Appendix 2.1

VEHICULAR POLLUTION CONTROL PROGRAMME IN INDIA

A2.1 INTRODUCTION

Air pollution is one of the serious environmental concerns of the urban Asian cities including India where majority of the population is exposed to poor air quality. The health related problems such as respiratory diseases, risk of developing cancers and other serious ailments etc. due to poor air quality are known and well documented. Besides the health affects, air pollution also contributes to tremendous economic losses, especially in the sense of financial resources that are required for giving medical assistance to the affected people. The poor are often the most affected segment of the population as they do not have adequate measures to protect themselves from air pollution.

Most of the Indian Cities are also experiencing rapid urbanization and the majority of the country’s population is expected to be living in cities within a span of next two decades. Since poor ambient air quality is largely an urban problem this will directly affect millions of the dwellers in the cities.

The rapid urbanization in India has also resulted in a tremendous increase the number of motor vehicles. The vehicle fleets have even doubled in some cities in the last one decade. This increased mobility, however, come with a high price. As the number of vehicles continues to grow and the consequent congestion increases, vehicles are now becoming the main source of air pollution in urban India. Although, the air quality can be improved through a combination of technical and non-technical measures, legislative reforms, institutional approaches and market-based instruments, there are certain unique challenges which the country has to face in tackling the problem of urban air pollution. These include, the transport features which are different from the developed countries particularly in terms of the types of vehicles commonly used, the manner in which the road network is operated and sharing of the limited space by pedestrians and non-motorized modes with modern vehicles in Indian cities. Vehicles in India are often much older and usually comprise technologies considered as out-dated in the developed world. The institutions responsible for managing urban air quality are also not as well developed as those in the developed countries. The country has however taken a number of measures for the improvement of the air quality in cities. These include, right from the improvement in the fuel quality, formulation of necessary legislation and
enforcement of vehicle emission standards, improved traffic planning and management etc. The non-technical measures taken include, awareness raising regarding the possible economic and health impacts of air pollution and available measures for improving air quality, increasing use of cleaner fuels and purchase of vehicles with advance emission control devices, increasing institutional framework and capacity building for the monitoring of vehicle emissions.

The following section presents a review of the problems associated with vehicular emissions, health and environmental effects of vehicular pollutants, vehicular pollution and climate change, vehicular pollution problems in India, control measures taken and details of legislative and implementing agencies.

A2.2 PROBLEMS ASSOCIATED WITH VEHICULAR EMISSIONS

The major problems associated with vehicular emission are mainly related to health and climate change.

A2.2.1 MAJOR VEHICLE/FUEL POLLUTANTS

Organization like TERI, UNEP/ WHO, World Bank, BARC/CESE/IIT, etc. have carried out studies in the past to estimate the contribution of various sources towards the ambient air quality. Automotive vehicles emit several pollutants depending upon the type of quality of the fuel consumed by them. The release of pollutants from vehicles also include fugitive emissions of the fuel, the source and level of these emissions depending upon the vehicle type, its maintenance etc. The major pollutants released as vehicle/fuel emissions are, carbon monoxide, nitrogen oxides, photochemical oxidants, air toxics namely benzene, aldehydes, 1-3 butadiene, lead, particulate matter, hydrocarbon, oxides of sulphur and polycyclic aromatic hydrocarbons. While the predominant pollutants in petrol/gasoline driven vehicles are hydrocarbons and carbon monoxide, the predominant pollutants from the diesel based vehicles are Oxides of nitrogen and particulates. The summary of the results of the above studies for Delhi & Mumbai are given pollutant wise in Table A2.1 below:
Table A2.1: Summary of The Results of Various Studies

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Parameter</th>
<th>Delhi</th>
<th>Mumbai</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Transport</td>
<td>Industrial</td>
<td>Domestic &amp; other Sources</td>
</tr>
<tr>
<td>1.</td>
<td>CO</td>
<td>76% to 90%</td>
<td>37% to 13%</td>
</tr>
<tr>
<td>2.</td>
<td>NOx</td>
<td>66% to 74%</td>
<td>13% to 29%</td>
</tr>
<tr>
<td>3.</td>
<td>SO₂</td>
<td>5% to 12%</td>
<td>84% to 95%</td>
</tr>
<tr>
<td>4.</td>
<td>PM</td>
<td>3% to 22%</td>
<td>74% to 16%</td>
</tr>
</tbody>
</table>

Source: Auto Fuel Policy Report

A2.3 HEALTH AND ENVIRONMENTAL EFFECTS OF VEHICULAR POLLUTANTS

The vehicular emissions have damaging effects on both human health and ecology. There is a wide range of adverse health/environmental effects of the pollutants released from vehicles. The effects may be direct as well as in-direct covering right from reduced visibility to cancers and death in some cases of acute exposure of pollutants specially carbon monoxide. These pollutants are believed to directly affect the respiratory and cardiovascular systems. In particular, high levels of Sulphur dioxide and Suspended Particulate Matter are associated with increased mortality, morbidity and impaired pulmonary function. The pollutant wise health effects are summarized in Table A2.2.
Table A2.2: Health effects associated with Air Pollutants

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Effect on Human Health</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon Monoxide</td>
<td>Affects the cardio vascular system, exacerbating cardiovascular disease symptoms, particularly angina; may also particularly affect foetuses, sick, anaemic and young children, affects nervous system impairing physical coordination, vision and judgments, creating nausea and headaches, reducing productivity and increasing personal discomfort.</td>
</tr>
<tr>
<td>Nitrogen Oxides</td>
<td>Increased susceptibility to infections, pulmonary diseases, impairment of lung function and eye, nose and throat irritations.</td>
</tr>
<tr>
<td>Sulphur Dioxide</td>
<td>Affect lung function adversely.</td>
</tr>
<tr>
<td>Particulate Matter and Respirable</td>
<td>Fine particulate matter may be toxic in itself or may carry toxic (including carcinogenic) trace substance, and can alter the immune system. Fine particulates penetrate deep into the respiratory system irritating lung tissue and causing long-term disorders.</td>
</tr>
<tr>
<td>Particulate Matter (SPM and RPM)</td>
<td></td>
</tr>
<tr>
<td>Lead</td>
<td>Impairs liver and kidney, causes brain damage in children resulting in lower I.Q., hyperactivity and reduced ability to concentrate.</td>
</tr>
<tr>
<td>Benzene</td>
<td>Both toxic and carcinogenic. Excessive incidence of leukaemia (blood cancer) in high exposure areas.</td>
</tr>
<tr>
<td>Hydrocarbons</td>
<td>Potential to cause cancer</td>
</tr>
</tbody>
</table>

A2.4 VEHICULAR POLLUTION AND CLIMATE CHANGE

Global Warming and Climate Change

The world average temperature has risen by about 1°F over the past century. It is widely accepted that the global warming is related to anthropogenic Green House Gases (GHGs). GHGs include, the common gases namely, carbon dioxide and water vapor, and rarer gases such as nitrous oxide, methane and chlorofluorocarbons (CFCs) whose properties relate to the transmission or reflection of different types of solar radiations. The increase in such gases in
the atmosphere is a result of the burning of fossil fuels, emission of pollutants into the atmosphere by power plants and vehicle engines, etc. Of all human activities, driving motor vehicles produces the most intensive CO₂ emissions and other toxic gases per capita. A single tank of gasoline releases 140 ~180 kilograms of CO₂. Over 25% of transportation-related GHG emissions originate from urban passenger travel (Yang M. 1998). Unsustainable trends in urban transportation have already manifested in frequent congestions, periodic gridlock and evidence linking respiratory illnesses and deaths to poor air quality.

