A Note on Internal Combustion Processes for Motor Vehicles

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These slides present a basic introduction to the internal combustion processes used in a motor vehicle burning hydrocarbons and the enormous improvements achieved in the last decades in reducing emissions from volatile organic compounds, carbon monoxide, and nitrogen oxides.

Internal Combustion Processes for Motor Vehicles

- Ingredients for combustion
  1. air - more precisely: oxygen (O_2)
  2. fuel - e.g., gasoline, i.e., hydrocarbons (HC)
  3. ignition source (e.g., a spark plug)
- "Perfect" combustion

  gasoline + air $\rightarrow$ water + CO2 + heat energy
- "Real" combustion

  HC + Air (O_2 + N_2) $\rightarrow$ water + CO_2 + heat energy + unburned HC (i.e., VOCs) + NO_x + CO

Major Milestones in Vehicle Emission Control

(See Timeline)

- 1975
  - "first generation" catalytic converters reducing VOC and CO emissions
- 1980-81
  - "three-way" catalyst reducing VOC, CO, and NO_x emissions, plus an on-board computer and oxygen sensor that optimizes the efficiency of the catalytic converter

Auto Emission Control: Federal Emission Standards

- Car emission improvements from the early 1950s to the mid-1990s
  - HC: from 13 grams per mile(*) to 0.25
  - NO_x: from 3.6 grams per mile(*) to 0.4
  - CO: from 87 grams per mile(*) to 3.4

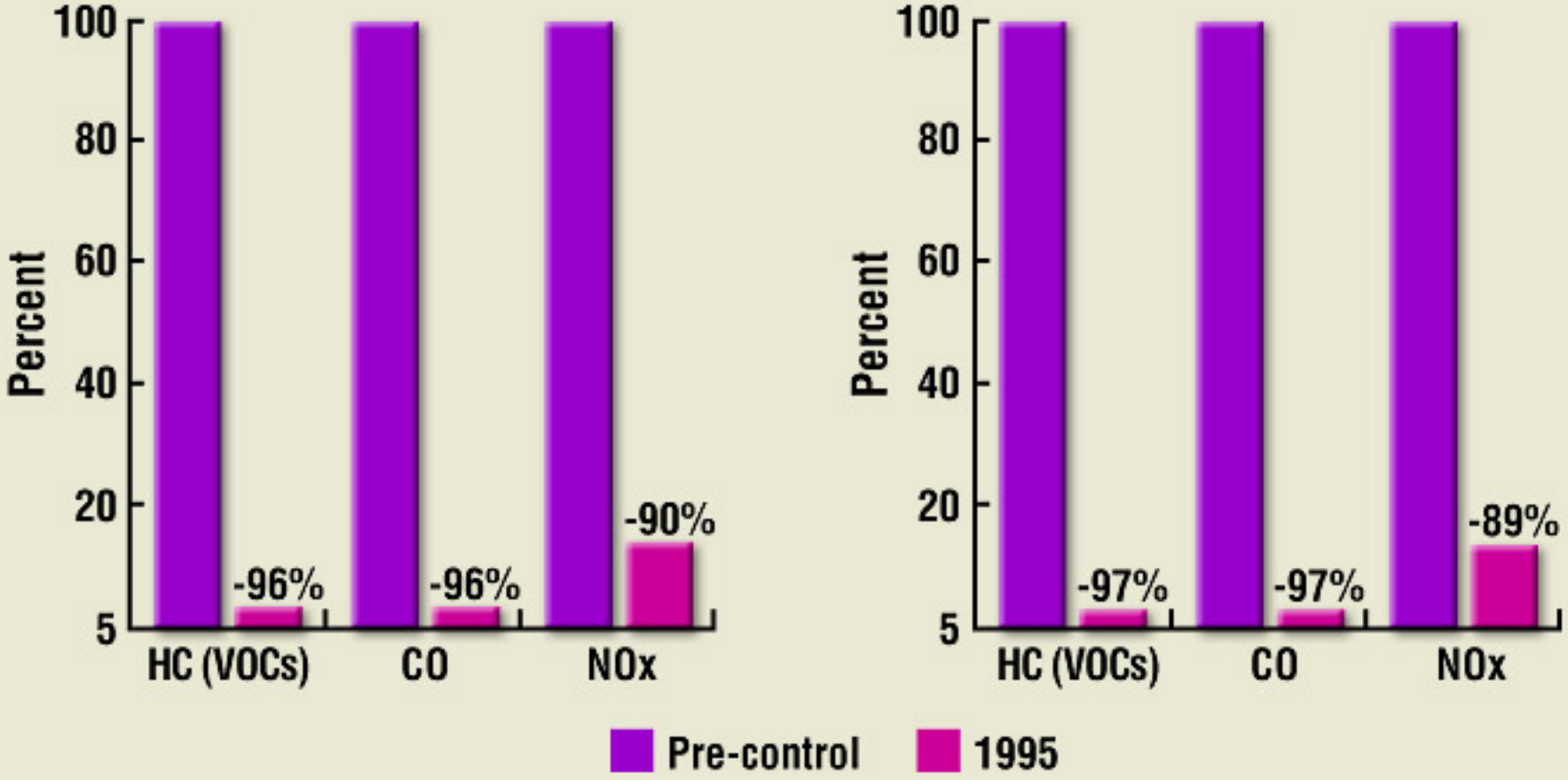
(*) An ounce is about 30 grams. The unit of grams per mile expresses the car's average total emission into the atmosphere for each mile of travel

	1950s	1994
HC (VOCs)	13 gm/mile	0.25 gm/m
NOx	3.6 gm/m	0.4 gm/m
CO	87 gm/m	3.4 gm/m

Reduction in Vehicle Emissions*

Passenger Cars

Light Duty Trucks
Under 3,750 lbs.
GVWR



*Based on 1995 federal 49-state emission standards
Source: U.S. Environmental Protection Agency

Improvements

- Improvements were achieved through
  - Federal government standards
  - New emission control technologies developed by the auto industry
  - Cleaner combustion technologies developed by the auto industry
  - Better fuel economy, e.g.:
    - Better aerodynamics
    - Lighter automobiles
    - Reduced loss of unburned fuel

Cont.

- These systems needed to provide a longer and hotter spark with more precise control of spark timing
- Automobile manufacturers turned to TFI integrated circuit technology for this purpose

Variation in a rich-air fuel ratio makes much less difference in power than the same variation in a lean air-fuel ratio