Particle Size and Number Emissions from Light-Duty Gasoline Vehicles

by

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Ultrafine and nanoparticle emissions were measured in the exhaust of different gasoline vehicles with model year between 1994 and 2003, using the Unified Driving Cycle (UDC). The engines in all vehicles were homogenous charge spark-ignited gasoline engines. A scanning mobility particle sizer (SMPS) combined with an electrical low pressure impactor (ELPI) were used to cover a particle size range from 10 nm to 800 nm. The measurement was performed under cold-start and hot-start vehicle operation using both normal ambient temperature of 25 °C and cold ambient temperature of 0 °C.

All vehicles tested showed an increase in sub-30 nm particle number under cold-start operation and under hard acceleration. Cold ambient temperature of 0 °C also lead to a higher increase in particle number, compared with that at normal ambient temperature of 25 °C.

New technology gasoline vehicles showed less increase in sub-30 nm particles, compared with older technology vehicles. This is likely due to a better management of fuel delivery and better control of fuel-air ratio.

Gasoline vehicles can be a major source of nanoparticle emission to the atmosphere due to the large number of vehicles on the road.

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Background

- This program was designed to characterize the emissions from different gasoline and natural gas vehicles using the Unified driving Cycle. The portion presented here focused on particle size and number emissions.

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Test Matrix

- Vehicles
  - Gasoline Vehicles (MY 1993 to MY 2003)
  - Natural Gas Vehicles (MY 1994 to MY 2003)
- Test Conditions
  - Ambient Temperature, 20 °C
  - Cold Ambient Temperature, 0 °C
- Test Cycles
  - Unified Driving Cycle

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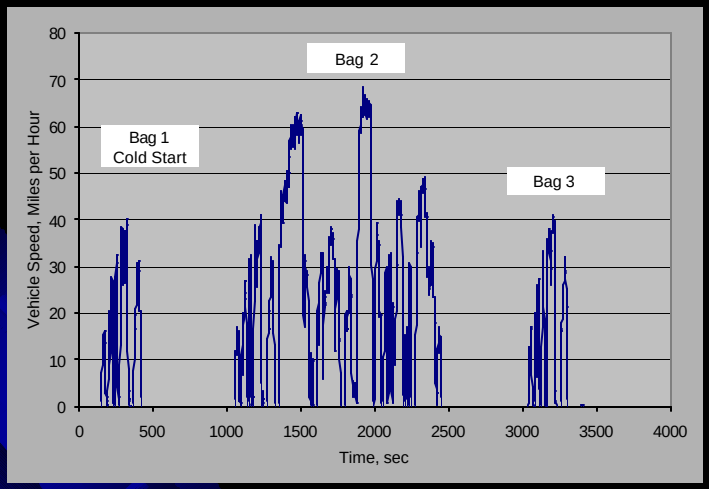
Unified Driving Cycle



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1993-1998 Gasoline Vehicles

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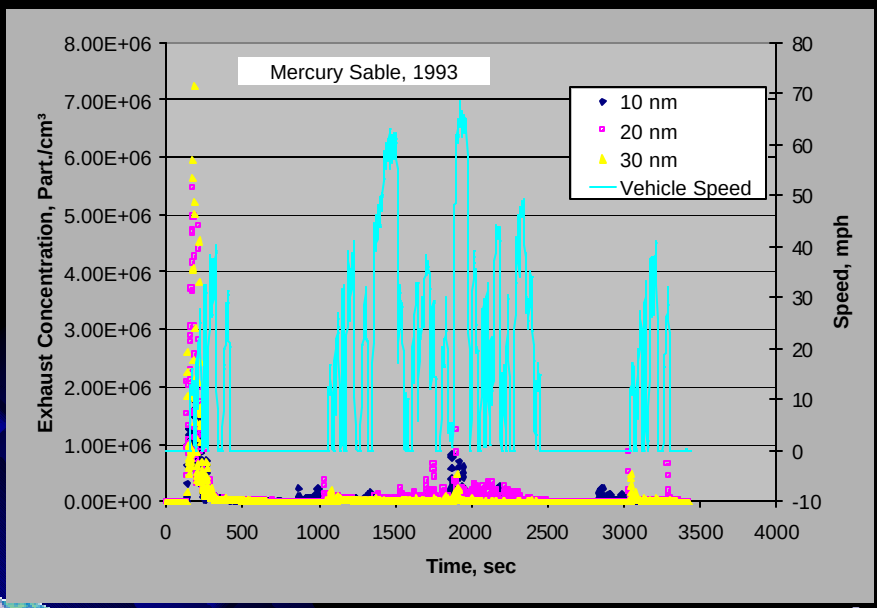
Nanoparticle Emissions Under Cold Start Operation



