or less, and "medium-size" are vehicles with EIW of more than 1.25t (vehicle weight of 1.265t).

(4) Implementation dates: 1997 for manual transmissions; 1998 for automatic transmissions.

- Maximum permitted age for vehicles in urban areas:

Vehicle Type	Age (Years)
Passenger cars	10
Commercial vehicles <5t	8
Heavy trucks	9
Buses	12

Japan Diesel Emissions Targets

In December 1998 the Central Environment Council (CEC) published its third report on "Future policy for motor vehicle exhaust emission reduction". This called for a further tightening of NOx and PM limits for diesel engines in two stages and these are described in **Part 1** and the **Appendix to Part 1**.

B.7.1.3. Long-Term Diesel Emissions Target (2003/2005)

In early 2002, the CEC recommended new long-term regulations for vehicles and fuels. The proposals are particularly stringent for heavy duty buses and trucks (above 3.5 tons) with regard to PM and NOx emissions. These are tabulated in **Part 1**, **Section 7.1.3**.

B.7.1.4. Japan Clean Air Programme

At the end of 1996, an Auto/Oil Programme was launched. The "Japan Clean Air Programme" (JCAP) was a tripartite activity between the government (mainly represented by MITI), the auto industry (JAMA) and the oil industry (PAJ). The Petroleum Energy Centre (PEC), in collaboration with automobile and oil industries in Japan, conducted the programme.

JCAP I

JCAP I activities were carried out for five years (1997 - 2001) as the first stage of the Japan Clean Air Programme. The programme can be summarized as follows:

- Analysis of the relationship between fuel properties and exhaust emissions reduction measures for current/future technology low emission engines (both spark- and compression ignition).
- Combustion analysis in diesel engines.
- An examination of the health effects of diesel particulate matter.

The first stage was completed in time for the results to be fed into the Japan Clean Air Act Three Year Amendment in 1999, leading to the gasoline vapour pressure voluntary agreement and phased reduction of fuel sulphur described in **Part 1**.

B.7.2. FUEL QUALITY REGULATIONS AND SPECIFICATIONS

B.7.2.1. Introduction

Unleaded regular gasoline was introduced in 1975 and the market became totally unleaded in 1987. Following an amendment to the air pollution laws in April 1995, it was required that from 1 April 1996 gasoline specifications should include mandatory limits on sulphur (0.01% m/m), benzene (5% v/v), methanol (nil) and MTBE (7% v/v max). There are, however, currently no specification limits on aromatics content or olefins content. Sulphur contents average around 35 ppm, well below the 100 ppm limit. In December 1998 the oil industry was requested to enter a voluntary agreement to further reduce summer vapour pressure to 72 kPa by 2001 and to supply all gasolines at the "lowest possible" vapour pressure. The industry adopted the voluntary limit of 72 kPa.

In the spring of 2002, the Central Environment Council (CEC) recommended new long-term regulations for vehicles and fuels. The proposed fuel quality requirements include a reduction in sulphur for both gasoline and diesel to less than 50 mg/kg by the end of 2004. The sulphur content of diesel fuel was reduced to 50 mg/kg in April 2003, ahead of the deadline for the end of 2004. The CEC has also suggested to further study sulphur reduction to facilitate the use of sophisticated after-treatment systems. In addition, the Council has requested that the VP of gasoline be set to below 65 kPa, commencing summer 2005 and the industry will adopt this voluntary limit.

The current specifications are shown in **Part 1**, **Section 7.2**.

B.7.3. EMISSIONS AND FUEL ECONOMY TEST PROCEDURES

B.7.3.1. Introduction – Obsolete Procedures

The exhaust emission test regime in Japan is complex and four procedures were used in the past. New tests were introduced in March 1991 and the obsolete tests are:

(1) ***10 Mode test*** - a hot start urban driving cycle including accelerations up to 40 km/h, the principal cycle used for passenger cars and light vehicles powered by gasoline or LPG fuelled engines. From 1986 this procedure also applied to diesel vehicles up to 1700 kg GVW.

(2) ***11 Mode test*** - a cold start driving cycle test introduced in 1975 to supplement the 10 mode test. Speeds up to 60 km/h are reached during the cycle.

(3) ***6 Mode test*** - a test based on weighted average emissions over steady-state modes. This test was used for vehicles over 2500 kg GVW and also for diesel-powered vehicles above 1700 kg GVW, different versions of the test being used for gasoline and diesel vehicles.

(4) ***Evaporative emission test*** - this is based on charcoal canisters to trap emitted vapours, similar to the original US test procedure. A SHED procedure was introduced from 2002. The canister method employs weighed activated carbon traps which are connected to the fuel system at locations where fuel vapours may

escape to the atmosphere (air cleaner, fuel tank vent, etc.). The vehicle is driven at 40 km/h ± 2 km/h under road conditions for 40 mins. on a chassis dynamometer at 25°C ± 5°C. Immediately after the engine is stopped, the exhaust is sealed and pre-weighed active carbon traps are connected to the fuel tank, air cleaner and any other fuel system vents. After one hour the traps are reweighed and the total increase in weight must be less than 2 grams. The test fuel used is the same as for the exhaust emission testing with an RVP of 0.57 to 0.60 kg/cm (56 to 59 kPa).

B.7.4. REFERENCE FUELS

B.7.4.1. Reference Gasolines

Table B.7.3 Technical Standard for 10•15-Mode Exhaust Emissions Measurement for Gasoline Fuelled Vehicles

Property	Units	Limits		Method
		Min	Max	
Research Octane Number		89		JIS K2280
Density at 15°C	kg/m^3	-	783	JIS K2249
Reid Vapour Pressure	kPa	44	78	JIS K2258
Distillation				JIS K2254
10% Distillation Point	°C	-	70	
50% Distillation Point	°C	75	110	
90% Distillation Point	°C	-	180	
FBP	°C	-	220	
Benzene	% v/v	-	1.0	JIS K2536
Oxidation Stability				
Existent gum	mg/100 ml		5	JIS K2261
Lead Content	g/l	Not detectable		JIS K2255
Sulphur Content	% m/m	-	0.01	JIS K2541
Kerosene Content	% v/v	-	4.0	JIS K2536
MTBE	% v/v	-	7.0	JIS K2536
Methyl Alcohol	% v/v	Not detectable		JIS K2536

B.7.4.2. Reference Diesel Fuels

Table B.7.4 Technical Standard for 10•15-Mode Exhaust Emissions Measurement for Diesel-Powered Motor Vehicles

Property	Units	Limits		Test Method
		Min.	Max.	
Cetane Number		45	-	JIS K2280
Distillation				JIS K2254
90% v/v Point	°C	-	350	
Flash Point	°C	50	-	JIS K2265
Viscosity at 40°C	mm^2/s	2.5	-	JIS K2283
Sulphur Content**	% m/m	-	0.2	JIS K2541

B.7.4.3. Reference Liquefied Petroleum Gas

Liquid petroleum gas shall have the same properties, etc. equivalent to JIS K2240 and shall contain 20 to 30% mole/mole of propane plus propylene and 70 to 80% mole/mole of butane plus butylene.

B.7.5. FUEL CONSUMPTION AND CO_2 REGULATIONS

B.7.5.1. Passenger Car Fuel Economy Targets for 2000

In January 1993 fuel economy targets for passenger cars in the year 2000 were officially published. The targets were drawn up by MITI and MOT, based on recommendations of a committee set up in 1990. These were the first such guidelines since 1979, when fuel economy limits were set for 1985. Since then there has been a steady decline in fuel efficiency, especially over the last few years due to the trend to larger engines and more widespread use of automatic transmissions etc. The current targets apply only to gasoline passenger cars and commercial vehicles but the government has been considering similar regulations for diesel cars and commercial vehicles (see overleaf). Details of the existing targets are given below.

Formally the targets are expressed in terms of the weighted average fuel economy for vehicles within the specified mass ranges. They are not mandatory, will not become a regulation, and there is no suggestion of penalties such as a ”gas guzzler” tax. However, for domestic manufacturers there is strong incentive to comply in order to maintain the goodwill of MITI. Fuel economy targets are specified over the 10.15 mode cycle for three vehicle mass categories. The estimated figure for the total car population is for information only and is not a target for individual manufacturers.

So as not to unfairly advantage or disadvantage vehicle manufacturers whose car production is all at the top or bottom of one of the three main mass categories, these have been further subdivided into six sub-ranges.

Table B.7.5 Japanese Passenger Car Fuel Economy Targets for 2000

Classification	Gross Vehicle Weight kg	Fuel Economy Target km/l	Improvement relative to 1990
Light cars	<827.5	19.0	7.3%
Small cars	827.5 - 1515.5	13.0	8.3%
Normal cars	>1515.5	9.1	11.0%
Estimate for total population		13.5	8.5%
Vehicle Mass sub-ranges			
Sub-Class 1	<702.5	19.2	6.5%
Sub-Class 2	702.5 - 827.5	18.2	7.0%
Sub-Class 3	827.5 - 1015.5	16.3	7.2%
Sub-Class 4	1015.5 - 1515.5	12.1	7.9%
Sub-Class 5	1515.5 - 2015.5	9.1	9.5%
Sub-Class 6	>2015.5	5.8	13.6%

B.7.6. IN-SERVICE EMISSIONS LEGISLATION AND ON-BOARD DIAGNOSTTIC SYSTEMS

Emissions testing forms an integral part of the Japanese roadworthiness test ("Shaken"). Details will be found in the **Appendix to Part 1**, **Section A.7.5**.

B.8. AUSTRALASIA

B.8.1. VEHICLE EMISSIONS LIMITS

B.8.1.1. Australia Pre-2000 Regulations

In 1989 a Federal Act of Parliament, the "Motor Vehicle Standards Act 1989" brought new vehicle standards under the jurisdiction of the Federal Government. The regulations, encoded as the Australian Design Rules (ADRs), are administered by the Federal Office of Road Safety. Standards are developed cooperatively by transport and environment agencies of both State and Federal Governments, in consultation with the automotive industry, oil companies and consumer organisations.

1997 motor vehicle emissions standards for gasoline engine vehicles (under 2.7 t) were contained in ADR 37/01, which was gazetted as a Federal Regulation on 31 March 1995. The regulations, based on US EPA 1981-93 standards, applied to new vehicle models from 1 January 1997 and applied to all vehicles from 1 January 1999. The standard was further reviewed and new regulations implemented the Australian Government's commitments under the Tax Package Agreement for European standards. This was introduced from 2003 to 2005 for petrol vehicles.