**Global Emissions of GHG’s from Transport Sector**

Transport sector contributes around 14% towards the global emissions of greenhouse gases. Carbon dioxide represents the largest proportion of basket of greenhouse gas emissions. During, the past three decades, carbon dioxide emissions from transport have increased faster than those from all other sectors and are projected to increase more rapidly in future. The Road transport alone emits around 16% of the global CO₂ emissions (Source: OICA). From 1990 to 2004, carbon dioxide emissions from the world’s transport sector have increased by 36.5%. For the same period, road transport emissions have increased by 29% in industrialized countries and 61% in the other countries (IEA, 2006).

**A2.5 VEHICULAR POLLUTION PROBLEMS IN INDIA**

Motor vehicles have been closely identified with increasing air pollution levels in urban centres of the world (Mage et al, 1996; Mayer 1999). Besides substantial CO₂ emissions, significant quantities of CO, HC, NOₓ, SPM and other air toxins are emitted from these motor vehicles in the atmosphere, causing serious environmental and health impacts. Like many other parts of the world, air pollution from motor vehicles is one of the most serious and rapidly growing problems in urban centres of India (UNEP/WHO, 1992). The problem of air pollution has assumed serious proportions in some of the major metropolitan cities of India and vehicular emissions have been identified as one of the major contributors in the deteriorating air quality in these urban centres. The problem has further been compounded by the concentration of large number of vehicles and comparatively high motor vehicles to population ratios in these cities. Reasons for increasing vehicular pollution problems in urban India are as below:

- High vehicle density in Indian urban centres.
- Older vehicles predominant in vehicle vintage
Predominance of private vehicles especially cars and two wheelers, owing to unsatisfactory public transport system, thereby causing higher idling emissions and traffic congestion.

Absence of adequate land use planning in development of urban areas, thereby causing more vehicle travel and fuel consumption

Inadequate inspection & maintenance facilities.

Adulteration of fuel & fuel products

Improper traffic management system & road conditions

High levels of pollution at traffic intersections

Absence of effective mass rapid transport system & intra-city railway networks

High population exodus to the urban centres.

Increasing number of towering buildings in the urban areas causes stagnation of the vehicular emissions to the ground level and unable its proper dispersion.

A2.6 VEHICULAR POLLUTION CONTROL MEASURES TAKEN IN INDIA

For containing vehicular pollution, the Government has taken important initiatives in recent years. The Union Government and the Provincial Governments in India have been emphasizing the need for planning and developing strategies to implement mitigation measures to maintain the urban air quality and make the cities cleaner and greener for achieving better air quality and good health for its citizens. Over the past decade or so, the government has bought in statutes aimed at regulating and monitoring industrial and vehicular pollution across the country.

A2.6.1 HISTORY OF THE EVENTS

The sequence of events covering the various measures/initiatives/action taken for vehicular pollution prevention and control in the past 25 years are as follows (CPCB, 2010):

i. During January 15, 1985 an expert committee was constituted by the Secretary, Department of Environment (Now MoEF) under the chairmanship of director ARAI with Member Secretary from CPCB. The terms of reference of the committee were:
   a) To finalize vehicular emission standards at the manufacturing stage and also at the road side
   b) To finalize the frequency and method of testing of vehicles at the manufacturing stage
c) To approve laboratories in India to carry out chassis dynamometer test on vehicles

The committee recommended mass emission norms and in-use emission norms for different categories of vehicles along with testing method (The recommendations of the committee were notified later under Environment (Protection) Act 1986 during 1990.

ii. During February 5, 1990, under Section 25 of Environment (Protection) Act 1986, Environment (Protection) Second Amendment Rule 1990 was notified where mass emission norms and in-use emission norms were prescribed for the first time in the country.

iii. The Hon’ble Supreme Court of India constituted a committee on Vehicular pollution control under the chairmanship of Retd. Justice Shri. K.N. Sakia with CPCB and MoEF as members. The terms of reference of the committee were to make an assessment of the technologies available for vehicular pollution control in world and in India to look at the low cost alternatives for operating vehicles at reduced pollution levels in the metropolitan cities of India and to examine the feasibility of measures to reduce pollution from motor vehicles both on short term and long term basis and make appropriate recommendations in this regard. The recommendation of the Sakia committee submitted to Hon’ble Supreme court in 1991 are as follows:

- For phasing out leaded petrol and phasing in unleaded or lead free petrol in Delhi by 01.04.1992 and with that end in view allowing fiscal and other incentives to lead free petrol users;
- For prescribing of strict medium and long term standards for different vehicular pollutants and strict enforcement of the same;
- To expand and strengthen the air pollution monitoring system and its working in Delhi to encourage public awareness and reaction to vehicular pollution;
- To encourage and finance advanced research and development in the field of vehicular pollution control through indigenous efforts, inter-regional and international exchange of data, co-operation and coordination;
- Of making it compulsory for all petrol vehicle on the road to retrofit a suitable catalytic converter or a suitable emission control device so as to control CO and HC with effect from 1.4.1992 and also a suitable emission control device on diesel vehicles so as to control particulate gases and smoke;
• Of issuing a directive by the Hon’ble Supreme court to the appropriate Ministry of the Central Government to stop forthwith the criminal waste of flaring up of natural gas in the different oil fields of the country, and to store and make the gas available for use as vehicular fuel;

• Of issuing of a directive by the Hon’ble Supreme Court to the appropriate departments of the central government to spread a national gas grid with network of pipelines reaching the metropolitan cities and supply compressed natural gas through such network for use as vehicular fuel at economic prices;

• Of issuing of a direction by the Hon’ble Supreme Court to Delhi transport Cooperation to convert at least 1/5th of its bus fleet every year to CNG and to purchase henceforth only new buses that use CNG as fuel and if licenses are issued to private buses those should be issued only for buses running on CNG or on batteries in Delhi;

• For Delhi Transport Corporation itself operating a fleet of electric trolley buses in Delhi area or inviting private enterprises including NRIs to operate such a system;

• Of improving the circular railway and treating it as a unit and increasing frequency of trains and issuing tickets on board like trams and buses;

• Of issuing of a directive for taking immediate steps for a metro for Delhi so as to function by 2000.

• These propositions led to the start of introduction of CNG in Delhi and phasing out of lead in gasoline.

iv. In 1992, MoEF brought out two documents namely, National Conservation Strategy & Policy Statement on Environment and Development and Policy Statement for Abatement of Pollution which identified that ambient air quality trends with respect to SPM in metro cities were higher than the prescribed limits especially during summer time. The levels of nitrogen di-oxide are increasing in urban centres with growth in vehicular emissions. For prevention and control of vehicular pollution and for development of environmentally compatible transport system, the following steps to be taken:

• Improvement in mass transport system to reduce increasing consumption of fuel, traffic congestion and pollution;
• Improved transport system based on bio-energy and other non-polluting energy sources
• Rail transport and pipelines transport instead of road transport, where ever possible, by appropriate freight pricing so as to reduce congestion, fuel consumption and environmental hazards;
• Improvement in traffic flow through proper maintenance of roads, updated traffic regulation and strict enforcement of prescribed standards;
• Enforcement of smoke emission standards for containing vehicular exhaust, at the manufacturer and user level;
• Phasing out of use of lead in motor spirit; and
• Regulation from environmental safety in transportation of hazardous substances

v. On May 16, 1991, CPCB constituted a committee to evolve mass emission standards for motor vehicles for year 1995 and 2000 under the chairmanship of Prof. H.B. Mathur. The terms of reference of the committee were:
  • To suggest the emission standards for 2, 3 & 4 wheelers to be implemented from year 1995 and 2000 with respect to carbon monoxide, hydrocarbons and oxides of nitrogen.
  • To identify the nature of changes required in engine design and types of devices to be installed to meet the suggested standards.

vi. During 1992 the committee recommended emission norms for vehicles applicable from 1995 and 2005 with technological options for meeting these norms. It also recommended redrafting the Indian standards to specify the fuel parameters affecting the emissions and make commercial fuel available. The lead free petrol has to be made available in limited quantity by 1995 and all commercially available petrol will have to be lead free by the year 2000. The recommendations of the committee were also deliberated at MoEF where 1995 norms were reviewed & postponed to 1996 and submitted to Ministry of Road Transport & Highways (MoRT&H) for notification.

vii. During the year 1992 a policy for providing clean fuels for power plants and motor vehicles were prepared by CPCB during its Board meeting and recommended to MoEF for Ministry of
Petroleum and Natural Gas (MoPNG) to take necessary action. During May 1994 a draft specification for motor gasoline and diesel was proposed by CPCB and submitted to MoEF.

viii. A meeting on fuel and fuel quality of automobiles was held on 17.6.1994 under the chairmanship of the Hon’ble Shri. Kamal Nath, Minister of Environment and Forests.