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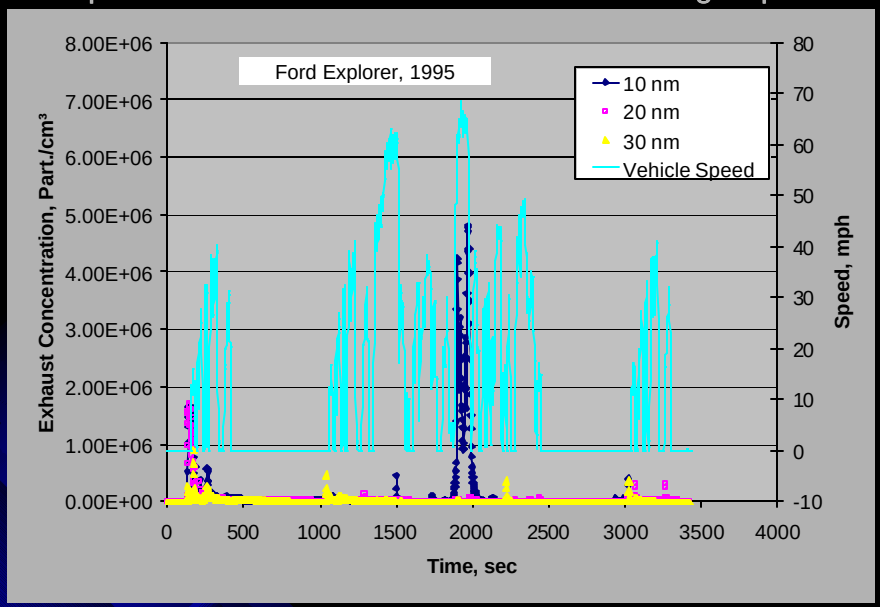
Nanoparticle Emissions Under Cold Start and High Speed



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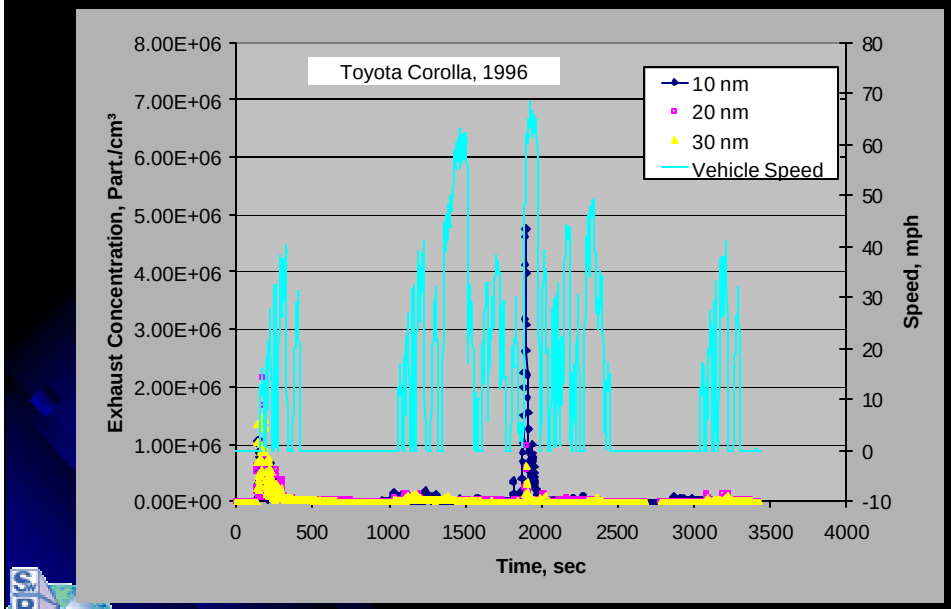
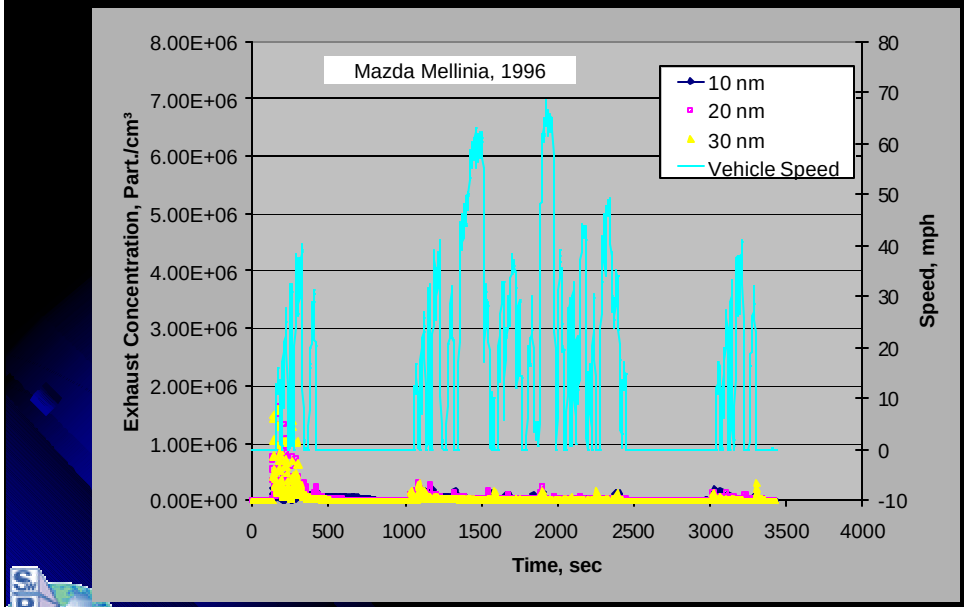
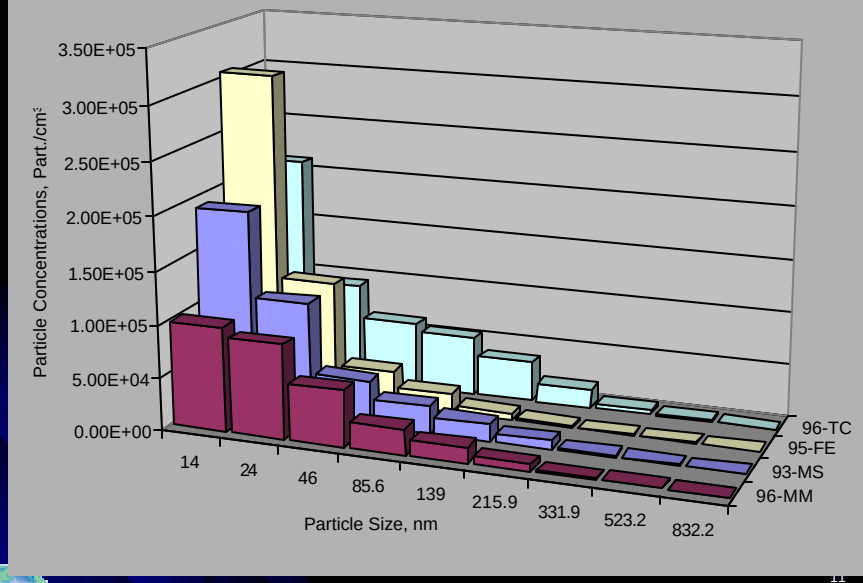
Nanoparticle Emissions Under Cold Start and High Speed