Table B.8.1 Australian 1997/1999 Emission Limits for Gasoline Engined Vehicles (<2.7 t) – ADR 37/01

Effective Date	CO (g/km)	HC (g/km)	NOx (g/km)	Evaporative Emissions (g/test)	Test Procedure
Note (1)	2.1	0.26	0.63	2.0	FTP75

(1) 1/1/97 for new models; 1/1/99 for all vehicles

ADR 70, which was gazetted on 29 September 1993, required compliance with UN ECE R83/01, incorporating the 01 series of amendments. With effect from 29 September 1993, diesel vehicles had to comply with UN ECE R83/01. Alternatively, vehicles which demonstrate compliance with the following regulations are also permitted:

- US EPA 1994 model year
- EU Directive 91/441/EEC
- EU Directive 91/542/EEC
- Japanese Ministry of Transport Ordinance No. 3 of 27 March 1991

New regulations implemented the Australian Government's commitments under the Tax Package Agreement for European standards. Five new ADRs were required to implement the package of new emission standards and these were introduced from 2002 to 2006

B.8.1.2. Australia Design Rules (2002/2006)

See **Part 1**, **Section 8.1.2**.

B.8.1.3. New Zealand Draft Land Transport Rule - Vehicle Exhaust Emissions 2003

Objectives

The Land Transport Rule: Vehicle Exhaust Emissions 2003 is one of a series of rules that sets requirements and standards for systems and components in motor vehicles operating in New Zealand (Rule 33001, 6 December 2002). This rule puts in place a vehicle exhaust emissions standards regime for motor vehicles that are manufactured after 1990. The aim of the rule is to ensure that all such motor vehicles entering the fleet for the first time have been manufactured to the applicable emissions standards specified in the rule, to the extent that those standards apply to exhaust emissions. The rule will come into force progressively over the period 1 January 2004 to 1 January 2007, depending upon vehicle and fuel type. The reader should refer to **Part 1**, **Section 8.1.3** for details.

B.8.2. FUEL QUALITY REGULATIONS AND SPECIFICATIONS

B.8.2.1. Pre-2000 Australia

Gasoline

Australia introduced unleaded gasoline in 1986 and benzene contents were limited to 5% v/v (see **Table B.8.2**).

Diesel Fuel

The sulphur content of diesel fuel in Australia was set at 0.50% m/m (see **Table B.8.3**). By agreement with suppliers, the sulphur content of automotive gas oil was limited to 0.3% m/m.

Table B.8.2 Australia Motor Gasoline Specifications (**Superseded**)

Property		Leaded	Regular Unleaded	Premium Unleaded
RON	min	97.0	91.0	95.0
RON	max	-	93.0	-
MON	min	-		82.0
Lead content (g/l)	max	(1)	0.013	0.013
Benzene content (% v/v)	max	5.0	5.0	5.0
Sulphur content (% m/m)	max	0.20	0.05 (2)	0.05 (2)
Gum (g/100ml)	max	4.0	4.0	4.0
Copper Corrosion	max	1	1	1
Oxidation Stability (min)	min	240	240	240
Specification		AS 1876 – 1990 (Amendment July 1994)		

(1) Maximum: "As permitted by legislation".

(2) When refinery limitations or market requirements make it impractical to meet this limit, "short term" excursions to a maximum of 0.10% m/m sulphur are permitted.

Table B.8.3 Australia Automotive Diesel Fuel Specification (**Superseded**)

Property		Limit Value
Cetane Number	min	45
Sulphur content (% m/m)	max	0.5
Distillation		
90% v/v rec. (°C)	max	357
Cloud Point (°C)	max	(1)
CFPP (°C)	max	(1)
Density @ 15°C (kg/l)		0.820 - 0.870
Viscosity @ 40°C (mm^2/s)		1.9 – 5.5
Flash Point (°C)	min	(2)
CCR on 10% resid. (% m/m)	max	0.2
Oxidation stability (mg/l)	max	25
Copper corrosion (3h. @ 100°C)	max	2
Ash (% m/m)	max	0.01
Water (% v/v)	max	0.05
Sediment (% m/m)	max	0.01
Or water & sediment (% v/v)	max	0.05
Specification		AS 3570 - 1998

(1) 12 geographical regions are designated with monthly cloud point/CFPP limits. The following overall limits applied from July 1998:

Zone *	CP (max.) °C	or CFPP (max.) °C	CP (max.) °C	or CFPP (max.) °C
North	+ 7	+ 4	+ 15	+ 12
West	0	- 3	+ 6	+ 3
East	- 1	- 4	+ 4	+ 1
South	- 4	- 7	- 4	- 7

* Refer to AS 3570 – 1998 for full geographical details of the zones. Entire meteorological areas are designated within the East Zone and reference should again be made to the specification.

(2) Minimum: "As permitted by legislation".

B.8.2.2. Australia Fuel Quality Standards Act 2000

The *Fuel Quality Standards Act 2000* (Act No. 153 of 2000 - as amended) and the *Fuel Quality Standards Regulations 2001* created national standards for fuels and provided a framework for enforcing those standards. Australian fuel quality standards have been harmonised with international standards. This compilation was prepared on 1 January 2002 taking into account amendments up to Act No. 118 of 2001. The legislation regulates any substance that is sold or represented as a fuel for which a fuel standard has been made. Fuel quality standards for gasoline and diesel have been made under the Act. The new standards are prescribed in the *Fuel Standard (Petrol) Determination 2001*, and the *Fuel Standard (Diesel) Determination 2001.*

Because Western Australia (WA) already had fuel standards in place, the Commonwealth standards operate concurrently. Importantly, where WA's standards were more stringent or regulate a fuel characteristic not covered by the

Commonwealth standard, the WA standards will apply. The specifications are tabulated in **Part 1**, **Section 8.2.2**.

B.8.2.3. Pre-2002 New Zealand

Gasoline

In New Zealand the lead content of leaded grades was limited in 1986 by agreement to a maximum of 0.45 gPb/l. A 91 RON unleaded regular was introduced in 1987 and a 96 RON grade has been available since the beginning of 1996. New Zealand reduced its benzene limit to 3% v/v in 1995. The introduction of the unleaded premium grade resulted in problems with seals in fuel systems due to the high aromatics content and, following public concern, the oil companies limited aromatics content to 48% v/v, with a maximum of 40% toluene plus xylene.

Diesel Fuel

The sulphur content of diesel fuel in New Zealand was also limited to 0.3% m/m (see **Table B.8.5**).

Table B.8.4 New Zealand Automotive Gasoline Specifications (September 1999 - **Superseded**)

Characteristics	Units	Specification		Test Methods
		Regular	Premium	
Density at 15ºC	kg/l	Report	Report	D1298 or D4052
RON	(min)	91.0	96.0	D2699
MON	(min)	82.0	86.0	D2700
Lead Content [1]	mg Pb/l (max)	3.0	3.0	IP 224 or UOP 350 or IP 352
Distillation				D86
E70	% v/v	25.0 - 45.0	25.0 - 45.0	
E100	% v/v	45.0 [2] - 65.0	45.0 [2] - 65.0	
E180 [2]	% v/v (min)	90.0	90.0	
End point	ºC (max)	215.0	215.0	
Residue [2]	% v/v (max)	2.0	2.0	
RVP at 37.8ºC	kPa			D323 or D5191
01/11 to 31/03	(max)	85.00	85.00	
01/04 to 31/05	(max)	90.00	90.00	
01/06 to 31/08	(max)	95.00	95.00	
01/09 to 31/10	(max)	90.00	90.00	
FVI = RVP + 0.7×E70	(min) [2]	77.5	77.5	D323 / D86
01/11 to 31/03	(max)	105.0	105.0	
01/04 to 31/05	(max)	112.5	112.5	
01/06 to 31/08 [2]	(max)	115.0	115.0	
01/09 to 31/10	(max)	112.5	112.5	
Existing gum (solvent washed)	mg/100 ml (max)	4	4	D381
Induction period	mins (min)	360	360	IP 40
Sulphur [2]	% m/m (max)	0.050	0.050	D1266 or D2622 or IP 336
Copper strip corrosion (2 hr @ 100ºC)	(max)	No. 1 strip	No. 1 strip	D130
Doctor test or		Negative	Negative	IP 30
Mercaptan Sulphur	% m/m (max)	0.0015	0.0015	D3227
Odour		Marketable	Marketable	
Colour		Red or Purple/Bronze [3]	Yellow [4]	
Durene [5]	% m/m (max)	3.0	3.0	Mobil Method 1385/1985
Oxygenates [1] [6]	% m/m (max)	0.10	0.10	D4815 or DIN 51413-01
Aromatics (incl. benzene)	% v/v	22.0 - 44.0	26.0 - 48.0 [2]	D5580 or D5443
Olefin content [7]	% v/v (max)	25.0	25.0	By declaration
Benzene [1]	% m/m (max)	5.00	5.00	D3606 or D5580
Toluene + xylenes	% v/v (max)	-	40.0	D5580

1. At refinery storage tank: max 3.0 mg/l at tank ship: max. 5.0 mg/l at service station: max. 13.0 mg/l.
2. Legal specification.
3. Matching the colour of: 4.0 mg/l Morton Automate Red B in iso-octane, or 6.0 mg/l Morton Automate Purple RS in iso-octane.
4. Matching the colour of 1.8 mg/l Morton Automate Yellow B in iso-octane.
5. Or calculated based on Methanex quality certificate of blending component.
6. For MTBE max. 1.0% v/v as contaminant only.
7. By calculation using ASTM D1319 testing history of component streams.

Table B.8.5 New Zealand Automotive Diesel Fuel Specification (**Outdated**)

Property		Limit Value	Property		Limit Value
Cetane Number	min	50 (1)	Oxidation stability (mg/l)	max	15
Sulphur content (% m/m)	max	0.30	Copper corrosion (3h. @ 100°C)	max	1
Distillation			TAN (mg KOH/g)	max	0.5
85% v/v rec. (°C)	max	350	SAN (mg KOH/g)	max	Nil
Cloud Point (°C	max	(2)	Electrical conductivity (pS/m)	min	100
CFPP (°C)	max	(2)		max	450
Density @ 15°C (kg/l)		0.810 – 0.860	Ash (% m/m)	max	0.01
Viscosity @ 40°C (mm^2/s)		1.9 – 4.5	Water (% v/v)	max	0.05
Flash Point (PMCC °C)	min	63	Sediment (% m/m)	max	0.01
CCR on 10% resid. (% m/m)	max	0.20	Colour (ASTM)	max	3.0

(1) Controlled by a minimum calculated cetane index of 47 (ASTM D976).

