News Letter

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Auto Emissions - June 1999

Editorial

With the recent directives of the Hon'ble Supreme Court regarding compliance of emission norms for sale of new cars in the National Capital Region, the various aspects of vehicular pollution have been brought to limelight. These include engine technologies, fuel quality, public transport, inspection and certification system for on-road vehicles and traffic management. In an earlier issue of Parivesh (December, 1997), we discussed these aspects in some detail. Based on findings of our air quality monitoring data, we had drawn the attention of concerned authorities and public at large for creation of awareness and for decisions on measures required for curbing the menace of auto emissions.

Dilip
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INTRODUCTION

With the exponential increase in the number of motor vehicles, vehicular exhaust has become a major source of air pollution in urban centres. For containing vehicular pollution, the Government has taken some important initiatives in recent years. These relate to progressive tightening of auto-emission norms (1991,1996, 1998 & 2000) and fuel quality specifications (1996) as recommended by the Central Pollution Control Board (CPCB). CPCB had also drawn up a series of Action Points (1995) and a Strategy for Vehicular Pollution Control (1997) with estimates of possible reduction in pollution load through the individual and combination of various measures including phasing out of grossly polluting old vehicles and introduction of systematic inspection and certification system for on-road vehicles.

Among the metro-cities, the capital city is most severely affected with the highest number of motor vehicles and as much as 70% of the air pollution is attributed to vehicular exhaust. This is why, the Environment Pollution (Prevention & Control) Authority for NCR, (constituted in January 1998) was asked to pay special attention to the measures for containment of vehicular pollution.

Based on the inputs provided by CPCB and discussions with the concerned agencies, the Authority had enlisted some priority measures and time targets for vehicular pollution control. The Hon'ble Supreme Court approved the proposed measures and directed that these measures should be implemented. Some of the measures have been implemented while others are in different stages of implementation (Table 9). A review of the steps so far taken and their impacts vis-à-vis the steps which need to be taken for an integrated approach towards control of vehicular pollution is presented in the following sections.

STEPS SO FOR TAKEN AND THEIR IMPACTS

As a result of initiatives taken in recent years which have been reinforced through the Environmental Pollution Control Authority and directions of the Hon'ble Supreme court, the impacts in terms of pollution reduction as confirmed by CPCB findings include the following:

(I) Unleaded Petrol

With the progressive reduction of lead content in petrol (from 0.56 gm./litre to 0.15 gm./litre), introduction of unleaded petrol for new passenger cars from April, 1995 and supply of only unleaded petrol for all vehicles from September, 1998, in UT of Delhi a lethal pollutant from vehicular exhaust has been removed. The lead content in the atmosphere near traffic intersections of UT of Delhi has reduced by more than 60% with the introduction of unleaded petrol. The apprehensions that the unleaded petrol would adversely affect the performance of engines and increase the emission of benzene have also been allayed. The refineries have been asked to ensure that the benzene content in unleaded petrol is not increased beyond the limit of 5% (v/v) as prescribed for the leaded petrol in 1996 and 3% (v/v) from 2000. However, the ambient air quality monitoring data indicate high levels of benzene and polyaromatic hydrocarbons before and after introduction of unleaded petrol. Hence, in addition to phasing out of lead it is necessary to reduce the benzene (to 1% or lower) and aromatics in petrol not only for Delhi but also for other parts of the country.

(II) Sulphur in Diesel

Sulphur content in diesel supplied in Delhi was reduced to 0.5% in 1996 and it was further reduced to 0.25% in 1997. It is expected that diesel with 0.25% sulphur will be - available throughout the country by September, 1999. Considering the fact that several countries have introduced diesel with much lower sulphur content and it is necessary to have low sulphur diesel for meeting the emission norms beyond EURO-II norms (for EURO-I to EURO-II norms, sulphur content in diesel is 0.3%), the refineries will need to take steps for bringing down the sulphur content.

