Bill Kuykendal
05/08/02 04:28 PM

To: Ron Myers/RTP/USEPA/US@EPA, Tom Pace/RTP/USEPA/US@EPA
cc: Phil Lorang/RTP/USEPA/US@EPA
Subject: comment2

#2
----- Forwarded by Bill Kuykendal/RTP/USEPA/US on 05/08/02 04:29 PM -----

LOHMEYER_DD@t-online.de (Ingenieurbüro Lohmeyer)
11/27/01 05:15 AM
Please respond to info.dd

To: Bill Kuykendal/RTP/USEPA/US@EPA
cc:
Subject: comment2

Dear Mr. Kuykendal,

referring to my questions from the 15th of November I'd like to add some ideas about PM10-emission-calculaions used in German projects. A file of the summary "Determination of 'non-exhaust-pipe' PM10 emissions of roads for practical traffic air pollution modelling" is enclosed. It contains issues about the modification of the EPA formula and some background information.

Maybe it could be interesting for you to note that in those projects it was distinguished between PM emissions from exhaust pipes and PM emissions due to resuspension and abrasion on the street itself.
It was recognized that on ordinary streets the proportion of exhaust pipe emission to other emission is about 50:50.
I think this is important regarding possible PM10-reductions due to precipitation if we consider independancy of exhaust pipe emissions to precipitation.

Best regards,

Evelyn Schulze

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Summary PM10 Saxony Berlin Ve

Determination of the "non exhaust pipe" PM10 emissions of roads for practical traffic air pollution modelling.

First draft, dated 21.9.2001

English summary of a report, dated June 2001, initiated and financed by Sächsisches Landesamt für Umwelt und Geologie, Radebeul and Senatsverwaltung für Stadtentwicklung, Berlin, prepared by Ingenieurbüro Dr.-Ing Achim Lohmeyer, Radebeul

Aim of the project

EC Council Directive 1999/30/EC sets a limit for the concentration of PM10 in the ambient air. Field measurements show an exceedance of this limit in the vicinity of roads (Lenschow et al., 2001), thus the problem has to be addressed and the reasons for the exceedances detected. However, PM10 pollution modelling in the vicinity of a paved road is deficient because the determination of the PM10 emissions is vague. For the vehicle fleet in Germany, there is comparatively good information on the contribution coming out of the exhaust pipe, but the quantification of the PM10 emissions resulting from abrasion of vehicle components and especially from the road surface is not satisfactorily solved.

Therefore a project was launched to proceed in the non exhaust pipe PM10 emission modelling in Germany. The modelling should be applicable for operational purposes by state and city authorities and consultants and it should be based on easily available input parameters. The project consisted of the following steps:

- Literature survey for identification of an available model
- Field measurements in a heavily trafficked street canyon in Leipzig and in Berlin to check the performance of the model
- First proposal for possible modifications of the model to improve its performance for use in Germany

Results of the project

a) Literature survey

The only operational models were found to be a model in Sweden (SMHI-model, Bringfeld et al., 1997) and the model of the US-EPA (EPA, 1997). For the EPA model, Rauterberg-Wulff (2000) showed, how it needed to be modified in order to describe the results of field measurements in Frankfurter Allee, Berlin. Landesumweltamt Brandenburg (LUA, 2000) modified it for the application in the State of Brandenburg.

Other countries for example Austria, UK, France determine the PM10 emissions of roads from the exhaust pipe emissions of NO_x, soot or particles.

The survey shows a large uncertainty concerning the PM10 emission of roads by dust re-suspension and abrasion. Much complaints about the lack of a decent model can be found. The performance of the EPA model is considered not to be suitable by an expert group in the US (Venkatram, 2000), and the UK Airborne Particle Expert Group (APEG, 1999) considers the model not to be applicable in the UK.

Nevertheless, as an operational model has to be provided to meet the EC Directives and as there is presently nothing else than the EPA model, this model was used as the basis for the project. The latest EPA version is

$$e = 0.56(sL)^{0.65}(W)^{1.5}$$

where sL is the silt load (PM75) in g/m^2, W is the average weight of the vehicle fleet in tons and e is the PM_{10} emission in g/VKT for days without rain, where VKT means Vehicle Kilometre Travelled.

The calculated emission contains all contributions, i.e. exhaust pipe emissions plus emissions by re-suspension and abrasion. No emission is supposed to occur during days with rain.

For most PM10 emission data, found in the literature, it could be derived, that the total PM10 emission in g/VKT of these roads was 2 to 4 times the exhaust pipe PM emission.

b) Field Measurements in Leipzig

From mid October to mid November 2000, field measurements in the street canyon Lützner Strasse in Leipzig were done, including determination of the silt load of the street, traffic counts (passenger cars and trucks), PM10 and PM2.5 concentrations including analysis of the PM components and PM10 and PM2.5 background concentrations. The findings are:

The PM75 silt load of the street (needed for the application of the EPA model) was 0.16 to 0.25 g/m^2 on the traffic lanes, 1.6 to 2 g/m^2 in 0 to 25 cm distance from the curb, leading to a mean (area weighted) load of 0.38 ± 0.21 g/m^2. This value is about double the value, found by Rauterberg-Wulff (2000) in Berlin, Frankfurter Allee.