(2) Provided no flow improver additive is used, low temperature properties are controlled by either Cloud Point or CFPP on the following geographical seasonal basis:

Delivery Location	Dates	Cloud Point (°C max.)	CFPP (°C max.)
Auckland, Wiri and/or Whangarei	01/09 – 29/02	+ 4	-
	01/03 – 31/08	-	- 6
Remainder of North Island	01/10 – 31/01	+ 4	-
	01/02 – 31/03	-	- 6
	01/04 – 31/07	-	- 9
	01/08 – 30/09	-	- 6
South Island	01/10 – 31/12	+ 4	-
	01/01 – 29/02	-	- 6
	01/03 – 31/07	-	- 9
	01/08 – 30/09	-	- 6

If flow improvers are to be used, consumers are to be given three months' notice and new specifications are to be established.

Table B.8.6 New Zealand Automotive Diesel Fuel Specification (September 1999 - **Superseded**)

Characteristics	Units	Specification	Test Methods
Density at 15ºC	kg/l	0.820 - 0.860 (1)	D1298 or D4052
Appearance (2)		Clear and Bright	D4176
ASTM Colour (1)	(max)	3.0	D1500
Cetane Number (3)	(min)	49.0	D613
Kinematic Viscosity at 40ºC	mm^2/s	1.90 - 4.50	D445
Cloud Point / CFPP (4) (5)	ºC		D2500/IP 309 or D5773
Sulphur	% m/m (max)	0.30 (1) (6)	IP 242 / D4294
Copper strip corrosion (3 hr @ 100ºC) (1)		max. No. 1 strip	D130
Micro Carbon Residue, on 10% distillation residue (7)	% m/m (max)	0.10	D4530
Water	% v/v (max)	max. 0.05	D95
Sediment	% m/m (max)	max. 0.01	D473
Ash (1)	% m/m (max)	max. 0.0100	D482
Strong Acid Number	mg KOH/g	Nil	D664 or D974
Total Acid Number	mg KOH/g	max. 0.50	D664 or D974
Flash Point, PMCC	ºC	min. 63.0	D93
Distillation			D86
85% v/v recovered (1)	ºC	max. 350.0	
Stability test	mg/100 ml	max. 1.5	D2274
Electrical conductivity at 20ºC (8)	pS/m	75 to 350	D2624

(1) Legal limit.

(2) Procedure 1, but temperature shall be 10ºC or lower.

(3) Controlled by calculating Cetane Index ASTM D976 of min. 49.0 or with use of cetane improver additive, Cetane Index must be at least 47.0 [1] and cetane improve should give an increment of up to 2 Cetane Numbers.

(4) Flow improver use allowed during certain periods (continued overleaf).

(Continued from previous page)

(5) For deliveries to:

Auckland, Wiri, and Whangarei		
01/09 to 28-29/02	Cloud Point, ºC	max. 3
01/03 to 31/03 [4] and	CFPP, ºC [1]	max. - 6
01/08 to 31/08 [4]	Cloud Point, ºC	max. 3
01/04 to 31/07 [4]	CFPP, ºC [1]	max. - 6
	Cloud Point, ºC	max. - 1
Remainder of North Island:		
01/10 to 31/01	Cloud Point, ºC	max. 3
01/02 to 31/03 [4] and	CFPP, ºC [1]	max. - 6
01/09 to 30/09 [4]	Cloud Point, ºC	max. 3
01/04 to 31/07 [4]	CFPP, ºC	max. - 9
	Cloud Point, ºC	max. - 1
01/08 to 31/08 [4]	CFPP, ºC [1]	max. - 6
	Cloud Point, ºC	max. - 1
Dunedin and Bluff:		
01/10 to 31/12	Cloud Point, ºC	max. 3
01/01 to 28-29/02 [4] and	CFPP, ºC	max. - 6
01/09 to 30/09 [4]	Cloud Point, ºC	max. 3
01/03 to 31/07 [4]	CFPP, ºC	max. - 15
	Cloud Point, ºC	max. - 1
01/08 to 31/08 [4]	CFPP, ºC [1]	max. - 6
	Cloud Point, ºC	max. - 1
All other South Island Locations:		
01/10 to 31/12	Cloud Point, ºC	max. 3
01/01 to 28-29/02 [4] and	CFPP, ºC	max. - 6
01/09 to 30/09 [4]	Cloud Point, ºC	max. 3
01/03 to 31/07 [4]	CFPP, ºC	max. - 9
	Cloud Point, ºC	max. - 1
01/08 to 31/08 [4]	CFPP, ºC [1]	max. - 6
	Cloud Point, ºC	max. - 1

6. For diesel fuel with a sulphur level below 0.05% m/m, satisfactory lubricity is controlled by HFRR test (wear scar diameter at 60ºC below 460 µm).
7. As an alternative, CCR on the 10% volume residue by the Ramsbottom method, ASTM D4524, is permitted with a limit of 0.20% m/m.
8. With cold flow improvers, the concentration of the static dissipater additive should be kept to a minimum. In any case the concentration of Stadis 450 may not exceed 6.0 mg/l.

B.8.2.4. New Zealand Petroleum Products Specifications Regulations 2002

These regulations came into force on 1 September 2002, revoking the Petroleum Product Regulations 1998 (SR 1998/267). Date of notification in the *Gazette* was 25 July 2002. Details will be found in **Part 1 Section 8.2.6**.

B.8.3. EMISSIONS AND FUEL ECONOMY TEST PROCEDURES

Emissions test procedures relevant to the emissions standards adopted will apply.

B.8.4. REFERENCE FUELS

CONCAWE have no information regarding reference fuel specifications.

B.8.5. FUEL CONSUMPTION AND CO_2 REGULATIONS

See the **Appendix to Part 1**, **Section 8.5**.

B.8.6. IN-SERVICE EMISSIONS LEGISLATION AND ON-BOARD DIAGNOSTICS

B.8.6.1. Australia

In December 1997 the Government of New South Wales outlined a plan for a vehicle I&M scheme. This ultimately calls for a loaded transient test in test only stations. It will apply to all light duty vehicles more than 4 years old in the Greater Sydney area. A pilot scheme started in July 1998 in two stations. Tests will be conducted on "modified" vehicles, those observed to be smoking and for voluntary testing. From 2000 the scheme will apply to all light duty vehicles in Sydney, but repairs will not be required for one year.

B.8.6.2. New Zealand

The New Zealand Department of Motor Industry and the oil industry are developing standards for vehicle emissions. The standards established to date (test procedure and implementation dates unknown) are as follows:

Table B.8.7 New Zealand In-Service Emission Limits

Vehicle model	CO (%)	HC (ppm)
pre 1982	4.5	800
1982-90	3.5	400
post 1992	2.5	400

A new system is expected to be in place by the latter half of 2006.

B.9. OTHER ASIAN COUNTRIES

B.9.1. VEHICLE EMISSIONS LIMITS

B.9.1.1. China

Chinese emissions regulations were revised in 1993. The implementation dates and limits for Light Duty Vehicles (≤3.5t), according to Regulation No. GB-11641.1-93, are based on ECE 15.03 limits but with higher HC limits and are given in **Table B.9.1.** Those for Heavy Duty Vehicles (>3.5t) according to Regulation No. GB-14761.2-93 are given in **Table B.9.3**. Regulations on gasoline engine idle emissions and diesel black smoke are given in **Table B.9.4**. Motorcycle emissions conform to the ECE R40 regulation (see **Report 6/97**, **Tables A.1.13** and **A.1.14**) and the additional idle regulations are given in **Table B.9.5**.

Table B.9.1 1993 Chinese light duty vehicle exhaust emission limits
Regulation GB-14761.1-93
(Test Cycle ECE R 15/R 83 Part 1)

Vehicle Ref. Mass, kg	Type Approval (g/test)			Conformity of Production (g/test)		
	CO	HC	NOx	CO	HC	NOx
≤750	65	10.8	8.5	78	14.0	10.2
751-850	71	11.3	8.5	85	14.8	10.2
851-1020	76	11.3	8.5	91	15.3	10.2
1021-1250	87	12.8	10.2	104	16.6	12.2
1251-1470	99	13.7	11.9	119	17.8	14.3
1471-1700	110	14.6	12.3	132	18.9	14.8
1701-1930	121	15.5	12.8	145	20.2	15.4
1931-2150	132	16.4	13.2	158	21.2	15.8
>2151	143	17.3	13.6	172	22.5	16.3

For vehicles designed and manufactured from 01/07/95, evaporative emissions: 2.0 g/test max

The Chinese State Environment Protection Agency (SEPA) proposed the adoption of EU Directive 91/441/EEC in 2000. Beijing proposed that three-way catalysts be installed from 1999 and promulgated its own legislation accordingly. The first tranche of standards went into effect on 1 January 1999 and are given in the following table:

Table B.9.2 China – Emissions Legislation in Beijing

Vehicle Type (1)	Effective Dates			
	01/01/99	01/01/04		
	All	Gasoline	IDI Diesel	DI Diesel
CO	3.16	2.22	1.0	1.0
HC+NOx	1.13	0.5	0.7	0.9
PM	0.18		0.08	0.10

(1) The maximum total mass of the automobile shall not exceed 2.5 t

In Shanghai all new passenger cars have had to comply with Euro 1 standards from July 1999. In addition, all light duty vehicles sold in the Shanghai region after 1 January 1998 were required to be retrofitted to the Euro 1 limits by the end of 1999. The cost was shared between the vehicle manufacturer, owner and the government.

