On-road diesel vehicle emissions in France considering IARC Monograph Volume 105 on the carcinogenicity of engine exhaust emissions

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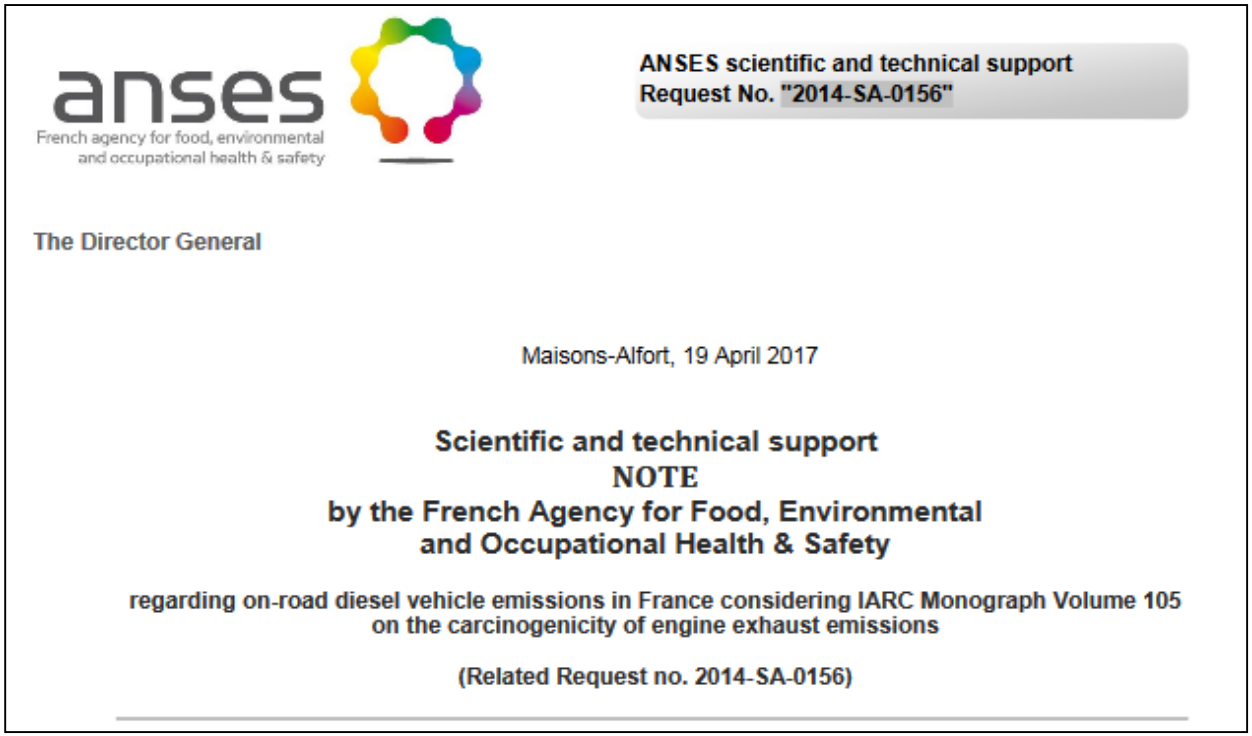
ETUI Conference, 14th November 2017, Brussels



anses
French agency for food, environmental and occupational health & safety

ANSES scientific and technical support
Request No. "2014-SA-0156"

The Director General

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Scientific and technical support
NOTE
by the French Agency for Food, Environmental and Occupational Health & Safety

regarding on-road diesel vehicle emissions in France considering IARC Monograph Volume 105 on the carcinogenicity of engine exhaust emissions

(Related Request no. 2014-SA-0156)

Note published on the ANSES website in April 2017:

https://www.anses.fr/en/system/files/AIR2014SA0156EN.pdf (English)
https://www.anses.fr/fr/system/files/AIR2014SA0156.pdf (French)

Note produced by ANSES's Air Risk Assessment Unit, part of the Risk Assessment Department. ANSES received assistance in drafting this note from its Expert Committee (CES) on "Assessment of risk related to air environments" (CES Air). Three expert rapporteurs, members of the CES Air, were mandated to provide their support. The note was presented to the CES for comments at its meeting on 9 March 2017.