SULPHUR IN DIESEL

Diesel emissions contain sulphur in particulate and gaseous form, and thus any reduction in sulphur has dual advantages. Recent evaluations carried out in Europe show the benefits of reduced sulphur in diesel fuel for lowering particulates. For example, preliminary data released from the Auto/Oil study showed that lowering the diesel fuel sulphur level from 2000 particles per million (ppm) 500 ppm reduced overall particulate from light-duty diesels by 2.4 percent, and from heavy-duty diesels by 13 percent. The relationship between particulates and sulphur level was found to be linear; for every 100 ppm reduction in sulphur, there is a 0.16 percent reduction in particulate from light-duty vehicles and a 0.87 percent reduction from heavy-duty vehicles.

Options to Reduce the Sulphur Content of Diesel Fuel

- In the crude state, increase the proportion of low-sulphur crude oil.
- Reduce the cut point of diesel fractions from both primary distillation as well as from the fractionation of secondary processing streams to 350-360 o C.
- Improve fractionation efficiency to eliminate inter-stream overlaps during fractionation of diesel oils.
- Hydro-treat straight-sun diesel and thermally cracked diesel and/or hydrofine; reduce proportions of FCC oil blended into final product diesel oil.
- Install hydrocrackers that would enable production of very low-sulphur saturated diesel with high cetane numbers.

GASOLINE LEAD PHASE OUT PROGRAMME IN INDIA			
Phase – I	June 1994	Lowleaded (0.15g/l)	Cities of Delhi, Mumbai, Calcutta and Chennai
Phase – II	1.4.1995	Unleaded (0.013g/l)	Cities of Delhi, Mumbai,

		(+ low leaded)	Calcutta and Chennai
Phase – III	1.1.1997	Lowleaded (0.15g/l)	Entire country
Phase – IV	1.9.1998	Ban on Leaded fuel (Only unleaded fuel)	NCT Delhi
Phase – V	31.12.1998(Advanced to 1.9.98)	Unleaded (0.013g/l) (+ low leaded)	All other capitals of States / UTs and other major cities.
Phase - VI	1.1.99	Unleaded only (0.013g/l)	NCR
Phase – VII	1.4.2000	Unleaded (0.013g/l) (+ low leaded)	Entire country •

DIESEL SULPHUR PHASE OUT ROGRAMME IN INDIA			
Phase I	April 96	Low Sulphur (0.5%)	Four metros and Taj Trapezium
Phase II	August 97	Low Sulphur (0.25%)	Delhi and Taj Trapezium
Phase III	April 98	Low Sulphur (0.25%)	Metro Cities
Phase IV	April 99	Low Sulphur (0.25%)	Entire Country

(III) Tightening of vehicular emission norms

During 1990-91, for the first time, mass emission norms for vehicles at manufacturing stage as well as for in-use vehicles have been notified. For meeting these norms, the manufacturers did not require any major modifications. The emission norms along with fuel quality specifications laid down in 1996 required the automobile manufacturers to make modification in the engine design particularly in regard to crankcase emission and evaporative emission control. From April, 1995 new passenger cars were allowed to register only if these were fitted with catalytic converters. Emission norms for such cars were tightened by 50 percent as compared to 1996 norms. The testing method for Passenger Cars norms was changed to cold start from hot start from April 98 which is a stricter procedure than the previous one. The norms for the year 2000 notified in August 1997 under the Motor Vehicle Rules require major modifications in the engine design specially in regard to fuel injection system in passenger cars and fitment of catalytic converters in 2 stroke engines. These standards are akin to EURO-I norms adopted in the European countries in 1992. With the recent directions of the Hon'ble Supreme Court, passenger cars (both petrol and diesel) are required to meet atleast EURO-I norms June 1999 and from April 2000 only such vehicles meeting EURO-II norms will be registered in the National Capital region. CNG operated vehicles are also permitted by the Supreme Court directions.

(IV) 2-T oil for 2 stroke engines

On the recommendation of CPCB, the Ministry of Environment & Forests notified the specifications for 2T oil which became effective from 01.04.99. The specifications required use of low smoke 2T oil which is one of the causes of pollution from 2 stroke engines. To prevent the use of 2T oil in excess of the required quantity, pre-mixed 2T oil dispensers have been installed in all the petrol filling stations of Delhi. Sale of loose 2T oil has also been banned from December, 1998.