Table B.9.3 Chinese heavy duty gasoline vehicle exhaust emissions limits Regulation GB-14761.2-93 (Test Cycle Chinese 9-Mode)

Vehicle Category	Effective Date	Type Approval (g/kWh)		Conformity of Production (g/kWh)	
		CO	HC + NOx	CO	HC + NOx
Type approved before 1995	01/01/96	54	22	96	38
	01/01/98	34	14	96	38
	01/01/99	34	14	54	22
Type approved after 1994	01/01/96	54	22	65	26
	01/01/98	34	14	65	26
	01/01/99	34	14	41	17

For vehicles designed and manufactured from 01/07/96, evaporative emissions 4 g/test max

Table B.9.4 Chinese regulations on gasoline vehicle idle emissions and diesel smoke

Vehicle	Date	Type Approval					Conformity of Production				
		Gasoline Vehicle Idle Emissions			Diesel Smoke (Bosch)		Gasoline Vehicle Idle Emissions			Diesel Smoke (Bosch)	
		CO (% v/v)	4-stroke HC (ppm)	2-stroke HC (ppm)	free accel	full load	CO (% v/v)	4-stroke HC (ppm)	2-stroke HC (ppm)	free accel.	full load
LDV ≤3.5t	1/7/95	3.0	600	6000	3.5	4.0	3.5	700	6500	4.0	4.5
HDV >3.5t	1/7/95	3.5	900	6500	3.5	4.0	4.0	1000	7000	4.0	4.5

Table B.9.5 Chinese regulations on motorcycle idle emissions

Category	Type Approval			Conformity of Production		
	CO (% v/v)	HC + NOx (ppm)		CO (% v/v)	HC + NOx (ppm)	
		4-stroke	2-stroke		4-stroke	2-stroke
Type approved before 1996	4.5	1500	7000	-	-	-
Produced before 1996	4.5	1500	7000	5.0	2000	7800
Type approved after 1995	4.5	1200	7000	4.5	1800	7000

B.9.1.2. Pre-2000 India

Idle CO and smoke tests for gasoline and diesel vehicles respectively have been in force since 1986 in a number of states. Following the enactment by the Indian federal government of a revised Motor Vehicle Act in 1990, these types of tests became mandatory throughout India for both new and in-use vehicles. Limits for gasoline mass emissions and diesel full load and free acceleration smoke became effective in 1991 and mass emissions from diesel vehicles were controlled from 1992. Limits and test procedures for gasoline vehicles and light duty diesel vehicles, incorporating conformity of production limits, have been adopted from ECE R15-04 but modified, using an Indian driving cycle after a hot start (see **Table B.9.6**). Diesel smoke and alternative mass emissions have been adopted from ECE R24 and ECE R49 respectively. The emissions limits were amended effective 1 April 1996 and were further tightened from the year 2000. Currently no evaporative emissions limits and deterioration factors or endurance tests have been prescribed but diesel particulate limits were introduced from 2000.

Table B.9.6 Emissions regulations for gasoline and diesel vehicles according to the Indian Driving Cycle

Vehicle Category	Reference Mass or Engine Size	Effective Date	Type Approval (g/km)		Conformity of Production (g/km)		Idle CO (% v/v)
			CO	HC	CO	HC	
Passenger and goods vehicles GVW ≤3.5t Gasoline	<1020 kg	before 01/04/96	14.3	2.0	17.3	2.7	3
	1020-1250 kg		16.5	2.1	19.7	2.7	3
	1250-1470 kg		18.8	2.1	22.5	2.8	3
	1470-1700 kg		20.7	2.3	24.9	3.0	3
	1700-1930 kg		22.9	2.5	27.6	3.3	3
	1930-2150 kg		24.9	2.7	29.9	3.5	3
	>2150 kg		27.1	2.9	32.6	3.7	3
2- and 3-wheeled GVW ≤1.0t	≤150 kg		12	8	15	10	4.5
	150-350 kg		(1)	(2)	(3)	(4)	4.5
	350 kg		30	12	40	15	4.5
			CO	**HC+NOx**	**CO**	**HC+NOx**	
Passenger and goods vehicles GVW ≤3.5t Diesel	<1020 kg	before 01/04/96 after 01/04/96 (5) 2000 (6)	14.3	4.7	17.3	5.9	3
	1020-1250 kg		16.5	5.1	19.7	6.3	3
	1250-1470 kg		18.8	5.4	22.5	6.8	3
	1470-1700 kg		20.7	5.8	24.9	7.3	3
	1700-1930 kg		22.9	6.2	27.6	7.7	3
	1930-2150 kg		24.9	6.5	29.9	8.2	3
	>2150 kg		27.1	6.9	32.6	8.6	3
Passenger cars Gasoline	<1.4 litre	01/04/96	8.68	3.0	10.0	3.6	3.0
	1.4-2.0 litre		11.2	3.84	13.4	4.6	3.0
	>2.0 litre		12.4	4.36	14.9	5.2	3.0
3-wheeled			6.75	7.43	5.4	6.5	3.0
2-wheeled			4.5	5.0	3.6	4.3	3.0
Passenger cars gasoline		2000	2.72	0.97	2.72	0.97	3.0
3-wheeled			4.0	1.5	4.8	1.8	3.0
2-wheeled			2.0	1.5	2.4	1.8	3.0

(1) Limit = 12 + 18 (R-150)/200 g/km

(2) Limit = 12 + 25(R-150)/200 g/km

(3) Limit = 8 + 4(R-150)/200 g/km

(4) Limit = 10 + 5(R-150)/200 g/km

(5) From 1996 conformity of production limits the same as for type approval

(6) From 2000 PM 0.14 g/km max, otherwise 1996 and 2000 limits are the same

(7) Crankcase emissions are not allowed from any vehicle

Table B.9.7 Indian diesel vehicle emissions regulations by the ECE R49 Cycle

Vehicle	Effective date	CO (g/kWh)	HC (g/kWh)	NOx (g/kWh)	PM (g/kWh)
all vehicles	before 01/04/96	14.0	3.5	18.0	-
all vehicles	after 01/04/96	11.2	2.4	14.4	-
GVW ≤3.5t	2000	4.4	1.1	8.0	0.61
GVW >3.5t	2000	4.4	1.1	8.0	0.36

- Crankcase emissions are not allowed from any vehicle

B.9.2. FUEL QUALITY REGULATIONS AND SPECIFICATIONS

B.9.2.1. China Gasoline Specifications

The SINOPEC 001 Specification issued in 1987 specified a leaded 97 RON Premium and leaded and unleaded 91 RON Regular grades. However, qualities have not been standardised throughout the country and there are also 70 MON, 90 RON and 93 RON leaded grades plus 95 RON, 93 RON and 90 RON unleaded gasolines available in certain parts of the country - see **Table B.9.8** and **B.9.9**. The State Council announced in September 1998 that, with effect from 1 July 1999, the marketing of leaded gasoline was banned in all major cities. This ban was extended nation-wide by July 2000 and the production of leaded gasoline ceased in January 2000.

Table B.9.8 Leaded Gasoline Specifications: China (**Banned: July 2000**)

Property		Leaded Grades [1]		
		90	**93**	**97**
Octane				
Research	min	90	93	97
(R+M)/2	min	85	89	92
Volatility				
Distillation				
10% (°C)	max	70	70	70
50% (°C)	max	120	120	120
90% (°C)	max	190	190	190
FBP (°C)	max	205	205	205
Residue % v/v	max	2.0	2.0	2.0
Vapour Pressure @ 37.8°C kPa [3]	max	S 88 W 74	S 88 W 74	S 88 W 74
Composition				
Sulphur (% m/m)	max	0.15	0.15	0.15
Lead (g/l)	max	0.35	0.45	0.45
MTBE (% v/v)	max			
Benzene content, % (v/v)	max			
Aromatics content, % (v/v)	max			
Olefins content, % (v /v)	max			
Mercaptan S (% m/m)	max	0.001	0.001	0.001
Doctor test		neg.	neg.	neg.
Additives				
Other Parameters				
copper corrosion (3h/50°C)	max	No. 1	No. 1	No. 1
oxidation stability (min)	min	480	480	480
existent gum (mg/100ml)	max	5	5	5
acidity (mg KOH/100ml)	max	3	3	3
water- soluble acid or alkali				
mechanical admixture and water				

The sale of leaded gasoline was banned from 1 July 2000.

Table B.9.9 Unleaded Gasoline Specification: China (GB/T 17930-1999)

Property		Unleaded Grades (1) (2)			Method
		No 90	No 93	No 95	
RON	min	90	93	95	GB/T 5487
(RON + MON)/2	min	85	88	90	GB/T 5487 GB/T 503
Distillation:					GB/T 6536
10% v/v (ºC)	max	70	70	70	
50% v/v (ºC)	max	120	120	120	
90% v/v (ºC)	max	190	190	190	
FBP (ºC)	max	205	205	205	
Residue% v/v	max	2.0	2.0	2.0	
Vapour pressure, kPa at 37.8ºC:					GB/T 8017
Sept. 16 - March 15	max	88	88	88	
March 16 - Sept. 15	max	74	74	74	
Sulphur content (mg/kg) (3)	max	800	800	800	GB/T 380
Lead content (mg/l)	max	5	5	5	GB/T 8020
Benzene content (% v/v)	max	2.5	2.5	2.5	
Aromatics content (% v/v)	max	40	40	40	GB/T 11132
Olefins content (% v/v) (4)	max	35	35	35	GB/T 11132
Mercaptan:					
Doctor test		Pass	Pass	Pass	SH/T 0174
or Mercaptan Sulphur (% m/m)	max	0.001	0.001	0.001	GB/T 1792
Additives		Note (5)	Note (5)	Note (5)	
Copper strip corrosion (3 hours, 50ºC); Class	max	1	1	1	GB/T 5096
Induction period (minutes)	min	480	480	480	GB/T 8018
Existent gum (mg/100ml)	max	5	5	5	GB/T 8019
Water-soluble acid or alkali		nil	nil	nil	GB/T 259
Mechanical contaminants or water		nil	nil	nil	Visual inspection

(1) The sale of leaded gasoline was banned from 1 July 2000.

(2) Specification GB/T 17930-1999 became effective on 1 January 2000.

(3) Outside the cities of Beijing, Shanghai and Guangzhou a maximum sulphur content of 1000 mg/kg was initially permitted. The 800 mg/kg limit applied to all Chinese cities from 1 July 2000.

(4) The olefins content regulation was applied in Beijing, Shanghai and Guangzhou from 1 July 2000 and became effective nationwide from the beginning of 2003.

(5) A maximum manganese content 0f 18 mg/l is permitted. Iron should not be added and the maximum iron content is 10 mg/l. Detergent additives must be used in gasolines supplied to Beijing, Shanghai and Guangzhou.

- When oxygenates are added, a maximum oxygen content of 2.7% m/m is permitted.