Context

- June 2012, the IARC classified exhaust emissions:
  - from diesel engines as carcinogenic to humans (Gr. 1)
  - from gasoline engines as possibly carcinogenic to humans (Gr. 2B)

- October 2013, the IARC classified outdoor air pollution:
  - as a whole, as carcinogenic to humans (Gr. 1)
  - the particulate matter making up this pollution, as carcinogenic to humans (Gr. 1)

- Preponderance of diesel vehicles on French roads

↳ ANSES was asked by the French Ministries of Health and the Environment "*its opinion as to the transposition of the conclusions issued in 2012 by the IARC on exhaust emissions from diesel engines, to the emissions from on-road diesel vehicles in France*"

Objective followed in the IARC monographs

- **IARC objective:**

  "*to examine all the relevant information in order to assess the strength of the available evidence on the carcinogenicity in humans of a chemical, a mixture, an occupational exposure, a physical agent, a biological agent or a lifestyle factor*" (grouped together under the term "agent")

- **Carcinogenicity of an agent:**

  "*its capability of causing cancer under some circumstances, i.e. to increase the incidence of malignant neoplasms, to reduce their latency or to increase their severity or multiplicity.*"

The IARC monographs do not seek to assess the cancer probability from exposure to an agent in a given situation (risk), but to assess the intrinsic capability of the agent to cause cancer in humans (hazard).

Conclusions of IARC Monograph Volume 105

- Following the publication of new epidemiological studies in workers, and after a 2012 review of all the available data, the IARC concluded that "***diesel engine exhaust causes lung cancer (sufficient evidence) and observed a positive association (limited evidence) with urinary bladder cancer***".

Source : IARC, 2014

- "Sufficient" evidence in humans
- "Sufficient" evidence in experimental animals for whole diesel engine exhaust, diesel engine exhaust particulate matter and the organic fraction of exhaust particles
- "Inadequate" evidence in experimental animals for the gaseous fraction
- "Strong mechanistic evidence" for diesel engine exhaust and many of its components through genotoxic mechanisms

Highlights from IARC Monograph Volume 105

Reviewed studies in humans and experimental animal:

- studies in humans including 3 major retrospective cohort studies.
  - 12,315 US miners exposed between 1947 and 1967, whose mortality was monitored until 1997 (*Attfield et al. 2012, Silverman et al. 2012*)
  - 54,973 US railroad workers followed between 1959 and 1996 (*Garshick et al. 2004, Garshick et al. 2006, Laden et al. 2006*)
  - 31,135 American transport industry workers, whose mortality was monitored between 1985 and 2000 (*Garshick et al. 2008, Garshick et al. 2012*)

- experimental animal studies, including several chronic inhalation exposure studies in rats, with diesel fuels and technologies dating from the early 1980s to the late 1990s.

Highlights from IARC Monograph Volume 105

- Combustion engine exhausts constitute a complex and varied mixture
- The qualitative and quantitative composition of the exhausts depends mainly on:
  - the type and quality of the fuel,
  - the lubricating oil,
  - the type and age of the engine,
  - the use of an emission control system,
  - the tuning of the engine, its state of maintenance and its pattern of use (load and acceleration).

Source : Ouest France, 2014

Highlights from IARC Monograph Volume 105

- Decrease of the sulphur concentration in fuels [less than 10 mg/kg since 2009 in France], and introduction of oxidation catalysts - OC [from 1996 in France] and "wall-flow" diesel particle filters - DPF [from 2000 in France]

  ↳ Significant reduction in emissions of pollutants, and changes of the exhaust composition:

  ↘ of total particulate matter (typically 99% by mass)

  ↘ of solid particles number (89% according to a study on five engines)

  ↘ of sulphates/nitrates, elemental carbon, soot, hydrocarbons

  ↘ of PAHs and nitro-PAHs (52%-99%)

  ↘ of dioxins and furans (60%-80%, 99% with catalysed particle filters and SCR systems)

  ↘ of nitrogen oxides*

* Some technologies (pre-dates Euro 6/VI) led to an increase in NO_2 emissions (AFSSET, 2009 : https://www.anses.fr/fr/system/files/AIR2006et0009Ra.pdf)

Emissions from on-road diesel vehicles in France

Should it be considered that the emissions from the current French fleet of on-road diesel vehicles are carcinogenic (hazard)?