Nanoparticle Emissions Under Cold Start Operation



Overall Particle Number-Weighted Size Distributions



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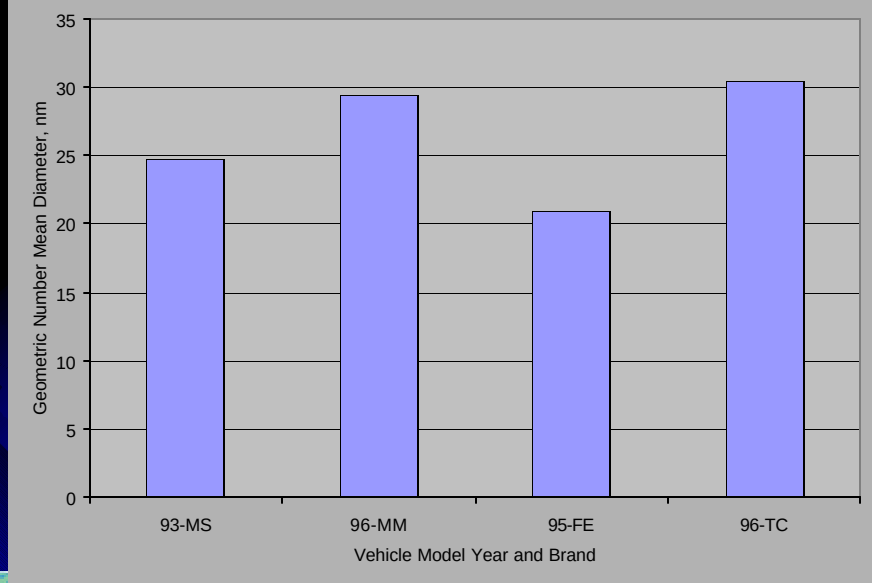
Number Mean Diameter