POLLUTION REDUCTION THROUGH PREMIX 2T OIL DISPENSER

The two stroke two and three wheelers require 2 T oil for lubrication of engine. The lubrication is carried out either through premixing modes or through oil injection modes. In either case it is a total loss system

as the oil is burnt along with the fuel and goes through the exhaust. The burnt oil comes out through the exhaust, which is responsible for smoke and particulate matter emission.The burning quality of mineral based lubricating oil is very poor as compared to that of petrol. Major fraction of the lubricating oil entering the engine may therefore burn only partially or remain unburned. Some of the burnt oil may lead to formation of solid particles while major fraction may remain unburnt. This reflects itself as visible smoke in the exhaust in the form of oil droplets and some solid particles. The totality of these solid particles is referred to as particulate matter. **The two stroke vehicles required 2 T oil at concentration not more than 2% i.e. 20 ml in a litre of petrol. There is tendency to mix excess oil in petrol keeping disbelief in mind that more lube oil increase engine life. Excess use of 2 T oil causes following problems :**

1. **Increases visible smoke and particulate matters. It has been found that with increase of 1% of oil there is increase of about 15% of particulate matter.**
2. **Oil consumption is more.**
3. **More engines deposit.**
4. **Reduction in life of spark plug and engine.**

(V) Phasing out of grossly polluting vehicles To begin with, 20-year old vehicles were prohibited from plying from December 1998, followed by phasing out of 17-year old vehicles from November 98 and 15-year old vehicles from December 1998. Registration of new auto-rickshaws with front engine has been banned from May 1996 and the registration of old defence service and govt. auctioned vehicles has been banned from April, 1998.

(VI) Impacts on pollution load and air quality The steps taken so far taken had some impact on vehicular pollution load and air quality. The major impacts have been observed through implementation of emission norms and fuel quality specifications effective from 1996, as also phasing out of 15-year old commercial vehicles and leaded petrol in the year 1998. Table 1 shows estimated vehicular pollution load in different years if no measures were taken and with various measures taken. Due to increase in growth of vehicles, the vehicular pollution load has increased from 1990-91 to 1995-96. With the implementation of emission norms and fuel quality specifications, phasing out of 15-year old vehicles and leaded gasoline the pollution load has decreased in 1998-99. The ambient air quality monitored in different areas of Delhi also shows a similar trend (Table 2). As compared to 1995, the levels of pollutants in the ambient air of Delhi has decreased by 4-40 percent in case of SO 2 , 4-13 percent in case of NO 2 , 6-17 percent in case of Particulate Matter, 3 percent in case of Carbon monoxide and 11 to 60 percent in case of lead during 1998.

Table 1 Estimated Vehicular Pollution Load in Delhi

Pollutants	**Pollution Load in thousand tonnes**					**% reduction as compared to 1995-96**
Without measures			**With measures**			
1990-91	**1995-96**	**1998-99**	**1995-96**	**1998-99**		
Carbon monoxide	243	373	451	351	337	4
Hydrocarbons	82	123	148	113	115	+2
Nitrogen Oxides	139	208	248	207	182	12
Sulphur dioxide	10	15	17	15	11	27
Lead	0.190	0.259	0.362	0.259	0.007	97
Particulate	19	28	33	28	21	25

Matter						
Total Pollution Load	394	747	897	714	666	
Emission Load in t/day	1351	2047	2459	1957	1825	

Table 2 Estimated Vehicular Emission load in Delhi

Pollutants	**Pollution load in thousand tonnes**			
1990-91	**1995-96**	**1998-99**	**% reduction as compared to 1995-96**	
Sulphur dioxide	10	15	11	27
Nitrogen dioxide	139	207	182	12
Particulate Matter	19	28	21	25
Lead	0.190	0.362	0.007	97
Carbon Monoxide	243	351	337	4
Hydrocarbons	0.83	113	115	+2

Table 3 Ambient air quality in Delhi

	1995	**1998**	**%Percent reduction as compared to 1995**
INDUSTRIAL AREA			
Sulphur dioxide	24.1	20.2	16
Nitrogen dioxide	35.5	34.7	4
Suspended Particulate Matter	420	367	13
Lead	110	105	5
RESIDENTIAL AREA			
Sulphur dioxide	16.5	15.8	4
Nitrogen dioxide	32.5	28.6	13
Suspended Particulate Matter	409	341	17
Lead	155	95	39
TRAFFIC INTERSECTIONS			
Sulphur dioxide	42	25	40
Nitrogen dioxide	66	63	5
Suspended Particulate Matter	452	426	6
Lead	335	136	60
Carbon Monoxide	5587	5450	3

all units are in microgramme/cubic metre except for lead which is in nanogramme/cubic metre.