- From April 1, 1995 unleaded petrol (i.e. petrol with lead content less than 0.013 g/l) will be supplied in metropolitan cities, along with leaded petrol as at present.
- All new vehicles (4 wheelers) sold in metros after 1st April 1995, will have to be equipped with catalytic converters.
- Diesel supplied in metro cities will have only 0.5% sulphur content as compared to 1% at present, from 1st April, 1996.
- All 2 stroke engine 2 – wheelers and 3 wheelers will have to meet notified norms of emission by 1st April, 1996, if not, production of 2 stroke engines not meeting the norms will have to cease.
- Norms for year 2000 were discussed and it was decided to finalize these within six months, after some more discussions. Thus there will be adequate time for technical changes in design, etc.
- Fiscal mechanism was discussed-price differentials for different types of fuels.
- Also administrative mechanism such as staggering peak etc., were also discussed.
- Fuel standards comments from IIP, Dehradun within 15 days.

ix. Low leaded fuel (0.15 g/l) was made available by MoPNG for metro from January 1994.

x. During October 21, 1994 Hon’ble Supreme Court passed following order:

- Petrol with 0.15 g/l TEL to made available by December 1996 to entire country.
- Lead free petrol to be made available at selected outlets in 4 metro cities by April 1995.
- New vehicles (Petrol driven) should be equipped with catalytic converter by April 1995.
xi. On January 20, 1995 MoEF has constituted a committee to finalize fuel quality specification for motor gasoline and diesel. The recommendations of the committee with respect to emission related fuel quality specification were later notified under EPA.

xii. Bureau of Indian Standards incorporated the emission related specifications and prescribed fuel quality specifications. Based on MoEF recommendations and Supreme Court order, unleaded Petrol was made available in four metro cities during June 1995 and passenger cars are made to fit catalytic converter.

xiii. During April 20, 1996 the fuel quality specifications were notified under EPA Act and directives were issued by CPCB to various refineries under Section 5 of EPA for compliance of the specifications. In the same year revised ambient air quality standard were notified.

xiv. During May 1997 a policy paper on control of automobile exhaust pollution was prepared by CPCB which recommended:

- Introduction of Inspection and maintenance programme for in-use vehicles
- Phasing out of 15 years old vehicles
- Improving Public Transport system by introducing high capacity bus system on dedicated pathways
- Introduction of fleet of alternate fuel vehicles

xv. During August 1997 mass emission norms for vehicles (equivalent to Euro-I norms) with effect from 1.4.2000 were notified under Motor vehicle Act.

xvi. During August 1997 MoEF brought a white paper on pollution in Delhi. To implement the recommendations of white paper, MoEF constituted “Environmental Pollution Control Authority” on January 1998 on the directions of the Supreme Court. The important directions issued by the Hon’ble court on 26.7.1998 are as follows:

- Augmentation of public transport to 10,000 buses by 1.4.2001
- Elimination of leaded petrol from NCT Delhi by 1.9.1998
- Supply of only pre-mix petrol by 31.12.1998 for two stroke engines of two wheelers and autos
• Replacement of all pre-1990 autos and taxis with new clean vehicles on clean fuels by 31.3.2000
• No 8-year-old buses to ply except on CNG or other clean fuels by 1.4.2000
• Entire city fleet (DTC & Private) to be converted to single fuel mode on CNG by 31.3.2001
• New ISBTs to be built at entry point in North and south west to avoid pollution due to entry of Interstate buses by 31.3.2000
• GAIL to expedite and expand from 9 to 80 CNG supply outlets by 31.3.2000
• Two independent fuel testing laboratories to be established by 1.6.1999
• Proper inspection and maintenance facilities to be set up for commercial vehicles with immediate effect
• Comprehensive inspection & maintenance programme to be started by transport department and private sector by 31.3.2000
• CPCB/DPCC to setup a few more monitoring stations and strengthen the air quality monitoring stations for monitoring critical pollutants by 1.4.2000. The Hon’ble Court also directed that the time frame as fixed by Environment Pollution (Prevention & Control) Authority should be strictly adhered to by all the authorities
• Some of these orders have led to phasing out of diesel commercial vehicles especially buses and petrol three wheelers will be replaced with CNG vehicles in Delhi

xvii. During September 1998 lead in petrol was phased out in Delhi while during February 2000 lead in petrol was phased out from petrol all over the country.

xviii. During November 1998, EPCA brought up the issue of phasing out of diesel private vehicles in Delhi. CPCB recommended to EPCA that these vehicles should meet Euro-II norms otherwise they should not be allowed to ply. During the hearing in Supreme Court, the court ordered that Euro-I norms has to be made applicable for private non-commercial vehicles registered after June 1999 in Delhi. This led to introduction of Euro-II norms for other categories of vehicles and in other cities of the country.

xix. CPCB constituted a working group to formulate the transport fuel specifications for the year 2005 under the chairmanship of Dr. P.K. Mukhopadhyay, Ex-Director IOC (R&D). The terms of reference of the working group were as follows:
To recommend the fuel specifications of automotive commercial fuels (gasoline and diesel) for the year 2005
To recommend the reference fuel quality specifications at the testing stage
To recommend technology to be adopted to meet the fuel quality specifications recommended for the year 2005
To draw-up a strategy for monitoring the fuel quality at petrol pump stations to check adulteration

xx. As per decision taken by the committee of secretaries Ministry of Petroleum and Natural Gas constituted an inter ministerial task force on auto fuel specifications and vehicular emission standards on August 14, 2000 under the chairmanship of the chairman CPCB. The committee in its report submitted to MoPNG on 31.3.2001 recommended the road map for introduction of Bharat stage –II norms in entire country along with fuel quality specifications.

xxi. In a meeting taken by the prime Minister on 30 August 2001 it was decided to constitute a committee of the experts of national repute under the chairmanship of Dr. R. A. Mashelkar which was formed on September 13, 2001. The expert committee on Auto fuel policy has proposed an auto fuel policy for India and also for selected major cities and a road map for its implementation. It has also recommended suitable auto fuels with their specification, taking into account the availability and logistic of fuel supplies, the economics of processing auto fuels and possibilities multiple fuel use in different categories of vehicles.

xxii. The Hon’ble Supreme Court of India, in the matter of CWP No. 13029 of 1985, passed the orders on 05.04.2001, regarding formulation and implementation of action plans for control of pollution in cities namely Kanpur, Lucknow, Varanasi, Agra, Jharia, Patna, Jodhpur, and Pune & Faridabad.

xxiii. During May 2002 the Hon’ble court has also asked the union of India to prepare a scheme for compulsory switch over to CNG/LPG as automotive fuels in the cities those are equally or more polluted than Delhi. Later CPCB identified these cities as Ahmedabad, Kanpur, Kolkata and Pune.
xxiv. In the year 2003 the Hon’ble Supreme Court vide its order dated 16.8.2003 directed Union of India and State Government to prepare action plan for lowering the rate of RSPM level for cities of Kanpur, Ahmedabad, Sholapur, Bangalore, Lucknow, Chennai, Hyderabad, Mumbai, Kolkata. Hon’ble Supreme Court also asked respective State Boards to place the proposed action plans before EPCA.

xxv. In the year 2004 new PUC norms have been implemented for in-use vehicles.

xxvi. In the year 2005 Bharat stage-III emission norms have been implemented in 11 megacities for all the new vehicles except 2 & 3 wheelers while Bharat stage-II norms have been implemented all over the country.

xxvii. On April 1, 2010 Bharat stage-IV emission norms have been implemented in 11 megacities for all the new vehicles except 2 & 3 wheelers while Bharat Stage-III norms have been implemented for 2 & 3 wheelers all over the country.