B.9.2.2. Hong Kong Gasoline Specifications

Leaded premium, intermediate and regular grades were marketed but were banned (along with lead containing additives) from 1 April 1999. Lead replacement

gasolines, containing valve seat protection additives were made available (see **Table B.9.10**). Unleaded gasolines, with a similar grade structure to the now defunct leaded grades, have been established for some years, with benzene limited to 5% v/v and with the option of adding oxygenates according to EU Directive 85/536/EEC. The sulphur content of unleaded gasoline is limited to 0.05% m/m. From 1 April 2000 the country moved partially to the Euro 3 specification, with a 1% v/v limit on benzene and a voluntary 350 ppm limit on sulphur content.

Table B.9.10 Hong Kong Gasoline Specifications

Property		Pre 1999 (1))			1999
		UL Prem.	UL Prem.	UL Reg.	
Octane Number					
Research	min	97	95.0	90	
Motor	min		85.0		
(R+M)/2	min	92		85	
Volatility					
distillation					
10% (°C)	max	70		70	
50% (°C)	max	120		120	
90% (°C)	max	190		190	
FBP (°C)	max	205		205	
residue	max	2.0		2.0	
E100 (% v/v)	min				
E150 (% v/v)	min				
RVP @ 37.8°C kPa	max	W 88 S 74		W 88 S 74	
Composition					
sulphur ppm)	max	500	500	500	500
lead (g/l)	max	0.005	0.005	0.005	
aromatics (% v/v)	max				
benzene (% v/v)	max	5.0	5.0	5.0	5.0
olefins (% v/v)	max				
oxygenates	max		(2)		
ethers (% v/v)	max				0 -10
Other Parameters					
copper corrosion (3h/50°C)	max	1		1	
mercaptan S (% m/m)	max	0.001		0.001	
doctor test		pass		pass	
acidity (mgKOH/100ml)	max	3		3	
oxidation stability (min)	min	480		480	
existent gum (mg/100ml)	max	5		5	

(1) Hong Kong banned the sale of leaded gasolines and lead containing fuel additives from 1 April 1999. Valve seat protection additives are incorporated.

(2) Oxygenates as per EU Directive 85/536/EEC.

B.9.2.3. India Gasoline Specifications

Unleaded regular was introduced in Delhi, Madras, Bombay and Calcutta from 1 April 1995 and pan-India availability was planned for 1999. An unleaded premium grade was introduced in 2000 and the specification included tighter volatility limits – see **Tables B.9.11** and **B.9.12**. The Supreme Court ordered a complete ban on the sale of leaded gasoline in Delhi with effect from 1 September 1998. The change to unleaded gasoline was scheduled to be extended to the entire country by the turn of the century.

Table B.9.11 Leaded Gasoline Specifications: India

Property		Regular (1)			Premium (1)
		Pre 2000	2000	2005	
Octane					
Research or	min	87	89	89	93
(R+M)/2	min	82	84	84	88
Volatility					
distillation					
IBP (°C)	max	report	report	report	report
E70 (% v/v)		10-45	10-45	10-45	10-45
E100 (% v/v)		40-70	40-70	40-70	40-70
E180 (% v/v)	min	90	90	90	90
FBP (°C)	max	215	215	215	215
residue % v/v	max	2.0	2.0	2.0	2.0
Vapour Pressure @ 37.8°C kPa (S-W)	max	35-70	35-60	35-60	35-70
VLI (2)		950	-	-	950
Composition					
sulphur (% m/m)	max	0.20	0.20	0.20	0.20
lead (g/l)	max	0.15	0.15	0.15	0.15
benzene (% v/v)	max				
oxygenates (% v/v) (3)	max				
Other Parameters					
density @ 15 °C	min max	report	report	report	report
copper corrosion (3h/50°C)	max	No.1	No.1	No.1	No. 1
mercaptan S (% m/m)	max				
doctor test					
water tolerance (4) (°C)	max	S 10 W 0 (5)	S 10 W 0 (5)	S 10 W 0 (5)	S 10 W 0 (5)
oxidation stability (min)	min				
potential gum (mg/100ml)	max	5	5	5	5
existent gum (mg/100ml)	max	4	4	4	4
colour		orange	orange	orange	red
Specification		IS 2796:1995			
Test Methods		IS 1448			

(1) Leaded premium will be banned by the year 2000, leaded regular will follow in 2005.

(2) VLI 750 May-July central and northern plains. VLI for new grades not known.

(3) Oxygenates permitted as per EU Directive 85/536/EEC (column A limits).

(4) For fuels containing oxygenates.

(5) Water tolerance –10°C in winter for the northern hilly region.

Table B.9.12 Unleaded Gasoline Specifications: India (Pre-2000)

Property		Regular	Premium
Octane			
Research or	min	87	93
(R+M)/2	min	82	88
Volatility			
Distillation			
IBP (°C)	max	report	
E70 (% v/v)		10-45	10-40
E100 (% v/v)		40-70	40-65
E180 (% v/v)	min	90	90
FBP (°C)	max	215	215
Residue	max	2.0	2.0
Vapour Pressure @ 37.8°C kPa (S-W)	max	35-70	35-60
Composition			
Sulphur (% m/m)	max	0.20	0.10
Lead (g/l)	max	0.013	0.013
Benzene (% v/v)	max		5.0
Oxygenates (% v/v) (2)	max		
Other Parameters			
Density @ 15 °C	min max	report	700 750
Copper corrosion (3h/50°C)	max	No.1	No.1
Water tolerance (3) (°C)	max	S 10 W 0 (4)	S 10 W 0 (4)
Potential gum (mg/100ml)	max	5	5
Existent gum (mg/100ml)	max	4	4
Colour		none	red

(1) Premium grade introduced in 1998/99.

(2) Oxygenates permitted as per EU Directive 85/536/EEC (column A limits).

(3) For fuels containing oxygenates.

(4) WT -10°C winter northern hilly region.

B.9.2.4. China Diesel Fuel Specifications

Table B.9.13 Diesel Fuel Specifications: China (**Superseded**)

Properties		Super (1)	First (1)	Pass (1)
Cetane Number	min	45	45	45
Sulphur (% m/m)	max	0.2	0.5	1.0
Distillation				
50% v/v rec. (°C)	max	300	300	300
90% v/v rec. (°C)	max	355	355	350
95% v/v rec. (°C)	max	365	365	365
Cold Flow Properties				
Pour Point (°C)	max	(1)	(1)	(1)
CFPP (°C)	max	(1)	(1)	(1)
Other Parameters				
Density @ 15°C		report	report	report
Kinematic viscosity @ 20°C (mm^2/s)		3.0-8.0 (2)	3.0-8.0 (2)	3.0-8.0 (2)
Flash Point PM (°C)	min	65 (2)	65 (2)	65 (2)
CCR 10% (% m/m)	max	0.3	0.3	0.3 (2)
Water (% v/v)	max	0.03	0.03	
Water & sediment (% v/v)				0.05
Ash (% m/m)	max	0.01	0.01	0.01
Copper corrosion 3h/100°C	max	1	1	1
Colour ASTM	max	3.5	3.5	
TAN mg KOH/g	max	0.5	0.5	1.0

(1) Super (or Premium) and First class grades are primarily for military use, whilst the "Pass" grade is for the civilian market. However, Guangzhou switched to the First grade in October 2000.

(2) Each grade is available in six classes of low temperature operability, with the following characteristics:

Pour Point °C	max	10	0	-10	-20	-35	-50
CFPP °C	max	12	4	-5	-14	-29	-44
CCR 10% (% m/m)	max	0.3, except for "Pass" grade 10°C and 0°C Pour Point versions, where 0.4 is allowed.					
Viscosity@ 20°C (mm/s^2)		3.0-8.0	3.0-8.0	3.0-8.0	2.5-8.0	1.8-7.0	1.8-7.0
Flash Point (closed) °C	min	65	65	65	65	45	45

B.9.2.5. India Diesel Fuel Specifications

It was proposed to reduce sulphur content from 1.0% m/m to 0.50% m/m in 1998 and to 0.25% m/m by 2000.

Table B.9.14 Diesel Fuel Specifications: India (1996/1999)

Property		1996	1999
Cetane Number	min	45	45
or Cetane Index	min	45	45
Sulphur (% m/m)	max	1.0 (1)	0.25
Distillation			
95% v/v rec. (°C)		380	380
Cold Flow Properties (2)			
CFPP °C (3)	max	W 9 S 21	W 9 S 21
Pour Point (°C) (3)	max	W 6 S 18	W 6 S 18
Other Parameters			
Density @ 15°C	kg/m^3	820-880	820-880
Viscosity @ 40°C (mm^2/s)		1.8-5.0	1.8-5.0
Flash Point Abel (°C)	min	32	32
Ramsbottom Carbon on 10% Residue % m/m	max	0.35	0.35
Water% v/v	max	0.05	0.05
Sediment (% m/m) (4)	max	0.05	0.05
Ash (% m/m)	max	0.01	0.01
Copper corrosion 3h/100°C	max	1	1
Inorganic acidity	max	nil	nil
Total acidity	max	0.30	0.30

(1) Sulphur content to be reduced to 0.50% m/m by 1998 and 0.25% m/m by 2000.

(2) Winter is November to February inclusive, other limits may apply in certain geographical areas.

(3) Alternative pour point or CFPP limits may be agreed between supplier and customer.

(4) Total sediment at the refinery before the addition of multi-functional additives 1.6 mg/100 ml.

B.9.2.6. South Korea Diesel Fuel Specification

Table B.9.15 Diesel Fuel Specification: South Korea (**Superseded**)

Property		No.2 Grade
Cetane Index	min	45
Sulphur (% m/m)	max	0.05
Distillation		
90% v/v rec. (°C)	max	360
Cold Flow Properties		
Pour Point (°C)	max	W –12.5 S 0
Other Parameters		
Viscosity@ 37.8 (38)°C (mm^2/s)	max	2.0-5.8
CCR 10% (% m/m)	max	0.20
Ash (% m/m)	max	0.02
Copper corrosion 3h/100°C	max	1

B.9.3. EMISSIONS AND FUEL ECONOMY TEST PROCEDURES

Table B.9.16 Summary of Test Procedures

Country	Gasoline Test Procedures		Diesel Test Procedures	
	Light Duty	**Heavy Duty**	**Light Duty**	**Heavy Duty**
China	ECE R 15/R 83 Part 1	Chinese 9-Mode		
Hong Kong	EU or ECE	EU or ECE	EU or ECE	EU or ECE
India	India Drive Cycle	ECE R24 and ECE R49	ECE R24 and ECE R49	ECE R24 and ECE R49
Malaysia	EU or ECE	EU or ECE	EU or ECE	EU or ECE
Philippines	EU or ECE	EU or ECE	EU or ECE	EU or ECE
Singapore (1)	EU or ECE	EU or ECE	EU or ECE	EU or ECE
South Korea	FTP 75 (2)	Japanese gasoline 13-mode (3)	FTP 75 (4)	Japanese 6-mode (5) 13-mode (ECE R 49) (6)
Taiwan	US Procedures			
Thailand	EU Procedures (7)			

(1) Motorcycles: US EPA.