Table 4 National Ambient Air Quality Standards

Pollutants	Time-weighted average	Concentration in ambient air			Method of measurement
Industrial Areas	**Residential, Rural & other Areas**	**Sensitive Areas**			
Sulphur Dioxide (SO 2)	Annual Average*	80 mg/m^3	60 mg/m^3	15 m g/m^3	- Improved West and Greake Method
24 hours**	120 mg/m^3	80 mg/m^3	30 mg/m^3	- Ultraviolet Fluorescence	
Oxides of Nitrogen as NO 2	Annual*	80 mg/m^3	60 mg/m^3	15 m g/m 3	- Jacob & Hochheiser Modified (Na-Arsenite) Method
24 hours**	120 mg/m^3	80 mg/m^3	30 mg/m^3	- Gas Phase Chemiluminescence	
Suspended Particulate Matter (SPM)	Annual*	360 mg/m^3	140 mg/m^3	70 mg/m^3	- High Volume Sampling,
24 hours**	500 mg/m^3	200 m g/m 3	100 mg/m^3	(Average flow rate not less than 1.1 m^3/minute).	
Respirable Particulate matter (RPM) (size less than 10 nm)	Annual*	120 mg/m^3	60 mg/m^3	50 mg/m^3	- Respirable particulate
24 hours**	150 mg/m^3	100 mg/m^3	75 m g/m	matter sampler	
Lead (Pb)	Annual*	1.0 mg/m^3	0.75 mg/m^3	0.50 m g/m 3	- ASS Method after sampling using EPM 2000 or equivalent Filter paper
24 hours**	1.5 mg/m^3	1.00 mg/m^3	0.75 mg/m^3		
Carbon Monoxide (CO)	8 hours**	5.0 mg/m^3	2.0 mg/m^3	1.0 mg/m^3	- Non dispersive infra end
1 hour	10.0 mg/m^3	4.0 mg/m^3	2.0 mg/m^3	Spectroscopy	

*** Annual Arithmetic mean of minimum 104 measurements in a year taken twice a week 24 hourly at uniform interval. ** 24 hourly/8 hourly values should be met 98% of the time in a year. However, 2% of the time, it may exceed but not on two consecutive days.**

NOTE:

1. National Ambient Air Quality Standard: The levels of air quality with an adequate margin of safety, to protect the public health,, vegetation and property.
2. Whenever and wherever two consecutive values exceeds the limit specified above forthe respective category, it would be considered adequate reason to institute regular/continuous monitoring and further investigations.

EURO NORMS

European Union regulations on vehicle emission published as directives have the force of law within EU member states under the provisions of the treaty of Rome. In its early years the European Union of generally adopted regulations which were technically identified with ECE (Economic commission for European) equivalents. This position has changed over the time with the European Union, gradually assuming a major role in formulating automotive emission standards .

