DELPHI

# Catalytic Aftertreatment and 2- and 3-Wheel Vehicles

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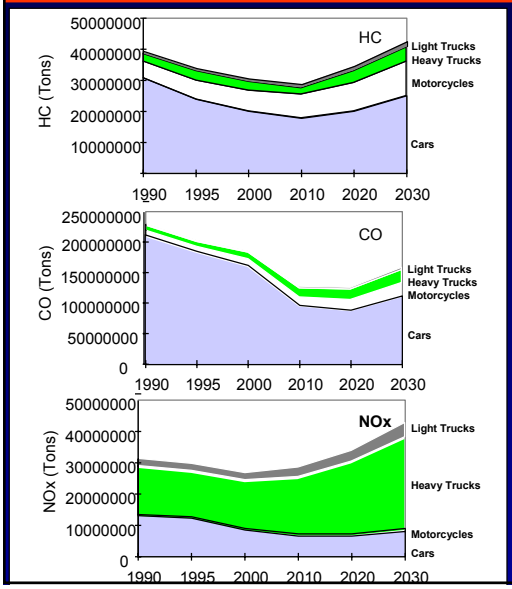
Asian Vehicle Emission Control Conference 2004

## Focus Vehicles

- Engine Varieties
  - 2-Stroke
  - 4-Stroke
- Small Displacement
  - 50 - 250 cc
- Air Cooled, Water Cooled
- Carburetor fuel delivery system

# Noxious Exhaust Emissions Must Be Reduced




## Global Emission Trends

M.P. Walsh, "Motorcycle Vehicle Pollution Control The Global Market", MECA Report, 1993

# Emissions Solutions Need to Preserve the Vehicles' Desirable Features

- Small and efficient power plant
- Uncomplicated
- Small vehicle envelope
- Economics
- Adaptable to different road and traffic conditions

*Catalytic aftertreatment offers a good solution*

## Historical Arguments Against Using Catalytic Aftertreatment to Reduce Undesired Tailpipe Emissions

- **Technically Impractical/Ineffective**
  - Limited efficiency
  - Limited durability
    - high operating temperatures
    - too much exposure to catalyst poisons
- **Too large/aesthetics**
- **Heat Hazard**
- **Too expensive**

*In contrast to the recognized success with automobiles*

## Catalyst Components

Similar to Automotive Catalysts

- **Noble Metal - Pt, Pd, Rh**
  - Primary catalytic agent
- **Washcoat - Alumina and Promoters**
  - Supports noble metal
  - Enables high noble metal dispersion
  - Enhances noble metal activity
  - Improve noble metal durability
  - Active in chemical processes
- **Substrate - Metallic**
  - Provides mechanical strength
  - Allows geometric and spatial orientation
  - Supports catalytically active components

## Automotive Catalysts

- Very effective on automobiles

- Not practical for small 2-/3-wheel vehicles

## Matrix Based Catalysts for 2-/3-Wheel Vehicles

- Typical Attributes
  - Metallic substrate
  - 100 cpsi
  - 50 - 175 $cm^3$
  - Welded in place
  - 0.2g NM typical

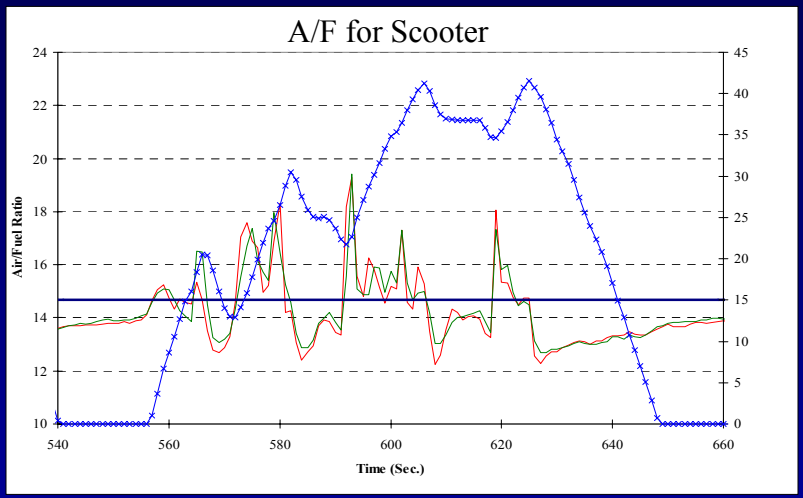
## Catalyst Application Opportunities

## Many Existing Exhaust System Components Can be Replaced by Comparable Catalyzed Forms

## Catalyst Design Criteria

- Small/no impact on space constraints
- Wide operating window
- Required activity
- High efficiency
- Durable performance
  - Resistance to thermal deactivation
  - Poisons
- Economical