**A2.6.2 VEHICULAR EMISSION STANDARDS**

The mass emission norms for vehicles at manufacturing stage as well as for in-use vehicles have been notified during 1990-91 but these did not require the manufactures any modification. The emission norms along with fuel specifications laid down in 1996 required the automobile manufacturers to make modifications in engine design particularly with regard to crankcase emissions and evaporative emission control. New standards have been laid time to time. Some of these are mentioned below:

a) **April 1995:** New passenger cars were registered only if fitted with catalytic converters in Delhi, Mumbai, Calcutta and Chennai.

b) **April 1998:** The testing method for passenger cars norms was changed to cold start, which is stricter procedure than the previous one.

c) **June 1999:** Private vehicles had been required to meet EURO-I or EURO-II and only those vehicles, which conformed to these rules, were registered.

d) **Year 2000:** The norms required major modification in the engine design especially with regard to the fuel injection system in passenger cars and fitment of catalytic converters in the two-stroke engines. These standards are akin to Euro-I norms adopted in the European countries in 1992.
e) **April 1, 2000**: Only such private vehicles, which meet EURO-II norms, were registered in NCR.

f) **October 6, 2003**: The National Auto Fuel policy was announced which envisages a phased program for introducing Euro II-IV emission and fuel regulations by 2010.

g) **In the year 2005 Bharat stage-III** emission norms have been implemented in 11 megacities for all the new vehicles except 2 & 3 wheelers while Bharat stage-II norms have been implemented all over the country.

h) **On April 1, 2010 Bharat stage-IV** emission norms have been implemented in 11 megacities for all the new vehicles except 2 & 3 wheelers while Bharat Stage-III norms have been implemented for 2 & 3 wheelers all over the country.

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**A2.7 LEGISLATIVE AND IMPLEMENTING AGENCIES**

The environmental legislation concerning vehicular pollution and the implementation authorities are given below in **Table A2.3**:

**Table A2.3: Environmental Legislation Concerning Vehicular Pollution and Implementation Authorities**

<table>
<thead>
<tr>
<th>Legislation / Act</th>
<th>Authority</th>
<th>Responsibility / Notifications</th>
</tr>
</thead>
</table>
  - Specification of Motors Gasoline for emission related parameters  
  - Specification of Diesel for emission related parameters  
  - Specifications of two-stroke engine oil  
  - Standard for emission smoke, vapour etc from motor vehicles  
  - Noise limits for Automobiles at the manufacturing stage |
| The Central Motor Vehicles Act, 1988 | Ministry of Road Transport | Makes rules regulating construction, equipment and maintenance of motor vehicles and trailers |
Legislation / Act | Authority | Responsibility / Notifications
--- | --- | ---
*The Central Motor Vehicles Rules, 1989 (Second amendment 2009)* | and Highways | as per section 110 of Motor Vehicle Act. The notified emission standards related to vehicular are as follows:
- Relating to Emission of smoke and vapour from agricultural tractors driven by diesel engines
- Relating to Diesel vehicles with original equipment fitment - Replacement of in-use diesel engine by new LPG engine - Applicable emissions norms
- Relating to Diesel driven Agricultural tractor for standards of gaseous pollutants
- Relating to idling emissions standards for petrol / CNG/LPG driven vehicles
- Mass emission standards Bharat Stage III for four wheeled vehicles in NCR & other cities
- Mass emission standards Bharat Stage III for two and three wheelers manufactured on and from 1st April, 2010.
- Mass emission standards Bharat Stage IV for M and N category vehicles

Since vehicular pollution has been recognized as the major contributor to air pollution especially in urban centres, government has introduced various policies and legislations from time to time to deal with such kind of a problem. A brief summary of various vehicular emission related legislations in India are given below:

**A2.7.1 VEHICULAR EMISSION RELATED LEGISLATIONS IN INDIA**

India is the one of the few countries of the world, which has provided for constitutional safe guards for the protection and conservation of the environment. Various laws have been enacted in India having direct or indirect bearing on various aspects
related to the transport and environment. Important amongst them are Air (Prevention and Control of Pollution) Act, 1981, the Environment Protection Act, 1986 and the Motor Vehicles Act, 1988 including the Central Motor Vehicle Rules, 1989 (CPCB, 2006). These laws cover a wide range of rules, regulations and/or provisions related to ambient air quality standards, vehicle emission norms for different categories of vehicles: in-use as well as for vehicles at conformity of production (CoP) stage, specification of fuels, guidelines for EIA for highway and road projects.

Apart from the legislative Acts, Constitution also empowers the parliament to enact legislations in conformity with various international agreements. India is already a signatory to international agreements pertaining to controlling the ozone depleting substances in the atmosphere (Montreal Protocol, 1986) and controlling the GHG’s emissions (Rio Declaration, 1992; Kyoto Protocol, 1997) and contributing to various global environmental conservation and management programmers under the auspices of United Nations.

In order to arrest the deterioration in air quality, Govt. of India has enacted Air (Prevention & Control of Pollution) Act in 1981. The responsibility has been further emphasized under Environment (Protection) Act, 1986. A brief summary of Air (Prevention and Control of Pollution) Acts enacted in India are given below:

A2.7.2 AIR (PREVENTION AND CONTROL OF POLLUTION) ACT 1981
Government of India enacted the Air (Prevention and Control of Pollution) Act 1981 to arrest the deterioration in the air quality. The act prescribes various functions for the Central Pollution Control Board at the apex level and State Pollution Control Board at the state level. The main functions of the Central Pollution Control Board are as follows:

- To advice the Central Government on any matter concerning the improvement of the quality of the air and the prevention, control and abatement of air pollution.
- To plan and cause to be executed a nation-wide programme for the prevention, control and abatement of air pollution.
- To provide technical assistance and guidance to the State Pollution Control Board.
- To carry out and sponsor investigations and research related to air pollution prevention, control and abatement of air pollution.
To collect, compile and publish technical and statistical data related to air pollution; and
To lay down standards for the quality of air and emission quantities.

The main functions of the State Pollution Control Board are as follows:

- To plan a comprehensive programme for prevention, control or abatement of air pollution and to secure the execution thereof;
- To advise the State Government on any matter concerning prevention, control and abatement of air pollution.
- To collect and disseminate information related to air pollution.
- To collaborate with Central Pollution Control Board in programme related to prevention, control and abatement of air pollution; and
- To inspect air pollution control areas, assess quality of air and to take steps for prevention, control and abatement of air pollution in such areas.

**A2.7.3 NATIONAL AMBIENT AIR QUALITY STANDARDS (NAAQS)**

The ambient air quality objectives/standards are pre-requisite for developing management programme for effective management of ambient air quality and to reduce the damaging effects of air pollution. The objectives of air quality standards are:

- To indicate the levels of air quality necessary with an adequate margin of safety to protect the public health, vegetation and property.
- To assist in establishing priorities for abatement and control of pollutant level.
- To provide uniform yardstick for assessing air quality at national level.
- To indicate the need and extent of monitoring programme.