Light duty vehicles (Passenger Cars) were the first to be regulated under the ECE Process and their limits have been subsequently amended four times ECE-15, ECE-15/01, ECE 15/02, ECE 15/03, ECE 15/04 from 1970 to 1984. In 1988 ECE adopted Directives ECE 83 (88/76/EEC) which amend Directives 70/220/EEC allows the certification of cars with an engine displacement above 1.4 litres on the basis of US procedure and limits. In practical terms this regulation was not implemented by any European Country in anticipation of adoption by EU of the Consolidate Emission directive or Euro I norms. In 1991 the council of Ministry of European Community adopted the Consolidate Emission Direction 91/441/EEC or Euro I norms. According to the Directive Exhaust emission standard have to be on the basis of new combined ECE - 15 (urban) cycle and EUDC Extra urban test cycle. In contrast to pervious directives a common set of gaseous emission standard will apply to all private passenger cars irrespective of engine capacity. Subsequent in Dec. 93 the Environmental Council agreed more stringent limit for 1996 onwards and these were adopted as Directives 94/12/EC on Euro II norms in March 1994. Compared with Euro I norms separate limits are given for gasoline and diesel fuel vehicles. These represent respective reduction of 30% CO, 55% HC+NOx for gasoline cars and 68% CO, 38% HC+NOx and 55% particulate emission for diesel vehicles. Contrary to the earlier standard, production vehicle must comply with the type approval limits. Based on Auto Oil study Euro III and Euro IV norms has been adopted which will be

implemented year 2000 and 2005. The comparative table of EURO I, II, III, IV along with Indian norms is given in table 5, 6, 7, & 8. India introduced emission norms for vehicle for the first time in 1991. Indian norms are behind Euro norms by 8 years although effort is being made to narrow the gap between Euro standard and Indian emission norms.

TOWARDS INTEGRATED APPROACH

Containment of vehicular pollution requires an integrated approach, the essential components of which include the following :

1. Improvement of public transport system (e.g. urban buses)
2. Optimisation of traffic flow and improvement in traffic management (e.g. area traffic control system, no-traffic zone, green corridors, removal of encroachment on roads, regulation of construction activities and digging of roads).
3. Comprehensive inspection and certification system for on-road vehicles.
4. Phasing out of grossly polluting vehicles.
5. Fuel quality improvement (e.g. benzene and aromatics in petrol, reformulated gasoline with oxygenates/additives, reduction of sulphur in diesel).
6. Tightening of emission norms (e.g. EURO-IV by 2005)
7. Improvement in vehicle technology (e.g. restriction on the 2 stroke engines, emission warranty, on-board diagnostic system).
8. Checking adulteration of fuel.
9. Checking evaporative emissions from storage tanks and fuel distribution system.

Improvement of Public Transport System

According to an estimate made by RITES, a modal split of 70-75% infavour of public transport needs to be planned for the city of Delhi. Presently, the modal share of public transport (Bus) is 62 percent. Along with the increase in number of buses, the passenger capacity should also be increased and the engines should conform to urban design. The existing circular ring railway network also requires to be improved. These measures will meet the immediate requirements since the mass rapid transport system (MRTS) will take some years to materialise.

Traffic Management System

Well planned Traffic management system results in better mobility level on road by providing higher journey speeds and reduced delay at intersection thereby bringing significant reduction in fuel consumption and emission. Automatic traffic control, signal optimisation, tidal flow and removal of encroachments are among the important components of traffic management system. This will reduce the congestion and consequently pollution. Frequent digging of roads and construction work also leads to congestion and pollution, which can be minimised through proper coordination with traffic police.

Comprehensive Inspection and Certification System

It is a system to reduce the pollution by requiring regular inspection and maintenance of motor vehicles already plying on roads. It identifies those in-use vehicles that need maintenance and repair because they pollute more than the new vehicles. The system helps in reducing the air pollution. Such system is

widely used in other countries and it has been possible to reduce about 30-40% of pollution loads by proper inspection and maintenance of vehicles. Such facilities for thorough inspection and maintenance of vehicles are required in different parts of the country.

Phasing Out of Grossly Polluted Vehicles

Pre-1990 vehicles emit more than ten times pollutants than the vehicles meeting Euro I norms (India 2000 norms). In Delhi, more than 15 year old commercial vehicles are not allowed to ply on roads. Similarly, de-registration of all older vehicles should be made effective so that the grossly polluting vehicles are phased out.

Fuel Quality Improvement

Benzene and aromatics in petrol

Due to high level of benzene in atmosphere, benzene content of gasoline needs to be reduced to 1% (v/v) or lower as in other countries. With the reduction of benzene in gasoline (<1%) it is possible to achieve significant reduction in benzene emission from exhaust. Benzene and PAH emission also depend upon the aromatic content of gasoline. Therefore, in addition to reduction of benzene, it is also necessary to reduce the aromatic content in petrol.