… when the IARC's classification (Gr. 1 carcinogenic to humans) is based on, among others, studies in occupational settings with higher exposure to emissions from old diesel engines

Emissions from on-road diesel vehicles in France

- No study enabling an answer
- The most recent studies on European or North American cohorts followed since the early 1990s indicate positive associations between traffic-related air pollution and lung cancer (*Hamra et al. 2015; Chen et al. 2015; Hart et al. 2015*), and also other cancers
- The current fleet of on-road diesel vehicles includes vehicles not fitted with technologies such as "wall-flow" DPF and OC
  - → In 2016, 42% of the diesel passenger cars in circulation not yet fitted with DPF (38% in vehicles.km) and few heavy duty vehicles fitted.
  - → Engine generations prior to the 2000s, for which exhaust carcinogenicity has been demonstrated in experimental animal studies, still present
- The emissions from the current fleet are still characterised by the presence of carcinogenic compounds.
  - → In addition to the diesel particulate matter, 35 chemicals in Gr. 1, 2A or 2B identified in diesel and/or gasoline engine exhausts (e.g. PAHs, benzene)
  - → These compounds were evaluated by the IARC among the thousands of combustion by-products present in the gas and particulate phases

Emissions from on-road diesel vehicles in France

And for the exhaust emissions
from new diesel technologies (NTDE) placed on the market?

- NTDE greatly reduce pollutant emissions including particulate matter and PAHs
- Exhaust emissions remain a complex mixture whose toxicity is difficult to predict.
- Currently, no human studies enabling a direct comparison with the carcinogenicity of older technologies

Emissions from on-road diesel vehicles in France

And for the exhaust emissions
from new diesel technologies (NTDE) placed on the market?

- No carcinogenic, mutagenic and genotoxic potential of exhaust emissions from a heavy duty diesel engine compliant with the US EPA 2007 emissions standards and fitted with a particulate filter and other emission control technologies (*McDonald et al. 2015, Bemis, Torous, and Dertinger 2015, Hallberg et al. 2015*)

  → the only major carcinogenicity study to include chronic inhalation exposure to emissions from a recent diesel engine and carried out on a single North American diesel technology

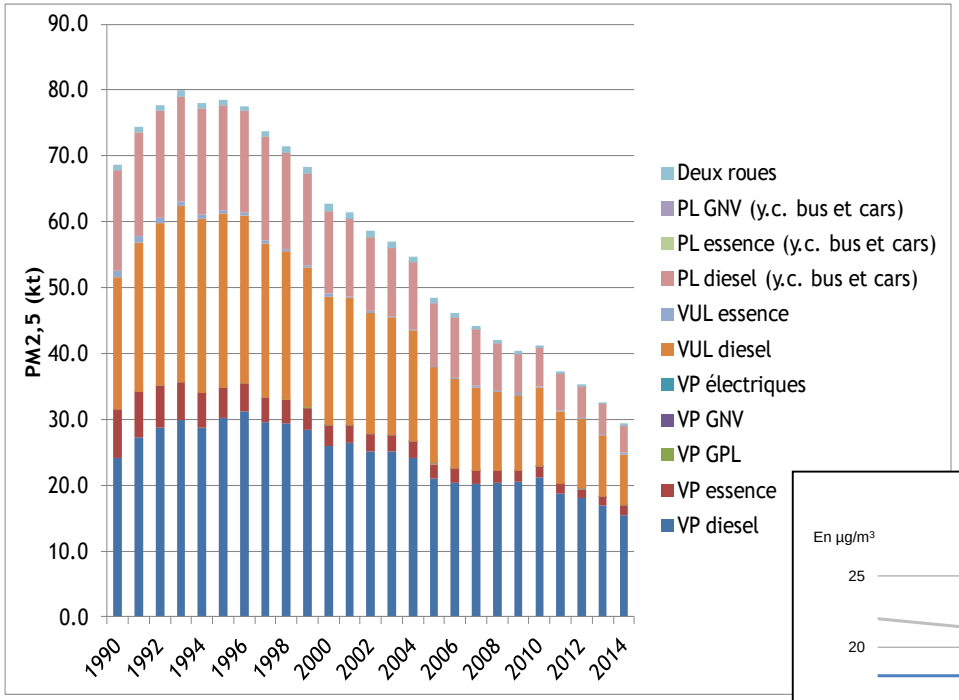
- Time needed to obtain epidemiological results