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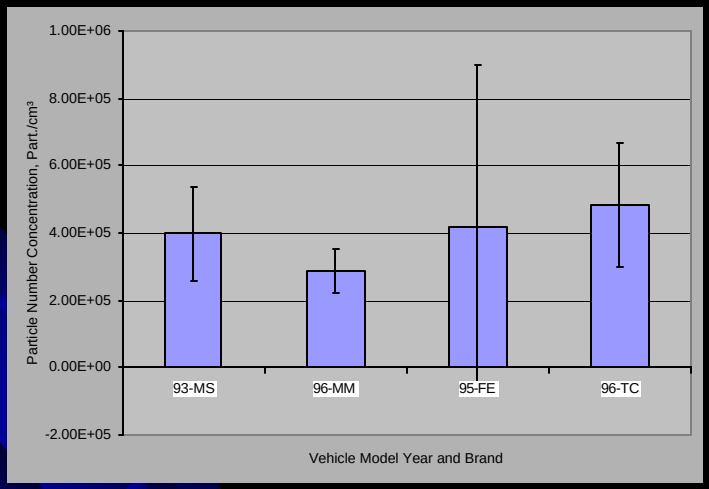
Average Number Concentration of Entire UDC



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O °C Ambient Temperature

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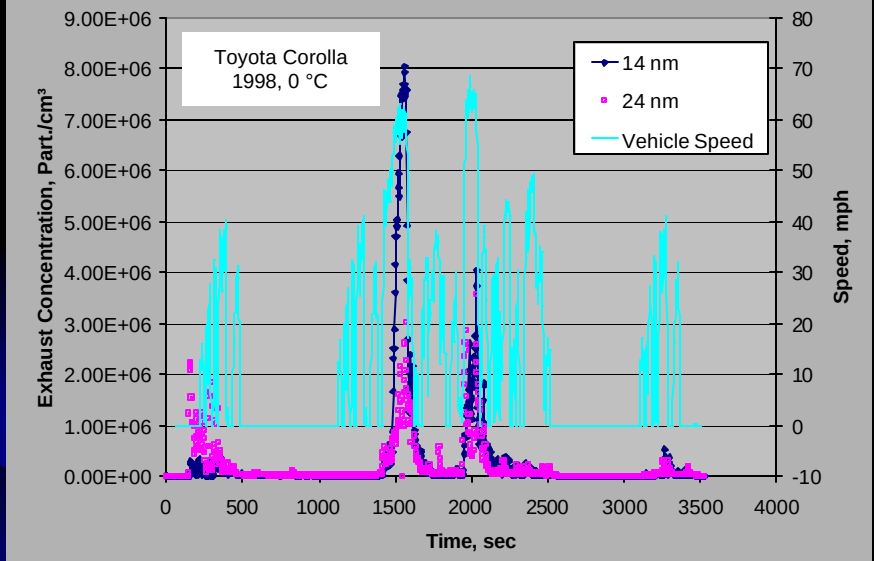
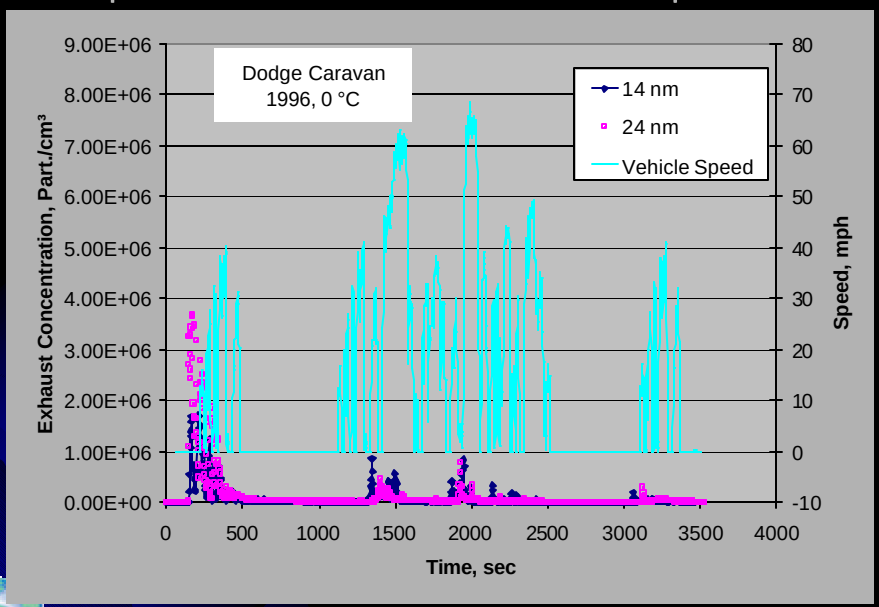
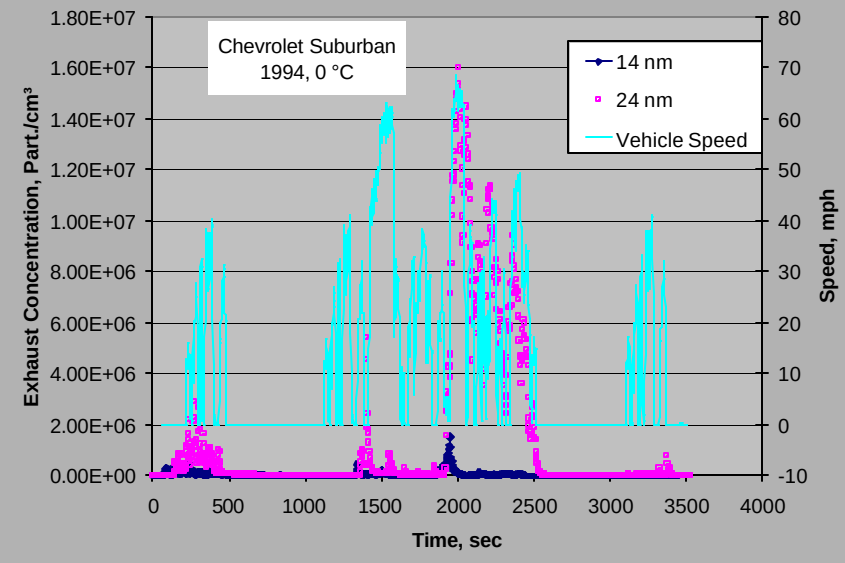
Nanoparticle Emissions at 0 °C Ambient Temperature