REDUCING BENZENE CONTENT IN MOTOR GASOLINE

Benzene is a proven carcinogen. The most significant health effects from a short or long term exposure to benzene are haemotoxicity, immunotoxicity, neurotoxicity and carcinogenicity.

Benzene in the crude oil is present at levels upto 4 g/l. Its concentration varies from one source to another. In India, Benzene content in motor gasoline varies from 3-5% by weight.

Although Benzene is also emitted from industrial activity, about 80 to 85% of benzene in atmosphere comes from automobiles. In heavy traffic area, upto 40 to 50 ug/m 3 of Benzene in the ambient air has been observed

About 80-90% of the Benzene from automobile sector is emitted from the exhaust. About 10-20% are from evaporation while 3-6% are from transportation, delivery and distribution at petrol stations. Most part of benzene in gasoline is oxidised during combustion while some part are emitted through exhaust. Some portion of benzene is formed from the other aromatics by process of dealkylation during combustion. On an European vehicle fuelled with gasoline containing 3% by wt of benzene and 30% by wt of other aromatics, it has been found that 44% of the benzene survived combustion and 56% was created during combustion from other aromatics.

Average benzene emission of 32 mg/km out of 1130 mg/km of HC has been measured on American automobiles equipped with catalytic converter in FTP cycle. European automobiles without catalytic converter emit about 270 mg/km of benzene in ECE cycle.

Benzene exhaust emission (B.E.E.) can be estimated by following equation,

BEE mg/km = [1.884 + (0.949 x % Benzene) x 0.113 + (% aromatics - % of Benzene)] x 1.609

By this equation, it can be estimated that if benzene control is reduced from 5% to 3% there will be 35% reduction in the exhaust emission of Benzene.

In USA, Europe and Japan, benzene content in motor gasoline has been reduced to 1%. In India, the benzene content of 5% has been prescribed which will be reduced to 3% from year 2000.

Sulphur Content in Diesel

Sulphur in diesel has direct effect on SO 2 and particulate emission and indirectly on other pollutants due to its poisoning effect on catalytic converter. In European countries, sulphur content in diesel has been reduced to 0.05% from 1996 and it will be further reduced to 0.005 from the year 2000.

Reformulated gasoline

Reformulated gasoline with the use of oxygenates and additives etc. help reducing pollution load from on-road vehicles. According to a study commissioned by CPCB, 3-5% ethanol can be used in petrol without affecting the engine performance and with the attendent benefits in terms of emission control.

Tightening of emission norms

The emission norms effective from 2005 need to be further tightened to offset the increase of pollution load due to exponential growth of vehicles. It is time to bridge the gap between Euro norms and Indian norms. Euro IV norms for petrol vehicles and diesel passenger cars and Euro III norms for heavy diesel vehicles may be a preferred target for 2005.

Improvement in Vehicles

In India, majority of vehicles is of two stroke engines. Although the two stroke engine technology for 2 or 3 - wheelers has been upgraded to some extent there is not much improvement in control of hydrocarbons and particulate (due to combustion of lube oil). Hence, it is necessary to consider as to whether 2-stroke technology should be replaced by 4-stroke technology for reducing the emission specially in terms of hydrocarbons and particulate matter apart from increased fuel efficiency in 4-stroke engines.

On Board Diagnostic System

The On Board Diagnostic System (OBD) electronically records the fault and their causes in combination with various Diagnostic Strategies to enable vehicle owner / driver to take corrective action. This is one of the requirements of emission regulation in USA and it will be followed in Europe from year 2000 which will be a part of Euro III norm for 2000.

Checking Fuel Adulteration

Adulteration of fuel plays a major role in emission of pollutants from on roads vehicles. Effective measures are required to prevent adulteration of fuel.

Evaporative Emission Control

To minimise evaporation losses of fuel and consequent pollution, adequate preventive steps need to be taken during storage, loading, unloading and distribution. Vapour recovery system in the filling stations is yet another important measure for reducing evaporative losses.