↳ Absence of carcinogenicity in humans cannot be established for exhausts from new diesel and gasoline engine technologies

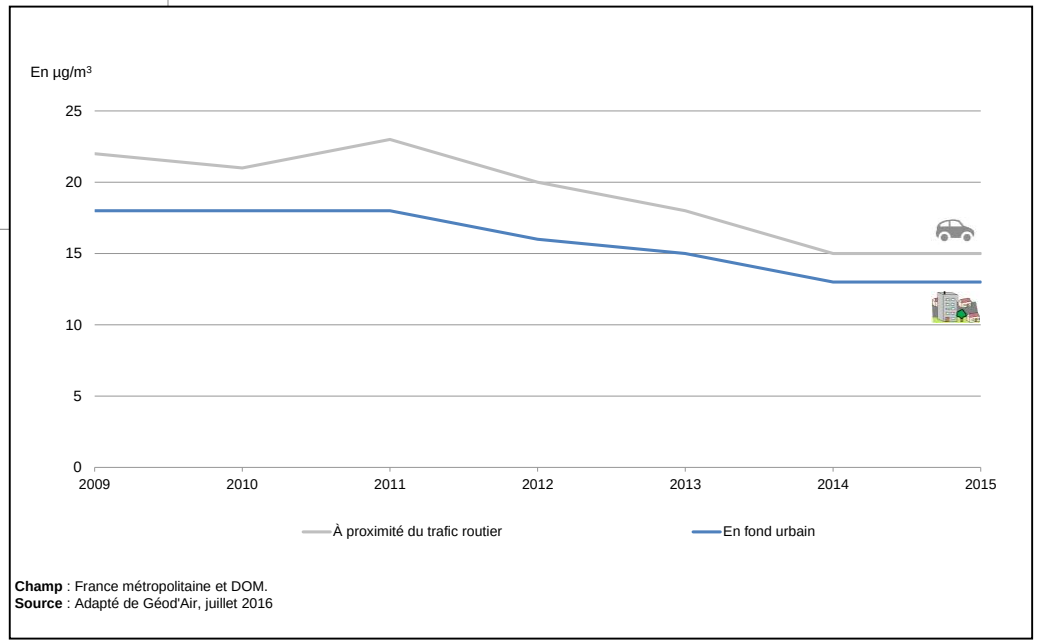
Emissions from on-road diesel vehicles in France

What is the impact of the emissions from on-road vehicles on the cancer risk in the general population?

Emissions from on-road diesel vehicles in France



Road transport PM2.5 Emissions, in kT/yr (Source CITEPA/Secten, 2016)



PM2.5 annual mean concentrations close to traffic and in urban background, in µg/m³ (Source Géod'Air, 2016)

Emissions from on-road diesel vehicles in France

- Human observational studies and experimental studies support an impact of outdoor ambient air pollution and traffic-related air pollution on the lung cancer risk of exposed populations (*IARC 2015, Hamra et al. 2015*)
- Atmospheric concentrations of pollutants such as particulate matter (in mass and number concentrations), carbon soot, PAHs and benzene are higher in the vicinity of roads (from few tens of meters to few hundreds)
- > 50% of the populations from 10 UE cities, including Paris and its inner suburbs, live within 150 m of busy roads (> 10,000 veh/d) (Aphekom, 2012) and 85% of the French population live in urban areas (INSEE data)
- The quantitative estimation of the excess risk (and the number of cases) of cancer attributable to emissions from on-road vehicles is complicated, especially given the lack of consensual exposure-risk relationship (ERR) specific to vehicle emissions

Emissions from on-road diesel vehicles in France

- *Vermeulen et al. 2014* estimated that exposure of the US general population to diesel engine exhaust emissions is associated with an excess lifetime risk of 21 lung cancer deaths for 10,000 individuals exposed to an average concentration of 0.8 µg/m^3 EC (> the risk acceptability benchmarks of 1/100,000 or 1/1,000,000)

- This risk estimate should be considered with caution:
  - based on a meta-analysis of ERR from the main cohort studies considered by the IARC, i.e. ERR associated with old diesel engines
  - do not take into account evolution of fuels and technologies, and does not extrapolate to more susceptible subpopulations (children, elderly, people with pre-existing comorbidities) (*HEI Diesel Epidemiology Panel 2015*)
  - relevance of these ERR is still the subject of debate for QRA: retrospective exposure assessment, potential effect of time- and age-related factors (*Crump, Van Landingham and McClellan 2016, Crump et al. 2015, Moolgavkar et al. 2015*)*

* The authors (Crump, Van Landingham and McClellan 2016, Crump et al. 2015, Moolgavkar et al. 2015) declared conflicts of interests, such as working on behalf of, or being funded by, the automotive, mining, rail or oil industries.