(2) Including LPG cars and gasoline/LPG light duty trucks (1.7 - 3.0 t).

(3) Includes LPG fuelled vehicles.

(4) Including diesel light duty trucks (≤1.7 t). Diesel light duty trucks (≤2.7 ton) employ the Japanese 6-mode cycle.

(5) Diesel heavy duty trucks (>2.7t, <3.0t).

(6) Diesel heavy duty trucks (>3.0t).

(7) Motorcycles: ECE R 40.01.

B.9.4. REFERENCE FUELS

CONCAWE have no data on reference fuels for Asian countries other than Japan.

B.9.5. FUEL CONSUMPTION AND CO_2 REGULATIONS

Please refer to the **Appendix to Part 1**, **Section A.9.5** for details of regulations in South Korea and Taiwan.

B.9.6. IN-SERVICE EMISSIONS LEGISLATION AND ON-BOARD DIAGNOSTIC SYSTEMS

B.9.6.1. Summary of In-Service Emissions Programmes

Introduction

This section provides a comprehensive regional review of in-service emissions programmes in table form. Where more detailed in formation is available, it is reported (on a country-by country basis) in the following sections. This information needs to be treated with caution as it at least five years old.

Table B.9.17 Inspection and Maintenance - Summary of Asian Programmes - Gasoline Cars

Country	Test	CO	HC	Comments
Bangladesh	See comment	24.0 g/km	2.0 g/km	Dynamic test (2/3 max RPM)
Cambodia	Idle	4.5% v/v	1200 mg/kg	All vehicles over 5 years old (counting from year of production)
		4.0% v/v	800 mg/kg	All newly imported vehicles and those up to 5 years old (counting from year of production)
India	Idle	3.0% v/v		
		0.50% v/v		Proposed for Euro II Vehicles.
Indonesia	Idle	4.5% v/v	1200 mg/kg	Stringency increase proposed
Malaysia	Idle	4.5% v/v	800 mg/kg	Existing models (after 1.1.97)
		3.5% v/v	600 mg/kg	New models (after 1.1.97)
Nepal	Idle	3.0% v/v	1000 mg/kg	
Philippines	Idle (high)	3.5% v/v	600 mg/kg	
China	Idle	4.5% v/v	900 mg/kg	
Singapore	Idle	3.5% v/v		
Sri Lanka	Idle	4.5% v/v	1200 mg/kg	Vehicles over 5 years old
		3.0% v/v	1200 mg/kg	Vehicles under 5 years old
Thailand	Idle	4.5% v/v	600 mg/kg	
Vietnam	Idle	4.5% v/v	1200 mg/kg	4 stroke
			7800 mg/kg	2 stroke

Table B.9.18 Inspection and Maintenance - Summary of Asian Programmes - Diesel Cars

Country	Test [1]	CO	HC	Smoke	Comments
Bangladesh	See comments	24 g/km	2 g/km	65 HSU	Dynamic test (2/3 max RPM)
Cambodia	Idle	4.5% v/v	1200 mg/kg	50 - Free acceleration	All vehicles over 5 years old (counting from year of production).
		4.0% v/v	800 mg/kg	50 - Free acceleration	All newly imported vehicles and those up to 5 years old (counting from year of production).
Hong Kong	FA			60 HSU	
India	FA			65 HSU 2.45 m^{-1}	(Includes 3 Wheeled)
				60 HSU	Proposed for Euro II vehicles (Includes 3 wheeled).
Indonesia	FA			50 HSU	Stringency increase proposed
Malaysia	FA			50 HSU	
Nepal	FA			65 HSU	
Philippines	FA			2.5m^{-1}	Naturally aspirated
				3.5 m^{-1}	Turbocharged
China	None				
Singapore	FA				Taxis only
Sri Lanka	Idle			65% Opacity	With effect from 1 January 2003
	FA			75% Opacity	
Taiwan					
Thailand	FA			50% Filter/ 45% Opacity	
Vietnam	FA			72 HSU	

(1) FA = Free acceleration

Table B.9.19 Inspection and Maintenance - Summary of Asian Programmes - Trucks

Country	Test [1]	CO	HC	Smoke	Comments
Bangladesh	See comments	24 g/km	2 g/km	65 HSU	Dynamic test (2/3 Max RPM)
Cambodia	FA			50 HSU	
Hong Kong	FA			60 HSU	
India	FA			65 HSU 2.45 m^{-1}	
				60 HSU	Proposed for Euro II vehicles.
Indonesia	FA			50 HSU	Stringency increase proposed
Malaysia	FA			50 HSU	
Nepal	FA			65 HSU	
Philippines	FA			2.5/m	Naturally aspirated
				3.5/m	Turbocharged
China	FA			FSN 4.5	
	FA			FSN 5.0	Produced before 7/1/95
	Idle	4.50% v/v	900 mg/kg		Gasoline light duty
	Idle	4.50% v/v	1200 mg/kg		Gasoline heavy duty
	Idle	4.50% v/v	1200 mg/kg		Heavy duty gasoline buses
Thailand	FA			50% Filter/ 45% Opacity	
Vietnam	FA			72 HSU	

(1) FA = Free acceleration

Table B.9.20 Inspection and Maintenance - Summary of Asian Programmes - Motorcycles

Country	Test	CO	HC	Comments
Bangladesh	See comments	24 g/km	2 g/km	Dynamic test (2/3 Max RPM)
Cambodia	Idle	4.50% v/v	10 000 mg/kg	2-Stroke - All vehicles over 5 years old (counting from year of production).
		4.0% v/v	3000 mg/kg	2-Stroke - All newly imported vehicles and those up to 5 years old (counting from year of production).
		4.50% v/v	10 000 mg/kg	4-Stroke - All vehicles over 5 years old (counting from year of production).
		4.0% v/v	2400 mg/kg	4-Stroke - All newly imported vehicles and those up to 5 years old (counting from year of production).
Hong Kong				
India	Idle	4.50% v/v		
		3.50% v/v		Proposed for post 2000 vehicles (including 3 wheeled gasoline).
Indonesia	Idle	4.50% v/v	3000 mg/kg	Two stroke - will be revised
		4.50% v/v	2400 mg/kg	Four stroke - will be revised
Nepal	Idle	4.50% v/v	7800 mg/kg	
		4.50% v/v	7800 mg/kg	3 wheeler Petrol
		3.00% v/v	7800 mg/kg	3 wheeler LPG
Philippines	Idle	6% v/v		
China	Idle	4.50% v/v	8000 mg/kg	Two stroke - Produced after 1/1/96
		5.00% v/v	9000 mg/kg	Two stroke - Produced before 1/1/96
		4.50% v/v	2200 mg/kg	Four stroke - Produced after 1/1/96
		5.00% v/v	2500 mg/kg	Four stroke - Produced before 1/1/96
Singapore	Idle	4.50% v/v		
Sri Lanka	Idle	6.0% v/v		With effect from 1 January 2003. Includes 3-wheelers.
Taiwan		3.50% v/v	2000 mg/kg	
Thailand	Idle	4.50% v/v	10 000 mg/kg	30% White smoke (2T Only)

B.9.6.2. India

Table B.9.21 India - Proposed Timetable for In-Use Emission Limits for Inter-State Buses & Trucks, Public Service Vehicles, City Buses, Taxis and 3 Wheelers (Autos/Tempos)

Location	Vehicle Type	Registration Date	Emission Limits	Effective Date
To/from: Delhi	Inter-State buses	-	India 2000 (Bharat Stage I)	1 April 2004
		-	Bharat Stage II	1 April 2008
	Inter-State trucks	-	India 2000 (Bharat Stage I)	1 April 2004
		-	Bharat Stage II	1 April 2008
To/from: Mumbai, Kolkata, Chennai, Bangalore, Hyderabad Ahmedabad, Pune, Surat, Kanpur and Agra	Inter-State buses	After 1 April 2000	2000 (Bharat Stage I)	1 April 2004
		Before 1 April 2000	1996 limits	
		After 1 April 2005	Bharat Stage II	1 April 2008
		Before 1 April 2005	India 2000 (Bharat Stage I)	
	City Buses and Taxis	After 1 April 1996	Applicable emission limits on the date of registration	1 April 2004
		Before 1 April 1996	1996 emission limit	
		After Bharat Stage II	Applicable emission limits on the date of registration	1 April 2008
		Before Bharat Stage II	India 2000 (Bharat Stage I)	
	3 Wheelers (Autos/Tempos)	After 1 April 2000	Applicable emission limits on the date of registration	1 April 2004
		Before 1 April 2000	1996 emission limit	
		After 1 April 2000	Applicable emission limits on the date of registration	1 April 2008
		Before 1 April 2000	India 2000 (Bharat Stage I)	

B.9.6.3. Malaysia

Malaysia introduced in-service emissions standards in 1996. However, it is not clear from the information available to CONCAWE at what age vehicle testing will commence or what frequency of testing is required. The limit values to be applied are as follows:

Table B.9.22 Malaysia Emission Standards for Gasoline Engines in Use

Model	Idle Emissions	
	CO (%)	HC (ppm)
Pre-1997	4.5	800
1997 and later	3.5	600

Malaysian in-service diesel smoke limits are determined using one of two test procedures:

- *Ringelmann Smoke Chart:* Diesel smoke must not exceed Ringelmann No. 2 for a continuous period of more than 10 seconds.
- *Free Acceleration Test:* 50 HSU (or equivalent) maximum.

B.9.6.4. Singapore

Singapore has the following in-use standards:

Table B.9.23 Singapore In-Service Emission Limits

Vehicle	Idle CO (% v/v)	Free Acceleration Smoke (HSU)
Diesel	-	50
Gasoline (1992 and later)	3.5	-
Gasoline (1986-1991)	4.5	-
Gasoline (Before 1986)	6.0	-

B.9.6.5. South Korea

The limits which apply to in-service emissions testing in South Korea are given in **Table B.9.24** below.