Table 5 Indian and EURO Norms for Petrol Driven Passenger Cars

1991/92			1996	1998	1996	2000		2005
INDIA		EURO-I	INDIA	INDIA	EURO-II	INDIA	EURO-III 2	EURO-IV 2
CO g/km	14.3-27.1	2.72	8.68-12.4	4.34-6.20	2.2	2.72	2.3	1.0
HC g/km	2.0-2.9	-	-	-	-	-	0.20	0.1

NOx g/km	-	-	-	-	-	-	0.15	0.08
HC+NOx g/km	-	0.97	3.4-4.36	1.5-2.18	0.57	0.97		

Note :

- Norms for Passenger Cars fitted with catalytic converter only
- In case of Euro III & Euro IV COP = type approved norms

Table 6 Indian and EURO norms for Diesel driven Passenger cars

1991/1992		1996		2000		
INDIA	**EURO-I**	**INDIA**	**EURO-II**	**INDIA**	**EURO-III**	
CO g/km	14.0 (g/KWH)	2.72	5.0 - 9.0	1.00	2.72-6.90	0.6
HC g/km	3.5 (g/KWH)		-			
NOx g/km	18.0 (g/KWH)					
HC+NOx g/km	-	0.97(IDI) 1.36 (DI)	2.0-4.0	0.7	0.97 - 1.70	0.56
PM g/km	-	0.14(IDI) 0.19 (DI)		0.08	0.14-0.25	0.05

Note:

- In case of EURO II and EURO III type approved norms = COP norms.
- In India there is also option for testing with engine dynamometer (in g/KWH) as given in Table 3 as these come under Diesel Light duty vehicles GVW<3.5 tons.
- In European norms Passenger Cars refers to Passenger Cars with seating capacity less than 6 and GVW less than 2.5 tons.

Table 7 Indian and EURO norms for Diesel Light duty Vehicles < 3.5 tonnes

1991/1992		1996		2000	
INDIA	**EURO-I**	**INDIA**	**EURO-II**	**INDIA**	
CO	14.0 g/KWH	2.72-6.90[2] g/km	11.2[1]g/km or 50-9.0[3] g/km	1.0 to 1.5[2] g/km	4.5[1]g/KWH or 2.75-6.90 3 g/km
HC	3.5[1] g/KWH	-	2.4[1]g/KWH or HC+NOx norms	-	1.1[1]g/KWH or HC+NOx Norms
NOx HC+NOx	18 g/KWH -	- 0.97-1.7[2] (g/km)	14.4[1] g/KWH or	- 0.7 - 1.3[2]	8.0[1]g/KWH or

			2.0 to 4.0[3] g/km		0.97-1.70[3] g/km
PM	-	0.14-.7 (g/km)	-	-	0.61 KWH or 0.14 - 0.25 g/km[3]

1 = 13 mode cycle

2 = EDC + EUDC

3 = Indian Driving Cycle

Table 8 Indian and EURO norms for Diesel Vehicles > 3.5 tonnes

1991/92		1996		2000		
INDIA	**EURO-I**	**INDIA**	**EURO-II**	**INDIA**	**EURO-III**	
CO g/KWH	14.0	4.5	11.2	4.00	4.5	2.1
HC g/KWH	3.5	1.10	2.4	1.10	1.10	0.66
NOx g/KWH	18.0	8.00	14.4	7.00	8.00	5.0
PM>85 g/KWH	-	0.36	-	0.15	0.36	0.1
PM<85 g/KWH	-	0.61	-	0.15	0.61	0.1

Table 9 Status of Implementation of Priority Measures

S. No.	Measures	Time Target	Concerned Agency	Status
1.	Complete removal of leaded petrol in NCT Delhi	01.09.1998	Ministry of Petroleum & Natural Gas	Done
2.	Phasing out of 15 years old commercial vehicles	31.12.1998	Transport Department, Govt. of NCT-Delhi.	Done
3.	Installation of pre-mixed 2T oil dispensers in petrol filling stations.	31.12.1998	Ministry of Petroleum & Natural Gas	Done
4.	Expansion of CNG Supply Network (from 9 to 80 stations)	31.03.2000	Gas Authority of India Limited	Pending issues relating to allotment of land for the CNG stations has been sorted out