Emissions from on-road diesel vehicles in France

A more recent study was based on the meta-analysis by *Vermeulen et al. 2014* and on some additional sensitivity analyses incorporating other published ERR *(Vermeulen and Portengen 2016)*:

- EC median levels in urban ambient air in Europe and USA: 0.5-2 µg/m^3
- In occupational environments, usual EC exposure levels: 1 µg/m^3 (parking attendants), 2-5 µg/m^3 (professional drivers), 5-10 µg/m^3 (construction workers and mechanics), and >100 µg/m^3 (underground mining)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- These EC exposure levels largely exceed the concentration range 0.009-0.017 µg/m^3 calculated for a risk acceptability benchmark of 4/100,000* and are close to or above the 0.85-1.67 µg/m^3 concentration range calculated for a maximum tolerable risk benchmark of 4/10,000*.

* Benchmark established for an occupational exposure scenario over 40 years, from the age of 20 to 60 years, and not over the lifetime.

Emissions from on-road diesel vehicles in France

- The authors roughly estimate that around 4.8% of annual deaths from lung cancer at the age of 70 years in the US and the UK are due to past environmental exposure to exhaust emissions from diesel engines (*Vermeulen et al. 2014*)
- Previous estimates for the fraction of lung cancers attributable to traffic-related air pollution in the 2000s have ranged between 5 and 7% (*Cohen et al. 2005, Vineis, Hoek, and Krzyzanowski 2007*)

Conclusions

- The emissions from the current French fleet of on-road diesel vehicles must be regarded as carcinogenic.

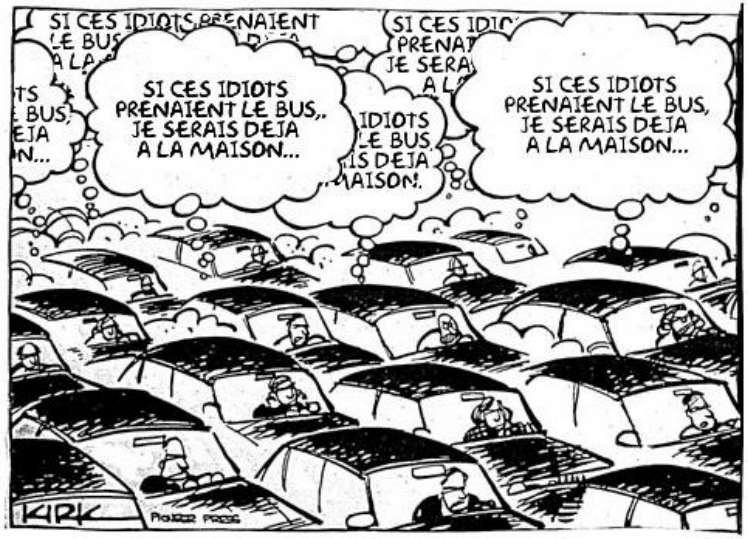
- While a precise estimate of the fraction of cancers attributable to the traffic-related air pollution will always remain inaccessible, given the time needed to obtain the results of epidemiological studies, the orders of magnitude of existing estimates can be used to examine the public health issues and thus the opportunity for action.

- Recent developments in the field of *in vitro* toxicology combined with sophisticated aerosol exposure systems suggest that even though exhaust toxicity is not predictable, fast and reliable assessments of new technologies will be possible.

Conclusions

- The introduction of new diesel technologies is likely to reduce the cancer risk attributable to emissions from on-road diesel vehicles circulating in France, for an equivalent number of kilometers travelled.

- Other possible measures include the development of sustainable transport (many guidelines, e.g. the OECD guidelines, the PEP programme by the UN-ECE / WHO-Europe)



Source : Reporterre, 2014

Source : Ouest France, 2017

Source : Wingz, 2014

Thank you for your attention!