The Central Pollution Control Board had adopted first Ambient Air Quality Standards on November 11, 1982 as per section 16 (2) (h) of the Air (Prevention and Control of Pollution) Act, 1981. The air quality standards have been revised by the Central Pollution Control Board on April 11, 1994 and were notified in Gazette of India, Extra-ordinary Part-II Section 3, subsection (ii), dated May 20, 1994. The Government has recently revised the National Ambient Air Quality Standards (NAAQS) and limits for 12 pollutants have been notified. Area classification based on land use has been done away with so that industrial areas have to conform to the same standards as those for residential areas. The annual average norms for Lead, Nitrogen Dioxide, Arsenic, Nickel, Benzene and Benzoalphaprylene in ambient air are
at par with the European Union norms. However, the norms for Particulate Matter having size less than 10 micron (PM$_{10}$) and Particulate Matter having size less than 2.5 micron (PM$_{2.5}$) are more relaxed than EU norms. Indian norms for Carbon Monoxide, Ozone and Sulphur Dioxide (SO$_2$) are more stringent than EU norms. Ammonia is additionally included in our NAAQS.

Under the Environment Surveillance Programme, CPCB has undertaken the task of development of monitoring protocols and the infrastructure needed for monitoring and enforcement of the new ambient air quality norms. It undertakes inspection of various industrial units under the 17 categories of highly polluting industries to verify compliance to the prescribed standards. Based on the level of non-compliance observed, directions are issued to the concerned State Pollution Control Boards under section 18(I) (b) of the water (Prevention and Control of Pollution) Act, 1974 and or The Air (Prevention and Control of Pollution) Act, 1981 as the case may be, and directly to the industries under section 5 of The Environment Protection Act, 1986. Such actions have been taken against major defaulters in sectors like Thermal Power, Cement, Fertilizers, etc., by the CPCB.

National Ambient Air Quality Standards are the limits for levels of air pollutants with an adequate margin of safety to protect the public health, vegetation and property. There were 7 parameters, namely, Sulphur Dioxide (SO$_2$), Oxides of Nitrogen (NOx), Suspended Particulate Matter (SPM), Respirable Particulate Matter (RSPM) Lead Carbon Monoxide (CO) and Ammonia (NH$_3$) notified under the Air Act, 1981 and the Environment (Protection) Act, 1986. National Ambient Air Quality Standards (NAAQS) were earlier notified in the year 1994 under the Air Act. There is a difference between the World Health Organisations norms-2005 and our revised standards (NAAQS). Whereas we have prescribed 12 parameters, mainly PM$_{10}$, PM$_{2.5}$, SO$_2$, NO$_2$, CO, NH$_3$, Ozone, Lead, Benzene, Arsenic and Nickel. WHO has suggested five parameters, out of which, only four are to be monitored i.e. PM$_{10}$/ PM$_{2.5}$, Sulphur Dioxide, Nitrogen Dioxide and Ozone. The CPCB monitors PM$_{2.5}$, Ozone (ground level), Carbon Monoxide, Lead, Hydrocarbons, Ammonia, Benzene, etc., at selected locations in few cities apart from Sulphur Dioxide, Nitrogen Dioxide and PM$_{10}$ at all locations under National Air Monitoring Programme (NAMP).

Initially the Central Pollution Control Board started the National Ambient Air Quality Monitoring (NAAQM) programme in the year 1984 with 7 stations at Agra and Anpara.
Subsequently the programme was renamed as National Air Quality Monitoring Programme. NAAQS have been notified for seven parameters viz. SPM, RSPM, NO\textsubscript{2}, SO\textsubscript{2}, CO, NH\textsubscript{3} and Pb. Under National Air Quality Monitoring Programme presently ambient air quality is being monitored at 342 monitoring stations covering 128 cities/towns as on 31st March 2009 which was at 328 stations as on 31st March 2008. During 2008-09, 42 stations have been sanctioned additionally. Further:

(i) Parameters SPM, RSPM, SO\textsubscript{2} and NO\textsubscript{2} are being monitored at all the locations.

(ii) Three more parameters i.e. CO, Pb, and NH\textsubscript{3} are being monitored at selected locations in few cities.

(iii) Other parameters i.e. O\textsubscript{3}, Benzene, Trace heavy metals and PAHs are being monitored occasionally at selected locations for creating data base. (National Ambient Air Quality Monitoring Series: Naaqms//2009-10).
CLASSIFIED TRAFFIC VOLUME COUNT FORMAT

1. Station No.:  
2. Location/Area:  
3. Traffic Direction:  
4. Date of Sampling and Month:

<table>
<thead>
<tr>
<th>Time (hours)</th>
<th>Two Wheeler</th>
<th>Three Wheeler</th>
<th>Car/Van/JEEP/Sumo</th>
<th>Mini Bus/Bus</th>
<th>Trucks</th>
<th>Tractor</th>
<th>Others</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>06:00 – 07:00</td>
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<td>08:00 – 09:00</td>
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<td>10:00 – 11:00</td>
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<td>11:00 – 12:00</td>
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<td>15:00 – 16:00</td>
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<td>21:00 – 22:00</td>
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</tr>
</tbody>
</table>
### AMBIENT AIR SAMPLING DATA FORMAT

**I. Parameter:**

1. Station No.:
2. Location/Area:
3. Distance from the edge of the Road:
4. Height of High Volume Sampler from Road:
5. Date of Sampling and Month:
6. Running Period of Sampler:
   - Started Time: 
   - End Time: 

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Time Period (hours)</th>
<th>Time Duration (hours)</th>
<th>Concentration (µg/m³)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>06:00 – 07:00</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>07:00 – 08:00</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>08:00 – 09:00</td>
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<td></td>
<td></td>
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<tr>
<td>4</td>
<td>09:00 – 10:00</td>
<td>1</td>
<td></td>
<td></td>
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<tr>
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<td></td>
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<tr>
<td>6</td>
<td>11:00 – 12:00</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>12:00 – 13:00</td>
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<td></td>
<td></td>
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<tr>
<td>8</td>
<td>13:00 – 14:00</td>
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<td>9</td>
<td>14:00 – 15:00</td>
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</tr>
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<td>16:00 – 17:00</td>
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<td>17:00 – 18:00</td>
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<td>18:00 – 19:00</td>
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<td>14</td>
<td>19:00 – 20:00</td>
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<td>20:00 – 21:00</td>
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<tr>
<td>16</td>
<td>21:00 – 22:00</td>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix – 3.3

**FUEL STATION SURVEY FORMAT**

1. Name of the Station No.:
2. Location/ Area:
3. Data on Vehicle type, fuel used and Vintage

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Type of Vehicle</th>
<th>Fuel used (Petrol/Diesel/CNG)</th>
<th>Year of Manufacture</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<tr>
<td>16</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix – 3.4

ROAD GEOMETRY SURVEY FORMAT

<table>
<thead>
<tr>
<th>Road Corridor Number</th>
<th>Laning of the road corridor (2/4/6/8)</th>
<th>Carriageway Width (m)</th>
<th>Median Width (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
A brief description about the data used in CALINE 4 model is as below:

### A3.1 DATA ENTRY SCREENS

CALINE 4 model contains five data entry screens, listed below, and must be complete in order to run CALINE 4:

I. Job Parameters  
II. Link Geometry  
III. Link Activity  
IV. Run Conditions  
V. Receptor Conditions

#### I. Job Parameters

The job parameters Screen contains general information that identifies the job, define general modeling parameters, and sets the units (feet or meters) that will be used to input data on the Link Geometry and Receptor Positions Screens.

**File Name:** Display only, not editable. Displays the name of the file where the current job is stored.

**Job Title:** Operational. Provides a space for the user to enter a brief job description, up to 40 characters in length.

**Run Type:** Different choices determine averaging times (for CO concentrations) and how the hourly average wind angle(s) will be determined. (Wind angle is the angle between the roadway link and the wind direction. CALINE 4 calculates the angles based on data in the Link Geometry and Run Conditions Screens). Most users should invoke the “worst-case wind angle” run type and apply a persistence factor of 0.6 to 0.7 in order to estimate an 8-hours average CO concentration.

i. **Standard** – Calculates 1-hour average CO concentrations at the receptors. The user must input a wind direction on the Run Conditions Screen.

ii. **Multi-Run** – Calculates 8-hours average CO Concentrations at the receptors. The user must input wind angles for each hour.

iii. **Worst-case wind angle** – Calculates 1-hour average CO concentrations at the receptors. The model selects the wind angles that produce the highest CO concentrations.
concentrations at each of the receptors. This is the most appropriate choice for most users.

iv. **Multi-Run/Worst-case hybrid** – Calculates 8-hours average CO concentrations at the receptors. The model selects the wind angles that produce the highest CO concentrations at each of the receptors.