Table B.9.24 South Korean in-service emissions limits

Type of Vehicle		Model Year	CO (%v/v)	HC (ppm)	Smoke Opacity (%)
passenger cars (gasoline & LPG)	≥800 cc but <2.7t	until 1987	4.5	1200	-
		from 1987	1.2	220 (1)	-
passenger cars (gasoline & LPG)	<800 cc or ≥2.7t	all models	4.5	1200	-
light duty trucks heavy duty trucks (gasoline & LPG)	all				
passenger cars, light & heavy duty trucks(diesel)	all	until 09/90	-	-	50
		1990-1995	-	-	40
		from 1995	-	-	35

(1) HC 400 ppm max for LPG passenger cars.

B.10. MIDDLE EAST & AFRICA

B.10.1. VEHICLE EMISSION LIMITS

B.10.1.1. Israel

Israel adopted EU legislation as shown in the following Table. Post 2004 information will be found in the **Appendix to Part 1**, **Section A.10.1.1**.

Table B.10.1 Israeli Exhaust Emissions Regulations (Prior to 2004)

Vehicle Type		Emission Limits
Passenger vehicles gvw ≤3500 kg & light duty gvw ≤2349 kg	gasoline gasoline	88/76/EEC or 88/436/EEC or 89/458/EEC or 89/491/EEC or 91/441/EEC
	diesel	72/306/EEC + 91/441/EEC
Light duty 2350-3500 kg	gasoline	83/351/EEC
Buses gvw >4000 kg Goods vehicles >3500 kg	diesel	72/306/EEC + 88/77/EEC

B.10.1.2. Saudi Arabia

Saudi Arabia has adopted standards equivalent to ECE R15.03.

B.10.1.3. South Africa

See the **Appendix to Part 1**, **Section A.10.1.3** for details

B.10.2. FUEL QUALITY REGULATIONS AND SPECIFICATIONS

B.10.2.1. Gasoline Specifications- African and Middle East Countries

A World Bank regional conference entitled “The Phase-Out of Leaded Gasoline in Sub-Saharan Africa” was held in Dakar, Senegal in June 2001. This resulted in the “Dakar Declaration” which confirmed the consensus of participants to phase out lead as soon as possible but no later than 2005. The Declaration also recommended that governments should reduce the lead content of gasoline to not more than 0.4 g/litre by 2002 and 0.2 g/litre by 2003. An action plan for lead phase out was similarly developed by East African government representatives, the private sector and non-government organisations at a meeting held in Nairobi, Kenya in June 2002. To monitor progress in implementing the plan, a review, organised by UNEP was planned to take place during the second half of 2003 or the first half of 2004.

It has been difficult to obtain definitive information on gasoline quality in many African and Middle Eastern countries and limited data are presented in the **Appendix to Part 1, Section 10.2**. More comprehensive specifications for Israel

and South Africa will be found in the **Appendix to Part 1**, **Sections A.10.2.1** and **A.10.2.2** respectively.

B.10.2.2. Diesel Fuel Specifications- African and Middle East Countries

As with gasolines, it has been difficult to obtain information on diesel fuel quality in Africa and the Middle East, and it is not always clear whether quoted limits refer to typical or maximum values. More comprehensive specifications for Israel and South Africa are included in the **Appendix to Part 1**, **Sections A.10.2.3** and **A.10.2.4** respectively.

B.10.3. EMISSIONS AND FUEL ECONOMY TEST PROCEDURES

Israel has adopted EU legislation and Saudi Arabia has adopted standards equivalent to ECE R15.03.

B.10.4. REFERENCE FUELS

CONCAWE have no data available.

B.10.5. FUEL CONSUMPTION AND CO_2 REGULATIONS

CONCAWE have no data available.

B.10.6. IN-SERVICE EMISSIONS LEGISLATION AND ON-BOARD DIAGNOSTIC SYSTEMS

See the **Appendix to Part 1**, **Section 10.6**.

B.11. WORLD-WIDE HARMONISATION OF TEST CYCLES

B.11.1. INTRODUCTION

Final proposals for both a heavy duty and motorcycle test procedures have now been tabled at GRPE. Full details will be found in **Part 1, Section 11**.

B.11.2. HEAVY DUTY EMISSIONS CYCLE

Efforts are being made to develop a common exhaust emissions test procedure for heavy duty vehicles with the support of industry and governments world-wide. Preliminary discussions were held at the thirty-second GRPE meeting in June 1996. The programme has international support from the heavy duty engine manufacturers and most governments.

B.11.2.1. Approach

A research programme was jointly conducted between October 1998 and October 2000 by TNO Automotive (The Netherlands) and TÜV Automotive (formerly FiGE, Germany). This programme was funded by the Netherlands Ministry of the Environment (VROM) and the German Federal Environmental Agency (UBA).

The objective of the research programme was to develop a world-wide harmonised engine test cycle for the emissions certification procedure of heavy duty engines that would:

- become a uniform global basis for engine certification regarding exhaust emissions,
- be representative of world-wide real life heavy duty engine operation,
- give the highest potential for the control of real-life emissions,
- be applicable to future state-of-the-art technology,
- match emissions in relative terms for accurate ranking of different engines/technologies

The basis of the development was the collection and analysis of driving behaviour data and statistical information about heavy duty vehicle use for the different regions of the world. From this database a representative world-wide transient vehicle cycle (WTVC), expressed in terms of vehicle speed and normalised power pattern, was derived. A vehicle test cycle was developed because a vehicle duty cycle is much more stable over longer periods of time than an engine duty cycle. This is because an engine duty cycle changes significantly with engine and drive train technology, whereas a vehicle duty cycle only changes with significant changes in traffic conditions.

However, since vehicle testing is more complex for heavy duty vehicles than for light duty vehicles, the heavy duty exhaust emission certification procedure utilises an engine cycle instead of a vehicle cycle. It was therefore necessary to transform the vehicle cycle (WTVC) into a reference transient engine test cycle. This cycle was defined in terms of normalised engine speed and load and was refined with the help of a newly developed drive train model. This model is capable to take into account different engine and drive train technologies.

After further validation work and refinement of the procedures, a final summary report on the Worldwide Harmonised Heavy Duty Emissions Certification Procedure was presented to GRPE in May 2003. This was followed by a draft proposal for a Global Technical Regulation (GTR) in January 2004. The proposal includes both a transient and a steady state cycle as described below.

B.11.2.2. Transient Test Cycle, WHTC

The transient test cycle, WHTC, is a second-by-second sequence of normalized speed and torque values applicable to all engines covered by the proposed GTR. In order to perform the test on an engine test cell, the normalized values shall be converted to the actual values for the individual engine under test, based on the engine mapping curve. The conversion is referred to as denormalization and the test cycle so developed is the reference cycle of the engine to be tested. With those reference speed and torque values, the cycle shall be run on the test cell, and the feedback speed, torque and power values shall be recorded. In order to validate the test run, a regression analysis between reference and feedback speed, torque and power values shall be conducted upon completion of the test. For calculation of the brake specific emissions, the actual cycle work shall be calculated by integrating actual engine power over the cycle. For cycle validation, the actual cycle work must be within prescribed limits of the cycle work of the reference cycle (reference cycle work).

The WHTC is shown schematically in **Figure B.11.1 and B.11.2**.

Figure B.11.1 Speed Pattern of the World-Wide Reference Transient Engine Cycle (WHTC)

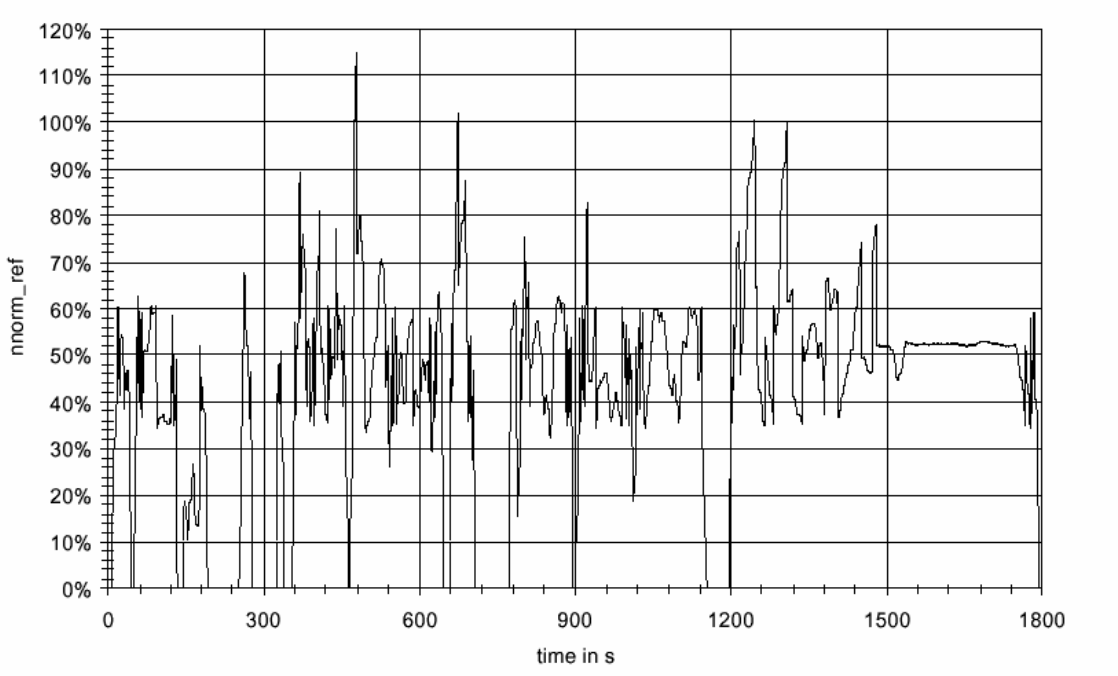
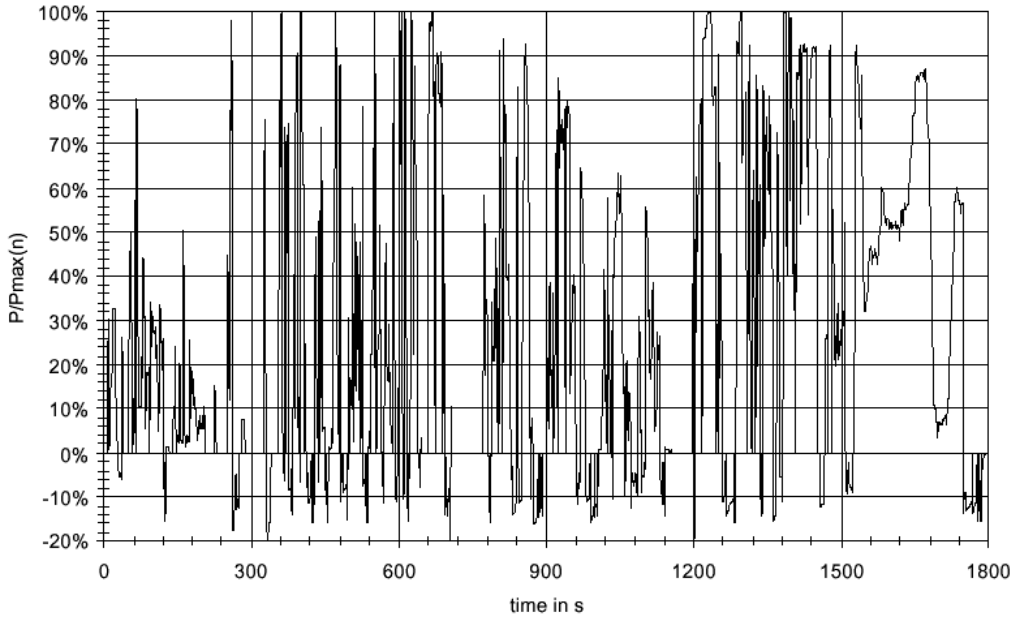