				through intervention of the Authority with the concerned land owning agencies.
5.	Setting up of two independent fuel testing laboratories for checking the quality of the fuel.	01.06.1999	Ministry of Petroleum & Natural Gas and Association of Indian Automobile Manufacturers (AIAM)	One laboratory is being set up at NOIDA and the other will be at Gurgaon.
6.	Replacement of all pre-1990 autos and taxis with new vehicles using clean fuel	31.03.2000	Transport Department, Govt. of NCT-Delhi.	Action due.
7.	No 8 years old bus is to ply except on CNG or other clean fuel.	01.04.2000	Transport Department, Govt. of NCT-Delhi.	Action due. Work plan not received.
8.	All buses to switch over to CNG instead of diesel	31.03.2001	Transport Department, Govt. of NCT-Delhi.	Action due.
9.	The bus fleet to be augmented to 10,000	01.04.2001	Transport Department, Govt. of NCT-Delhi	Action due.
10.	New ISBTs to be set up at entry points in north and south-west to avoid congestion and pollution due to entry of inter-state buses.	31.03.2000	Transport Department, Govt. of NCT-Delhi.	Action due.
11.	Automated inspection and certification facilities to be set up for commercial vehicles in the first phase.	31.03.2000	Transport Department, Govt. of NCT-Delhi.	Action due. As of now, only one station is in operation.
12.	Augmentation of air quality monitoring network.	31.03.2000	Central Pollution Control Board, Ministry of Environment & Forests and Delhi Pollution Control Committee, Govt. of NCT-Delhi.	CPCB has prepared a comprehensive proposal. DPCC has been asked to set up monitoring facilities in addition to the monitoring stations set up

				by CPCB. Besides the criteria pollutants, facilities for monitoring of additional parameters like benzene, RSPM, Poly aromatics and Ozone have been set up by CPCB.

DRIVING CYCLE

The method of measuring exhaust emission rates from motor vehicles is determined by statutory test procedure, the objective being to establish the mass of each exhaust component emitted during the test. The mass is computed from the measured concentration of each pollutant in the known exhaust gas volume. Exhaust species are generated when the vehicle is operated on a chasis dynamometer according to certain driving cycle which are designated to simulate driving condition in urban traffic. To be able to check the application of the regulation in measurement conditions that are reproducible as possible it is necessary to adopt these test procedures. The Indian driving cycle has been developed by IIP, Dehradun and ARAI Pune.

Different countries used different test cycles. A comparision of different test cycle for passenger cars is given in Table 10. So far unfortunately the countries have not been unanimous in adopting universally applicable procedures and several types of test cycles are in use, for which no correlation exists for converting from one to another.

In Europe, Extra urban cycle (EUDC) was introduced under pressure from Netherland which showed that over 70% of European mileage was driven at more than 70 km/hr, conditions that lead to 40% of HC emission and 80% of NOx emission.

Table 10 Comparision of Different Driving Cycles for Passengers Cars

Parmeters	Units	ECE-15 cycle	ECE-15+EUDC cycle	FTP – 75 cycle	Japan 11 mode cycle	Japan 10.15 mode	Indian driving cycle (IDC)
Total time	Seconds	780	1220	2477	120	660	648
Distance covered	Km	4.052	11.007	17.87	1.021	4.16	3.948
Average Speed	Km/hr	18.7	33.6	34.1	30.6	22.7	21.93
Max. Speed	Km/hr	50	120	91.2	60	70	42
Idling	% time	35.4	31	17.3	21.7	31.4	14.81
Acceleration	% time	21.6		33.7	34.2		38.89
Constant Speed	% time	29.3		20.5	13.3		12.04
Deceleration	% time	13.8		26.5	30.8		34.26
Implementation in countries		Earlier by	Most of	USA,	Earlier	Japan	India

		EEC Countries, Malasiya	EEC countries	California, Canada, Australia, Norway, Sweden, Brazil, S. Koria	by Japan		

*** Modified Indian Driving cycle is similar to ECE-15+EUDC expect the maximum speed is restricted to 90 km/hr.**