**Aerodynamic Roughness Coefficient:** Also known as the Davenport – Wieringa roughness-length. These choices determine the amount of local air turbulence that affects plume spreading. This subject is usually discussed in elementary meteorology books. CALINE 4 offers the following 4 choices for aerodynamics roughness coefficient:

- **Rural:** Roughness Coefficient = 10 cm
- **Suburban:** Roughness Coefficient = 100 cm
- **Central Business District:** Roughness Coefficient = 400 cm
- **Other:** Use Table A3.1 as guidance to select an appropriate value.

**Model Information:** Provides summary information for convenience and quality assurance.

**Link/Receptor Geometry Units:** Select whether meter or feet will be used to define the geometry of the roadway links and receptor positions. This choice only affects the Altitude input choice, and the data shown on the Link Geometry and Receptor Positions pages. Meteorological inputs always require inputs with metric units. Emission factors are always defined in terms of grams per mile. (Note that CALINE 4 reports data in metric units, with the exception of the Altitude).

**Table A3.1: Aerodynamic Roughness Coefficient Defined for various Types of Landscapes**

<table>
<thead>
<tr>
<th>Roughness Coefficient (cm)</th>
<th>Landscape Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.002</td>
<td>Sea, paved areas, snow-covered flat plain, tide flat, smooth desert</td>
</tr>
<tr>
<td>0.5</td>
<td>Beaches, pack ice, morass, snow-covered fields</td>
</tr>
<tr>
<td>3</td>
<td>Grass prairies or farm fields, tundra, airports, heather</td>
</tr>
<tr>
<td>10</td>
<td>Cultivated areas with low crops and occasional obstacles (such as bushes)</td>
</tr>
<tr>
<td>25</td>
<td>High crops, crops with varied height, scattered obstacles (such as trees or hedgerows), vineyards</td>
</tr>
<tr>
<td>50</td>
<td>Mixed far fields and forests clumps, orchards, scattered buildings</td>
</tr>
</tbody>
</table>
### Altitude above sea Level
Define the altitude above mean sea level. This input is used to determine the rate of plume spreading. It does not affect the Link Geometry or Receptor Positions.

### Number of Links
The sum total number of links that the user has defined on the Link Geometry page.

### Number of Receptors
The sum total number of receptors that the user has defined on the Receptor Position page.

### Averaging Interval
Indicates whether the user has opted to calculate 1-hour or 8-hour average CO concentrations at the receptors.

### “Run”
Click this button to run the job as specified. First, be sure that the information on all five pages of CALINE 4 is complete: Job Parameters, Link Geometry, Link Activity, Run Conditions and Receptor Conditions.

### “Exit”
Click this button to exit the CALINE 4 program. CALINE 4 issues a warning if changes or new user inputs might be lost.

## II. Link Geometry Screen
Fill in the matrix to define the roadway network to be modelled. Each row in the matrix defines a single link. Up to 20 links may be entered. Links are defined as straight-line segments. The distance between the centreline of the curved roadway, and the straight-line link should be no greater than 3 meters.

### Link Type
The user must select one of the following 5 choices to define the type of roadway that each link represents. (Click a cell in this column to view a drop list and select from the following 5 options).

<table>
<thead>
<tr>
<th>Roughness Coefficient (cm)</th>
<th>Landscape Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>Regular coverage with large obstacles, open spaces roughly equal to obstacle heights, suburban houses, villages, mature forests</td>
</tr>
<tr>
<td>≥ 200</td>
<td>Centers of large towns or cities, irregular forests with scattered clearings</td>
</tr>
</tbody>
</table>

(Source: User’s guide for CALINE 4, Coe et al., 1998)
- **At-Grade** – For at-grade sections, CALINE does not permit the plume to mix below ground level, which is assumed to be at a height of zero. The height of the link above the ground is defined in the Link Height cell.

- **Fill** – For fill sections, CALINE 4 automatically resets the link height to zero, and assumes that air flow follows the surface terrain, undisturbed. This choice is functionally no different than the At-Grade choice with a link height defined as zero. If you wish to model a link that is slightly elevated above ground, the At-Grade choice is more appropriate.

- **Depressed** – For depressed sections, CALINE 4 increases the residence time of an air parcel in the mixing zone. The residence time increases in relation to the depth of the roadway depression. (Mixing zone = width of traffic lanes(s) plus 3 meters on each side). In such a case, CO concentrations adjacent to the mixing zone are higher than those for an equivalent at-grade or fill section. CO concentration drops more rapidly downwind of a depressed link because vertical mixing increases with residence time.

- **Bridge** – For bridge sections, CALINE 4 allows air to flow above and below the link. The plume is permitted to mix downward from the link, until it reaches the distance defined in the Link Height cell.

- **Parking Lot** – Parking lot links should be defined to be coincident with the parking lot access ways. The CALINE 4 algorithms adjust to account for the reduced mechanical and thermal turbulence anticipated from slow moving, cold-start vehicles.

**Endpoint Coordinates**: Links are defined as straight-line segments. The entire length of each link should be deviate no further than 3 meters from the centreline of the actual roadway. The endpoint coordinates, \((x_1, y_1)\) and \((x_2, y_2)\), define the positions of link endpoints.

- The units of measure (feet or meters) are user-specified on the Job Parameters Page.
- The user must define the link geometry and receptor positions with a consistent Cartesian coordinate system. The position of the coordinate system origin is arbitrary and at the user’s discretion. The y-axis should be oriented north-south, with values increasing in the eastward direction. The choice of magnetic north, true north, or some other approximation is at the user’s discretion. However, the wind direction must be defined on the Run Conditions page according to the same direction of north.
**Link Height:** For all link types except bridges, Link Height represents the height of the link above the surrounding terrain. Ground level is defined at 0 meters or feet (z=0). The units of measure (feet or meters) are user-specified on the Job Parameters Page. For at-grade links, the link height may be defined as 0 or a positive value. For fill links, CALINE 4 always treats the link as through its height was zero. For depressed links, the depth of the depression should be indicated as a negative value. For parking lots, the link height should be defined as zero. For bridges, Link Height defines the height of the bridge above the surface beneath it (a positive value), while the link itself is considered to be at z=0.

**Mixing Zone Width:** Mixing zone is defined as the width of the roadway, plus 3 meters on either side. The minimum allowable value is 10 meters, or 32.81 feet.

**Canyon/Bluff Mix:** CALINE 4 is based on two somewhat restrictive assumptions:

1) Horizontally homogeneous wind flow, and
2) Steady-state meteorological conditions.

Complex topography can invalidate each of these assumptions. Land features such as canyons can channel winds. Hill and valleys are likely to cause frequent shifts in wind direction. For these reasons, use of CALINE 4 in complex terrain should be approached with care. CALINE 4 handles certain bluff and canyon situations by reflecting the plume at the distances specified on one or both sides of the mixing zone (Turner, 1970). CALINE 4 assumes that the topographic barrier and wind direction are parallel to the roadway. CALINE 4 also alters the vertical dispersion curve to account for vehicle-related heat flux distributed over the width of the canyon. This is especially important in the case of a narrow urban street canyon. The Canyon/Bluff Mix feature has not been validated with field measurements. Only very rare circumstances warrant its use. Use extreme caution with this feature. Users of the Canyon/Bluff Mix feature should be thoroughly familiar with dispersion modeling, with key reference (Turner, 1970), and with the CALINE 4 source code. All other users should leave the Canyon/Bluff input values set to zero, which disables the feature.