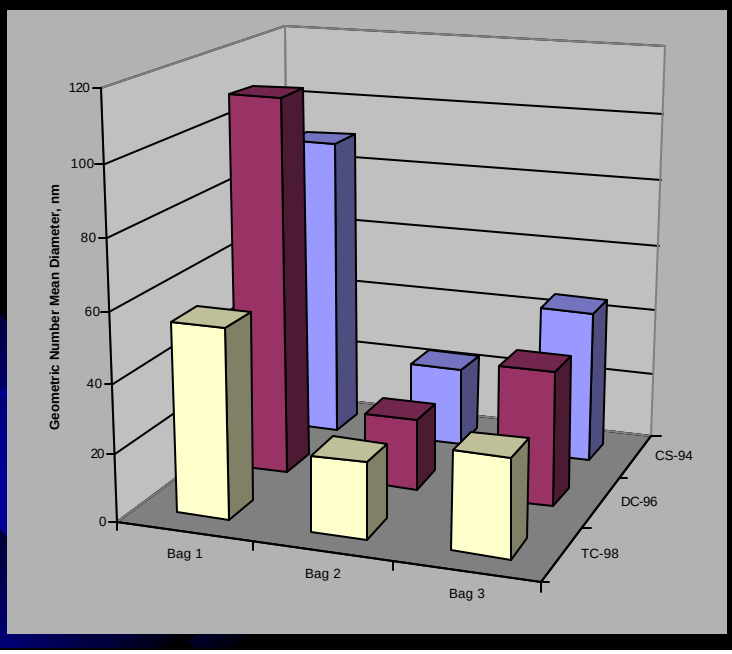
Nanoparticle Emissions at 0 °C Ambient Temperature



Nanoparticle Emissions at 0 °C Ambient Temperature



Number Mean Diameter at different Portions of the UDC Cycle



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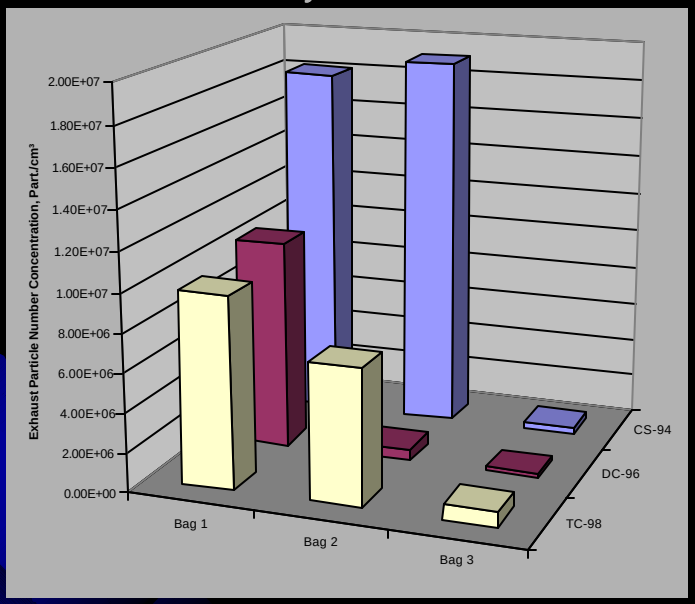
Average Number Concentration at Different Portions of the UDC Cycle



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2003 Gasoline Vehicles, 20 °C and 0 °C Operations