Figure 11.2 Load Pattern of the World-Wide Reference Transient Engine Cycle (WHTC)



B.11.2.3. Steady State Test Cycle, WHSC

The steady state test cycle, WHSC, consists of a number of speed and power modes which cover the typical operating range of heavy duty engines. During each mode the concentration of each gaseous pollutant, exhaust flow and power output shall be determined, and the measured values weighted. The particulate sample shall be diluted with conditioned ambient air. One sample over the complete test procedure shall be taken, and collected on suitable filters.

The WHSC is shown schematically in **Figure B.11.2**, with further definition including emissions weighting factors (WF) in **Table B.11.1**.

Figure B.11.3 Engine Speed/Load Points for the Worldwide Steady State Cycle (WHSC)

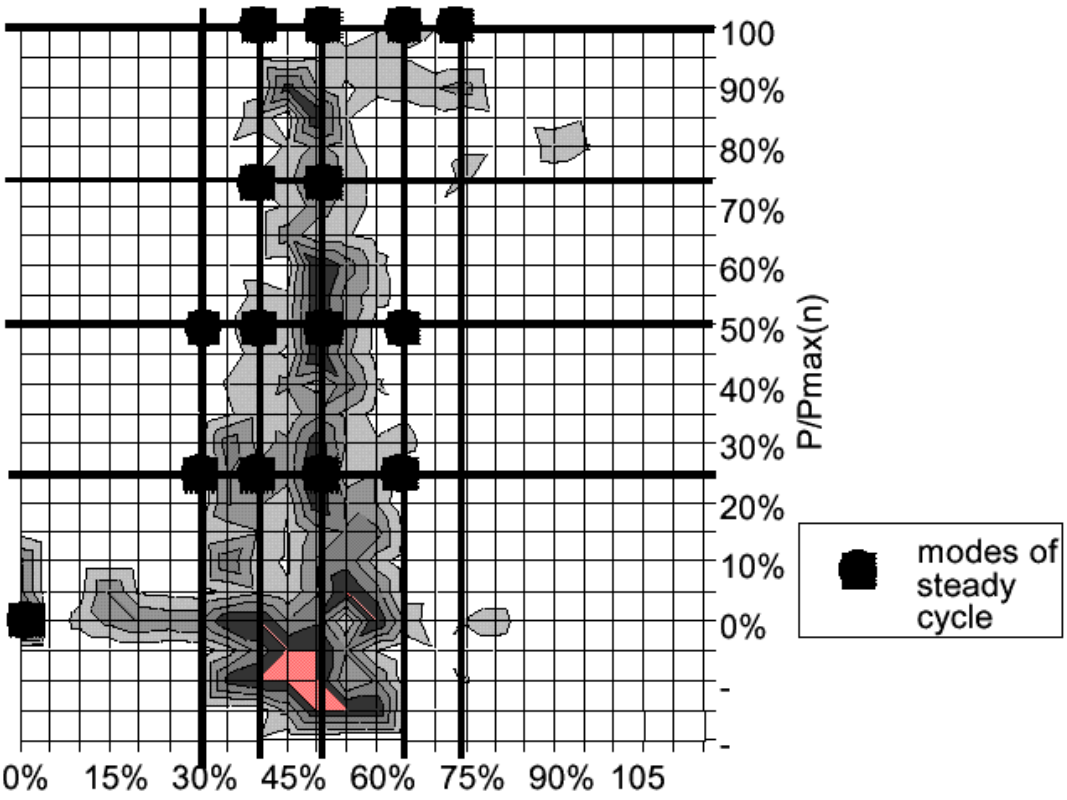


Table B.11.1 Weighting Factors for the World-wide Steady State Cycle (WHSC)

Engine Speed (%)	Engine Load (%)				
	0	25	50	75	100
0	30				
30		3.8	1.4		
40		8.0	4.1	3.8	2.2
50		10.3	14.1	8.4	3.2
65		3.5	1.9		3.1
75					2.2

B.11.3. MOTOR CYCLE EMISSION CYCLES

B.11.3.1. Introduction

Similar efforts have made to develop a common exhaust emissions test procedure for motor cycles. The first informal meeting of the GRPE working group on the worldwide motorcycle emission test cycle (WMTC) was held on 23 May 2000 and reported on progress to the 40th meeting of GRPE in June 2000. By January 2003 the work on the test procedure was nearly complete. The test cycle, gearshift model, test protocol and emission validation test have been finalised and were reported to GRPE in May 2003 as Informal Document 15 .

B.11.3.2. Vehicle Classification

Motorcycles and similar vehicle types are classified as follows:

Class	Engine Capacity (cm^3)	Maximum Speed (v_{max}, km/h)
1	≤ 50	50 < v_{max} < 60
	50 < 150	≤ 50
	< 150	< 130
2	< 150	≥ 100
	≥ 150	< 130
3	≥ 150	≥ 130

B.11.3.3. Test Procedures

The vehicle will be subjected, according to its category, to two types of test as specified below.

Type-I Test

The Type-I Test verifies the average emission of gaseous pollutants, CO_2 emissions and fuel consumption in a characteristic driving cycle. The test is repeated three times and consists of prescribed sequences of dynamometer preparation, fuelling, parking, and operating conditions. The test is designed to determine HC, CO, NOx, CO_2 mass emissions and fuel consumption while simulating real world operation. The test consists of engine start-ups and motorcycle operation on a chassis dynamometer, through a specified driving cycle.

Type-II Test

The Type-II test is a test of CO measured at idling speed providing the emissions data required for roadworthiness testing. CO is checked by a test with the engine at both normal idling speed and a "high idle" speed (i.e. > 2000 min^{-1}). The Type II test must be measured immediately after the Type I test with the engine at both normal idling and high idle speeds. The following parameters are measured and recorded at both speeds:

- CO% v/v,
- CO_2% v/v,
- engine speed, including any tolerances,
- engine oil temperature.

B.11.3.4. Driving Schedules

Test Cycles

The test cycle for the Type I test consists of up to three parts, or segments. Depending on the vehicle class (see above) the following segments have to be run:

Vehicle Class 1: Part 1, reduced speed in cold condition followed by Part 1, reduced speed in hot condition, if:
engine capacity $\leq$ 50 cm^3 and 50 km/h < v_{max} < 60 km/h or
50 cm^3 < Engine capacity < 150 cm^3 and $v_{max} \leq$ 50 km/h.

Part 1 in cold condition followed by Part 1 in hot condition, if
$v_{max} \geq$ 60 km/h

Vehicle Class 2: Part 1 in cold condition followed by Part 2, reduced speed in hot condition, if:
v_{max} < 115 km/h

Part 1 in cold condition followed by Part 2 in hot condition, if:
$v_{max} \geq$ 115 km/h

Vehicle Class 3: Part 1 in cold condition followed by Part 2 and Part 3, reduced speed in hot condition, if:
v_{max} < 140 km/h

Part 1 in cold condition followed by Part 2 and Part 3 in hot condition, if:
$v_{max} \geq$ 140 km/h

Where: v_{max} is the maximum vehicle speed.

Weighting of Results

The emission results in g/km and the fuel consumption in l/100 km obtained for the three tests are averaged for each cycle part. The final result is calculated by means of the following formulae, depending on the vehicle class:

Class 1 R = R1cold × w1cold + R1hot × w1hot

Class 2 R = R1cold × w1 + R2 × w2

Class 3 R = R1cold × w1 + R2 × w2 + R3 × w3

Where "R" is the result and "w" is the weighting factor.

The appropriate weightings are shown in the following Table:

Vehicle Class	Cycle Segment	Weighting (w, %)
1	Part 1, cold	50
	Part 1, hot	50
2	Part 1, cold	30
	Part 2	70
3	Part 1, cold	25
	Part 2	50
	Part 3	25

Reference Fuels

The WMTC have proposed the adoption of gasoline, diesel and gaseous reference fuels aligned with those specified in Directive 2002/80/EC for Euro 3 type approval (see **Part 1, Section 1.4** for details).

Validation

The procedure is now available and validation work is going on.

B.11.4. ISO 8178 TEST CYCLE

ISO 8178, Part 4 specifies test cycles for the measurement and evaluation of gaseous and particulate emissions from reciprocating internal combustion (RIC) engines under test conditions and, with certain restrictions, under site conditions. The test is steady-state, using cycles according to the given application. For the sake of brevity, only the C1 cycle, applicable to larger engines, is shown in **Table B.11.2**.

Table B.11.2 ISO 8178-4 Test Cycle Type C1 for Off-road Vehicles, Industrial & Medium/High Load.

Measuring Point	1	2	3	4	5	6	7	8
Speed	Rated Speed				Intermediate Speed			Low No-load Speed
Torque	100	75	50	10	100	75	50	0
Weighting Factor	0.15	0.15	0.15	0.1	0.1	0.1	0.1	0.15

B.12. ACKNOWLEDGEMENT

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