### III. Link Activity Screen

The Link Activity screen defines the level of traffic and auto emission rate observed at each link.

**Traffic Volume:** The hourly traffic volume anticipated to travel on each link, in units of vehicles per hour. If a multi-run scenario is selected, traffic volume must be defined for 8 hours.
**Emission Factor:** The weighted average emission rate of the local vehicle fleet, expressed in terms of grams per mile per vehicle. Emission factors should be modelled using the CT-EMFFAC computer model 3. Emission rates vary by time of day. Therefore, if a multi-run scenario is selected, emission factors must be defined for 8 hours.

**IV. Run Condition Screen**

The Run Conditions screen contains the meteorological parameters needed to run CALINE 4. Users should employ the worst-case meteorological conditions that can be anticipated at the project location. The selection of worst-case conditions should be made in consultation with the local air district.

**Wind Speed:** Expressed in meters per second. The minimum choice of wind speed available for CALINE 4 is 0.5 m/s. Alternatively, EPA (1992) recommends a value of 1 m/s as the worst-case wind speed. The local air district should be consulted to make a decision that is appropriate for the project location.

**Wind Direction** – The direction of the wind is blowing from, measured clockwise in degrees from the north (0 = north, 90 = east, 180 = south, 270 = west). Most users should opt for the “Worst Case Wind Angle” choice on the Job Parameters screen. If “Worst-case” is selected, CALINE 4 does not use this input.

Wind Direction Standard Deviation – The statistical standard deviation of the Wind Direction, sometimes termed “sigma theta”. **Table A3.2** provides guidance for this choice.

<table>
<thead>
<tr>
<th>Initial estimate of P-G stability category</th>
<th>Standard deviation of wind azimuth angle σ (degrees)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>22.5 ≤ σ</td>
</tr>
<tr>
<td>B</td>
<td>17.5 ≤ σ &lt; 22.5</td>
</tr>
<tr>
<td>C</td>
<td>12.5 ≤ σ &lt; 17.5</td>
</tr>
<tr>
<td>D</td>
<td>7.5 ≤ σ &lt; 12.5</td>
</tr>
<tr>
<td>E</td>
<td>3.8 ≤ σ 7.5</td>
</tr>
<tr>
<td>F</td>
<td>σ &lt; 3.5</td>
</tr>
</tbody>
</table>
**Atmospheric Stability Class**: It is a measure of the turbulence of the atmosphere. This concept is discussed further in elementary meteorological textbooks. The hourly stability classes viz., A-F (Pasquill and Gilford; P-G) were obtained by the Turner Scheme (Turner, 1964) (Ref. Table 3.5).

**Mixing Height** – The altitude to which thermal turbulence occurs due to solar heating of the ground. This concept is discussed further in elementary meteorological textbooks. Reasonable values for the worst-case mixing height rarely have a significant impact on CALINE 4 model results. If an extreme condition could be anticipated at the project location (mixing height x 10 meters), the local air district should be consulted for guidance.

**Ambient Temperature** – The ambient air temperature significantly affects vehicle CO emissions. A temperature that reflects wintertime conditions should be selected, expressed in degree Celsius.

**Ambient Pollutant Concentration** - This measure reflects the pre-existing background level of Carbon monoxide, expressed in parts per million. CALINE 4 adds the pre-existing and modeled CO concentrations together to determine the total impact at each receptor.

**V. Receptor Position Screen**
The Receptor Positions Screen contains the data inputs for all receptor positions, and also displays a diagram of the link geometry and receptor positions.

Receptor should be defined with the same Cartesian coordinates system and units of measure as the link geometry. For each receptor (maximum no. of receptors = 20), space is provided for an 8-character description, the X-coordinate, the Y-coordinate, and the height (Z).

**A3.2 CALINE 4 OUTPUT FILE**
The CALINE 4 output file is divided into four sections - Header, Site Variables, Link Variables and Receptor Locations and Model Results. The variables named in CALINE 4 output files are defined below:

- **U** = wind speed
- **Z0** = aerodynamic roughness coefficient
- **ALT** = altitude above sea level
BRG = wind angle
VD = deposition velocity
CLAS = atmospheric stability class
VS = settling velocity
MIXH = atmospheric mixing height
AMB = ambient CO concentration
SIGTH = standard deviation of wind direction
TEMP = ambient temperature
Type = Link type (AG = at-grade, etc., DP = depressed, FL = fill, PK = parking lot)
VPH = vehicles per hour
EF = Emission Factor
H = Link Height
W = Mixing Zone Width
Pred. Conc. = Predicted CO concentration contributed by each link at a receptor position
AVG = Average 8-hour CO concentration predicted at the receptor.
### Appendix 4.1
### NATIONAL AMBIENT AIR QUALITY STANDARDS

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Time Weighted Average</th>
<th>Industrial, Residential, Rural and Other Area</th>
<th>Ecologically Sensitive Area (notified by Central Government)</th>
<th>Method of Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulphur Dioxide (SO$_2$) $\mu g/m^3$</td>
<td>Annual*</td>
<td>50</td>
<td>20</td>
<td>Improved West and Geake Method, Ultraviolet Fluorescence</td>
</tr>
<tr>
<td></td>
<td>24 hours**</td>
<td>80</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>Oxides of Nitrogen (NO$_x$) $\mu g/m^3$</td>
<td>Annual*</td>
<td>40</td>
<td>30</td>
<td>Jacob &amp; Hochheiser Modified (Na-Arsenite) Method, Chemiluminescence</td>
</tr>
<tr>
<td></td>
<td>24 hours**</td>
<td>80</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>Particulate Matter (Size less than 10 $\mu m$) or PM$_{10}$ $\mu g/m^3$</td>
<td>Annual*</td>
<td>60</td>
<td>60</td>
<td>Gravimetric, TOEM, Beta attenuation</td>
</tr>
<tr>
<td></td>
<td>24 hours**</td>
<td>100</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Particulate Matter (Size less than 2.5 $\mu m$) or PM$_{2.5}$ $\mu g/m^3$</td>
<td>Annual*</td>
<td>40</td>
<td>40</td>
<td>Gravimetric, TOEM, Beta attenuation</td>
</tr>
<tr>
<td></td>
<td>24 hours**</td>
<td>60</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>Ozone (O$_3$) $\mu g/m^3$</td>
<td>8 hours**</td>
<td>100</td>
<td>100</td>
<td>UV Photometric, Chemiluminescence, Chemical Method</td>
</tr>
<tr>
<td></td>
<td>1 hour**</td>
<td>180</td>
<td>180</td>
<td></td>
</tr>
<tr>
<td>Lead (Pb)</td>
<td>Annual*</td>
<td>0.5</td>
<td>0.5</td>
<td>ASS/ICP Method</td>
</tr>
<tr>
<td>Pollutant</td>
<td>Time Weighted Average</td>
<td>Industrial, Residential, Rural and Other Area</td>
<td>Ecologically Sensitive Area (notified by Central Government)</td>
<td>Method of Measurement</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>-----------------------</td>
<td>-----------------------------------------------</td>
<td>-------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>µg/m³</td>
<td>24 hours**</td>
<td>1.0</td>
<td>1.0</td>
<td>after sampling on EPM 2000 or equivalent Filter paper</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>ED – XRF using Teflon filter</td>
</tr>
<tr>
<td>Carbon Monoxide (CO) mg/m³</td>
<td>8 hours**</td>
<td>02</td>
<td>02</td>
<td>Non Dispersive Infra Red (NDIR) Spectroscopy</td>
</tr>
<tr>
<td></td>
<td>1 hour**</td>
<td>04</td>
<td>04</td>
<td></td>
</tr>
<tr>
<td>Ammonia (NH₃) µg/m³</td>
<td>Annual*</td>
<td>100</td>
<td>100</td>
<td>Chemiluminescence Indophenol blue method</td>
</tr>
<tr>
<td></td>
<td>24 hours**</td>
<td>400</td>
<td>400</td>
<td></td>
</tr>
<tr>
<td>Benzene (C₆H₆) µg/m³</td>
<td>Annual*</td>
<td>05</td>
<td>05</td>
<td>Gas Chromatography based continuous analyzer</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Adsorption and Desorption followed by GC analysis</td>
</tr>
<tr>
<td>Benzo (a) pyrene (BaP) – Particulate phase only, ng/m³</td>
<td>Annual*</td>
<td>01</td>
<td>01</td>
<td>Solvent extraction followed by HPLC/GC analysis</td>
</tr>
<tr>
<td>Arsenic (As) ng/m³</td>
<td>Annual*</td>
<td>06</td>
<td>06</td>
<td>AAS/ICP method after sampling on EPM 2000 or equivalent filter paper</td>
</tr>
<tr>
<td>Pollutant</td>
<td>Time Weighted Average</td>
<td>Industrial, Residential, Rural and Other Area</td>
<td>Ecologically Sensitive Area (notified by Central Government)</td>
<td>Method of Measurement</td>
</tr>
<tr>
<td>-----------</td>
<td>----------------------</td>
<td>---------------------------------------------</td>
<td>------------------------------------------------------------</td>
<td>----------------------</td>
</tr>
<tr>
<td>Nickel (Ni) ng/m³</td>
<td>Annual*</td>
<td>20</td>
<td>20</td>
<td>AAS/ICP method after sampling on EPM 2000 or equivalent filter paper</td>
</tr>
</tbody>
</table>