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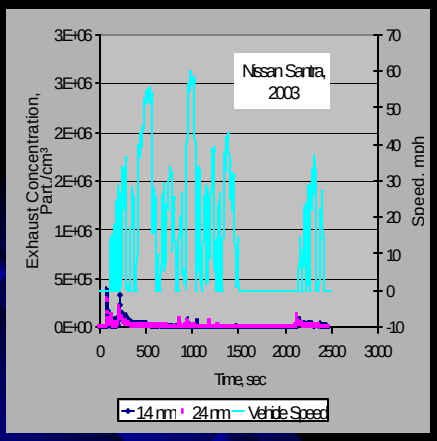
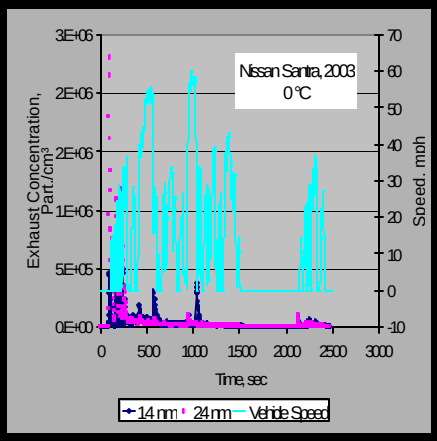
Nanoparticle Emissions from Model Year 2003 Gasoline Vehicles

20 °C



0 °C



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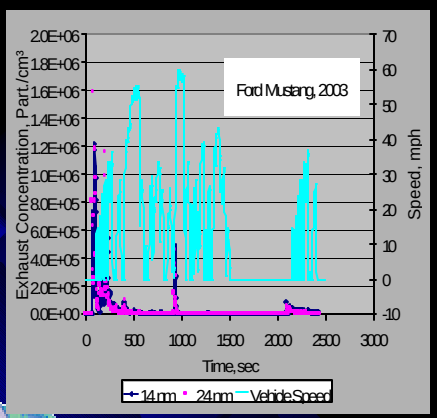
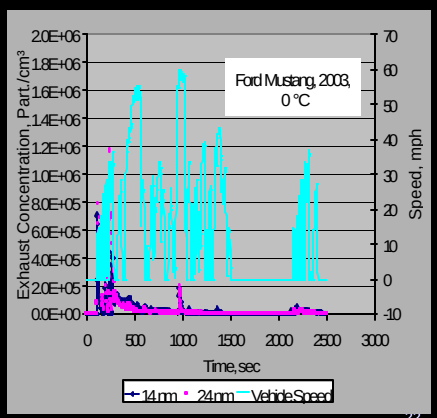
Example of Nanoparticle Emissions from Model Year 2003 Gasoline Vehicles

20 °C



0 °C



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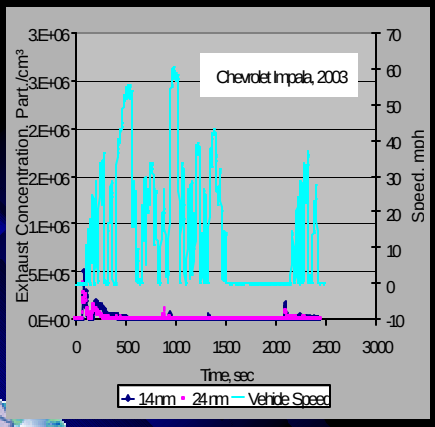
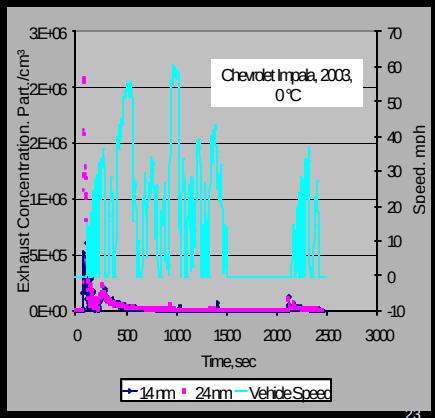
Example of Nanoparticle Emissions from Model Year 2003 Gasoline Vehicles