In spite of the short period of the measurements and unfavourable wind conditions, the total PM10 emissions, determined by inverse dispersion modelling (0.47 to 1.1 g/VKT), are higher than calculated by the EPA formula (0.37 to 0.84 g/VKT, depending on the silt load applied). On the basis of the German Exhaust Pipe Emission Factor Handbook (INFRAS, 1999), an emission of 0.056 g/VKT is determined, thus the non exhaust pipe contribution is 0.55 to 0.65 g/VKT. So, in this street for that time period, there was roughly a factor of 10 between emission by re-suspension/abrasion and exhaust pipe.

This high emission by re-suspension/abrasion could be caused by the bad condition of the road surface, being very old and cracked, additionally by the heavily silt loaded pedestrian walkways and the unpaved parking spaces parallel to the road.

c) Field Measurements in Berlin

From mid November to mid December 2000, field measurements in the street canyon Schildhornstrasse in Berlin were done, including determination of the silt load of the street, traffic counts (passenger cars and trucks), PM10, PM2.5 and NO_x concentrations at the street and in the background including analysis of the PM components at all monitoring stations. The findings are:

The PM75 silt load of the street was 0.06 to 0.14 g/m^2 on the traffic lanes, 1.7 to 2.3 g/m^2 in 0 to 25 cm distance from the curb, leading to a mean load of 0.16 ± 0.09 g/m^2. This value is nearly the same as found by Rauterberg-Wulff (2000) in Berlin, Frankfurter Allee with ca. 0.2 g/m^2. The components of the silt load were found to be ca. 86 % mineral components, ca. 4 % EC and ca. 2.8 % OC, all percentages being nearly independent from their position on the road.

As the PM10 component analysis of the PM10 concentrations was done for the measurements at the street and in the background, the additional street concentration could be determined to be 52 % consisting of mineral components (mostly re-suspension and abrasion), 7 % tire wear and 41 % exhaust pipe emission.

By inverse dispersion modelling, the total PM10 emission factor of the road could be determined to be 0.091 to 0.096 g/VKT.

By an alternative, less effort consuming method, using NO_x as a tracer (without dispersion modelling but using the NO_x emissions and the NO_x additional street concentrations) 0.081 to 0.095 g/VKT were found. Thus it was shown, that the 2 methods yielded nearly the same result in this case.

The total PM10 emissions, determined by inverse dispersion modelling (0.091 to 0.096 g/VKT), are lower than calculated by the EPA formula (0.19 to 0.45 g/VKT, depending on the silt load applied).

On the basis of the German Exhaust Pipe Emission Factor Handbook (INFRAS, 1999), an emission of 0.045 g/VKT is determined. Thus the non exhaust pipe contribution in this street for that time period, was roughly the same as the exhaust pipe emission.

By separate analysis of the results during working days and weekends, a separate estimation of the emission factors for trucks and for passenger cars could be done.

The problem of the modification of the emission factors by rain is addressed.

d) Modified model

On the basis of measurements in Switzerland and Germany, a first modification of the EPA model was done, dividing in a first step into exhaust pipe emissions and the contributions by resuspension and abrasion as

$$e = e_{exhaust\ pipe} + e_{road\ abrasion+re-suspension}$$

The exhaust pipe contribution is taken from the German Exhaust Pipe Emission Factor Handbook (1999). Thus it is depending on the year under consideration, in contrary to the contribution by road abrasion and re-suspension.

The road abrasion and re-suspension contribution is considered to be depending on the silt load, the average weight of the vehicle fleet and the number of rainy days. Default parameters for city streets, streets in the open country and motorways are given in the report. A completely separate model is given for the emissions of tunnels.

As the model is mostly based on the EPA model, it still contains its problems.

Open tasks

At this moment, although we do not have enough data, we propose to discuss a model with the following input parameters:

- Composition of the road surface (as, for example, asphalt has a larger abrasion than concrete)
- State of the road (new, old, porous, smooth, rough, patched, cracked, weather beaten etc.)
- Driving pattern, vehicle speed, ADT, truck content, etc
- Amount of dirt deposited from outside sources
- Local conditions of rain and humidity

More theoretical work is needed as well as communication input from road maintaining civil engineers. More experiments have to be designed to determine the relevance of the above-mentioned parameters and also to find new possible parameters governing PM_{10} emission.

Ongoing and future projects

Presently the following projects are going on or will go on.

In September 2001, Senatsverwaltung für Stadtentwicklung, Berlin started a measurement campaign, exceeding the measuring period to 1 year and additional monitoring positions.

Niedersächsisches Landesamt für Ökologie, Hannover, will add to the 3 year measurements for VALIUM sophisticated sophisticated measurements of the PMx street canyon and background concentrations to do a source apportionment for PM10 concentration hot spots.

BWPLUS will finance from beginning 2002 to mid 2003 a program to collect the results of all PM10 concentrations measured routinely by the German States near roads and to evaluate them for the local PM10 emission factors. Additionally it will finance a detailed study at a street including windward/leeward concentration measurements, rain, wind, traffic etc. in high temporal resolution.

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Availability of report

The report can be downloaded from www.Lohmeyer.de/Literatur/zusammenfassung_06_01.pdf. It is in German.