*Annual Arithmetic mean of minimum 104 measurements in a year at a particular site taken twice a week 24 hourly at uniform interval.

**24 hourly or 08 hourly or 01 hourly monitored values, as applicable, shall be complied with 98% of the time in a year. 2% of the time, they may exceed the limits but not on two consecutive days of monitoring.
BRIEF BIODATA OF AUTHOR

Mr. Deepak Malik is an Engineering Graduate and holds Master’s degree of Environmental Science in Ecology and Environment; Master of Philosophy (M. Phil.) in Environmental Science; Post-graduation in Environmental Management (specialization - Industrial Pollution Management) and pursuing research studies leading to Doctorate in Environmental Engineering. He has over 20 years of Professional experience of addressing environmental issues in various infrastructure Development Projects in the field of Urban Development, Highways, Expressways, Railways, Tunnels, Airports, Hydro Electric Power, Power Transmission & Distribution Projects and Modernization of Irrigation System, Dam Safety & Water Bodies Restoration Projects Funded by multilateral financial institutions such as World Bank, Asian Development Bank, JICA etc. Mr. Malik has vast exposure of working in East Africa (Tanzania) and Indian Sub Continent (about 22 Indian States).

Mr. Malik is an approved Environmental Coordinator under EIA accreditation scheme for Airports, Highways, Railways and Mass Transit Systems from Quality Council of India, Government of India. He is also an approved Chartered Engineer from The Institution of Engineers (India). He is also a Member of Indian Roads Congress and member of Environment Committee of Indian Roads Congress, which formulates guidelines for road development in India.

He is well versed with World Banks Operational Policies and guidelines - OP 4.01 Environmental Assessment; OP 4.02 Environmental Action Plans; OP 4.04 Natural Habitats and OP 4.36 Forests. He is also well versed with ADB’s Environment Policy (2002); Environmental Assessment Guidelines (2003) and ADB’s Safeguard Policy Statement (2009). Mr. Malik has vast experience in carrying out Environmental Impact Assessment (EIA) relating to infrastructure development projects and preparation of Detailed Project Report (DPR) and Environmental Management Plan (EMP). He is an approved air modeler and is well versed with various air dispersion modelling softwares.
PAPERS PUBLISHED

PAPER 1: ASSESSMENT OF TRAFFIC IMPACT ON AMBIENT AIR QUALITY IN GURGAON CITY

By
Deepak Malik\(^1\), Dr. Mukesh Saxena\(^2\), Dr. Niraj Sharma\(^3\)
(\(^1\)PhD. Scholar, University of Petroleum and Energy Studies, Dehradun 248007, India; \(^2\)College of Engineering Studies, University of Petroleum and Energy Studies, Dehradun 248007, India; \(^3\)Environmental Science Division, CSIR- Central Road Research Institute, New Delhi 110025, India,

PAPER 2: ENVIRONMENTAL MANAGEMENT PLAN FOR SATELLITE TOWN OF GURGAON

By
Deepak Malik\(^1\), Dr. Mukesh Saxena\(^2\), Dr. Niraj Sharma\(^3\)
(\(^1\)PhD. Scholar, University of Petroleum and Energy Studies, Dehradun 248007, India; \(^2\)College of Engineering Studies, University of Petroleum and Energy Studies, Dehradun 248007, India; \(^3\)Environmental Science Division, CSIR- Central Road Research Institute, New Delhi 110025, India,
(Research Paper presented in International Conference organized by IILM Institute for Higher Education, New Delhi on Responsible Management Education and Practice.

IILM International Conference on
Responsible Management Education and Practice
IILM Auditorium, Lodhi Road Campus
January 10-11, 2014, New Delhi

D AY 1 – Friday, January 10, 2014

Registration 9.00 -10.00 am

Inauguration : H.E. Mr. Stewart Beck, The High Commissioner of Canada in India

10.00 -10.05 am

Welcome Address, Professor Sapna Popli, Director IILM

10.05 – 10.10 am

and

Mr. Jonas Haertle, Head – PRME Secretariat, UN Global Compact, New York

10.10 – 10.15 am

Session 1/1

Opening Plenary : Keynote Address - Responsible Management: A Pressing Need

10.15 -11.00 am

H.E. Mr. Stewart Beck, The High Commissioner of Canada in India

Mr. Sunil Jain, Managing Editor, The Financial Express

Tea Break 11.00-11.30 am

Session 2/1

Responsible Management Practice: The New Imperative for a Competitive Edge

11.30-1.00 pm

Dr R Narayanaswamy, Professor of Finance and Control, Indian Institute of Management, Bangalore

Mr Deepak Thombre, Values Ombudsman, Dalmia Bharat Group

Mr Raman Sethu, Chairman, European Business Group, India

Research Paper:
Environment Management Plan for Satellite Town of Gurgaon: Mr. Deepak Malik,
Dr. Mukesh Saxena, Dr. Niraj Sharma

Networking Lunch on Campus 1.00-2.30 pm

Session 3/1

Framework for Responsible Management Education

2.30-4.00 pm

Mr. Jonas Haertle, Head – PRME Secretariat, UN Global Compact, New York

Mr. Jacob Jacob, Chief People Officer, Apollo Hospitals Enterprise Limited, Chennai

Dr. Sunita Singh Sengupta, Professor of Organizational Behaviour, Faculty of Management Studies, University of Delhi

Page 2 of 4
PAPER 3: ASSESSMENT OF VEHICULAR IMPACT ON AMBIENT AIR QUALITY DUE TO SEASONAL VARIATION: A CASE STUDY OF GURGAON

By
Deepak Malik¹, Dr. Mukesh Saxena², Dr. Niraj Sharma³
(¹PhD. Scholar, University of Petroleum and Energy Studies, Dehradun 248007, India; ²College of Engineering Studies, University of Petroleum and Energy Studies, Dehradun 248007, India; ³Environmental Science Division, CSIR- Central Road Research Institute, New Delhi 110025, India,


Abstract: Gurgaon city a satellite town in NCR is also facing air pollution problem due to rapid urbanization. The deterioration of urban air in arterial streets due to vehicular traffic exhaust and its interaction with the environment is causing a perceivable discomfort in daily life. Hence, an effort has been made through this paper to understand the vehicular impact on Ambient Air Quality due to seasonal variation in Gurgaon city.

Keywords: Vehicular impact, Air pollution, Traffic impact on air quality, Air quality, Gurgaon pollution, Ambient air quality