20 ^{0}C



0 ^{0}C



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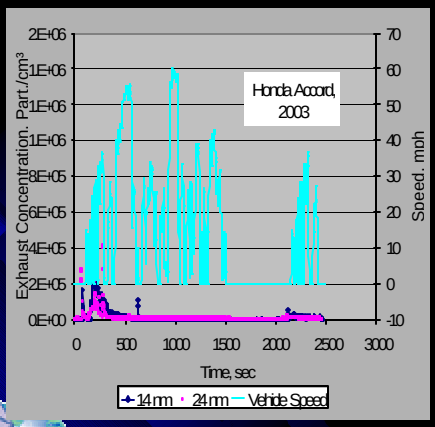
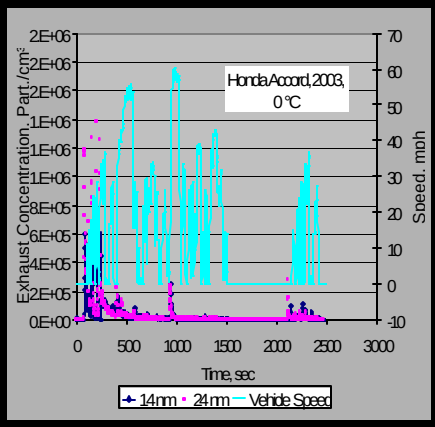
Example of Nanoparticle Emissions from Model Year 2003 Gasoline Vehicles

20 ^{0}C

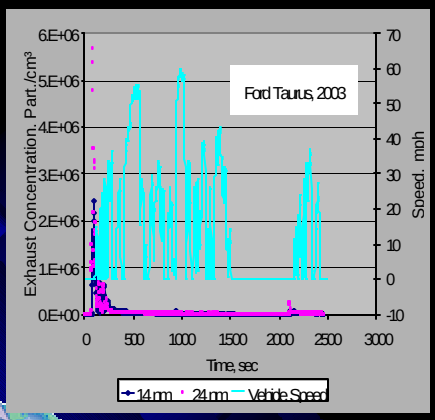


0 ^{0}C

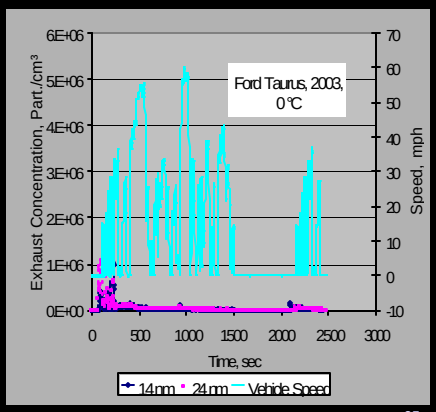


Example of Nanoparticle Emissions from Model Year 2003 Gasoline Vehicles

20 ^{0}C



0 ^{0}C



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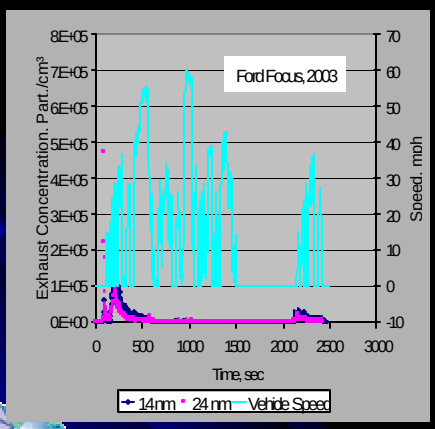
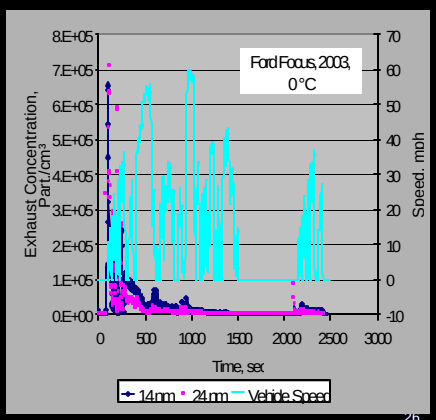
Example of Nanoparticle Emissions from Model Year 2003 Gasoline Vehicles

20 ^{0}C



0 ^{0}C



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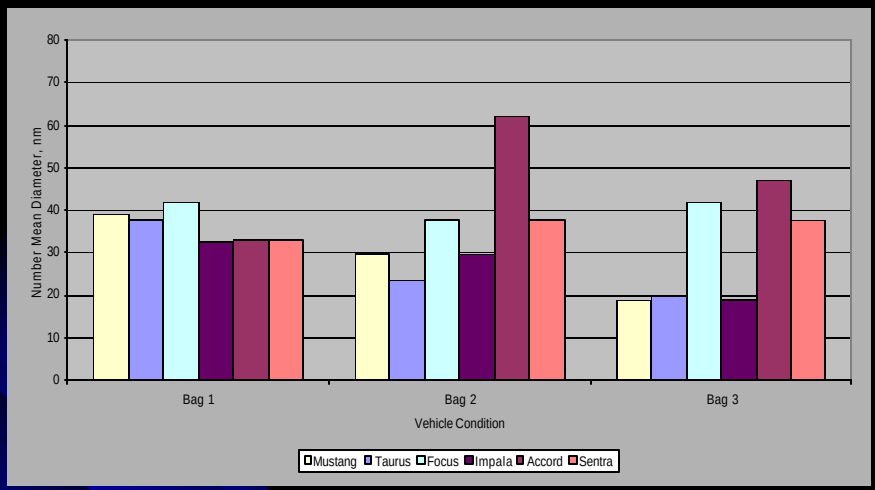
Number Mean Diameter, 20 °C



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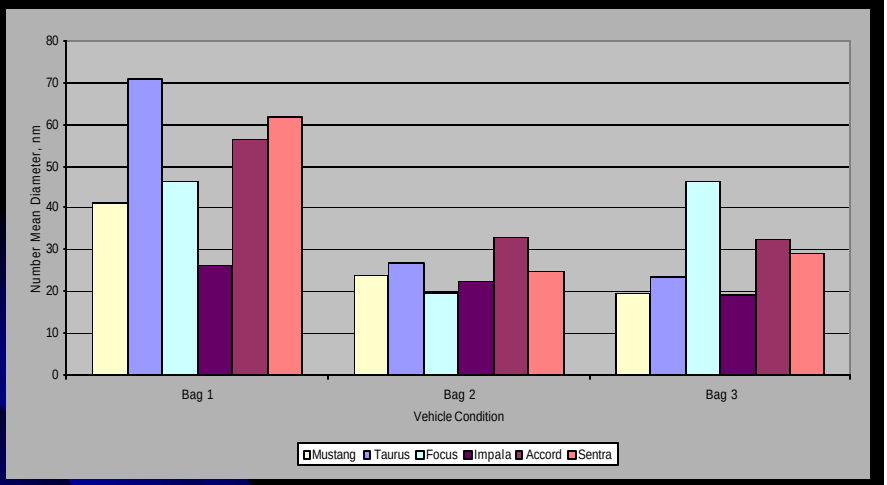
Number Mean Diameter, 0 °C



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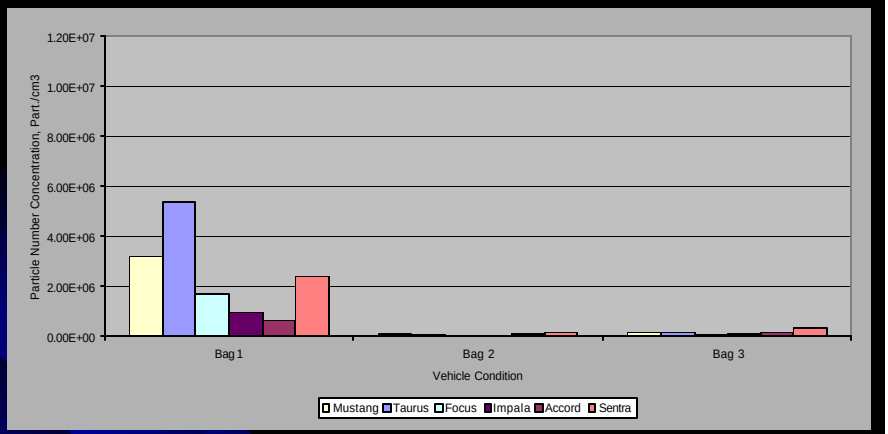
Number Concentration, 20 °C



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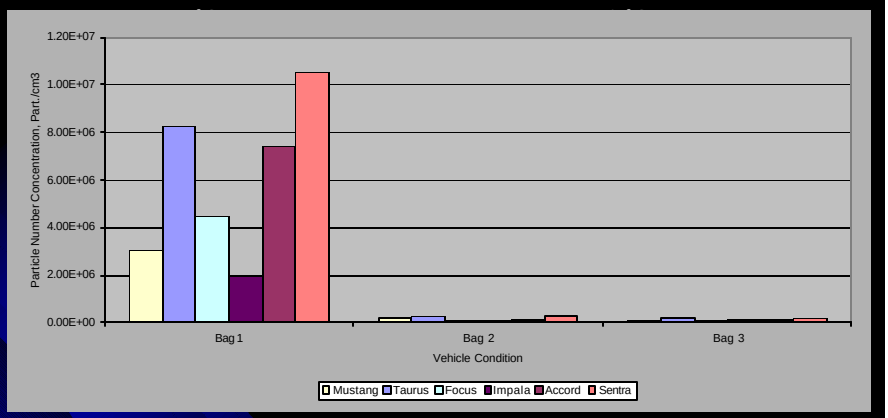
Number Concentration, 0 °C



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SUMMARY

- Particle Emissions from Light Duty Vehicles is generally low, except during the following operations:
  - Cold Start
  - High Speed
  - Cold Environment, 0 °C
- Even New Gasoline Vehicles continue to show high Nanoparticle emissions during cold-start, although the concentration is less that of older technology vehicles.