## Wide Operating Window Requires Specially Formulated Technologies

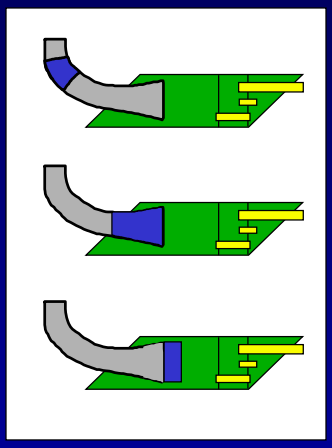


## Appropriate Catalyst Solution Depends on Requirements

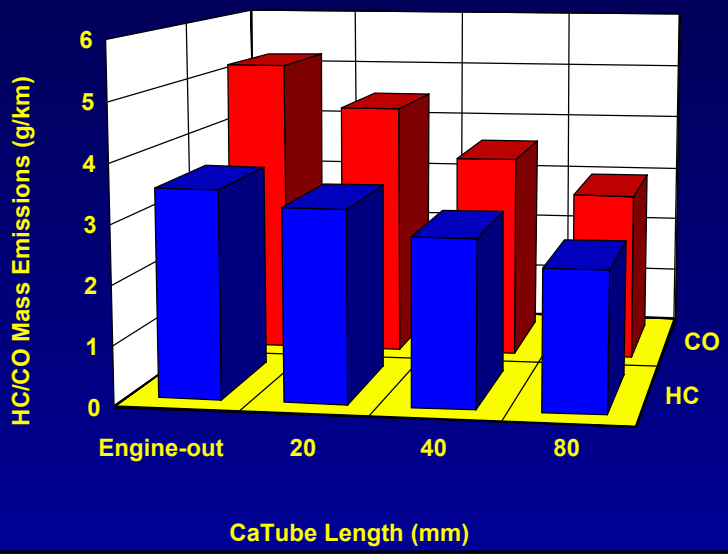
| Configuration | Efficiency/Demands |
| --- | --- |
| CaTube/tube/cone | Low/moderate |
| Monolithic catalyst | Moderate/high |
| CaTube /tube and monolith | High |

## Catalytic Aftertreatment Configurations

- CaTubes/tubes/cones
  - Low to moderate reductions
  - Strong surface area/performance relationship
  - Diffusional limitations
  - No backpressure

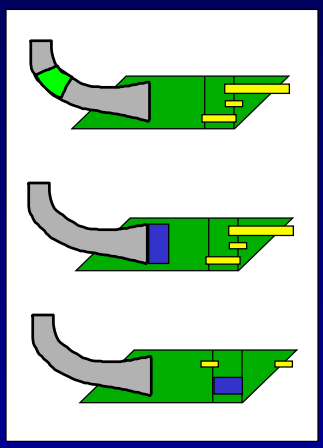


## The Performance of CaTubes/Tubes Are a Strong Function of Substrate Surface Area

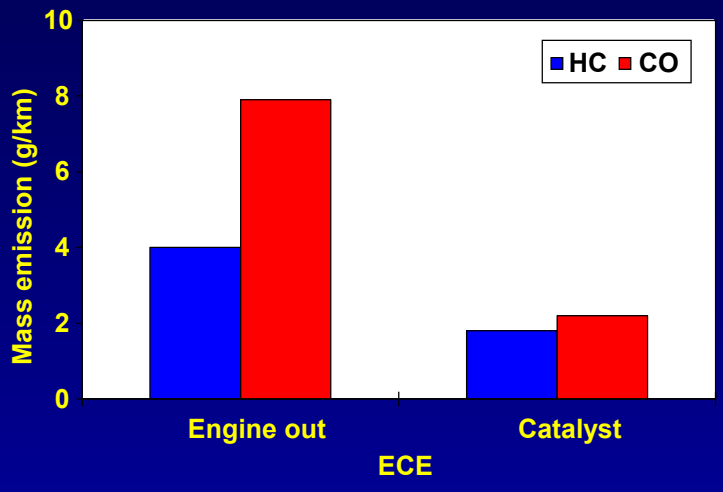



## Catalytic Aftertreatment Configurations

- Monolithic Catalysts
  - Moderate to high reductions
  - Oxygen limitations are possible

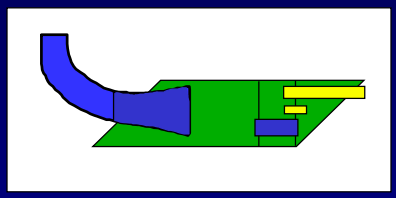


## Monolithic Catalysts are Very Effective in Reducing Tailpipe HC and CO Emissions

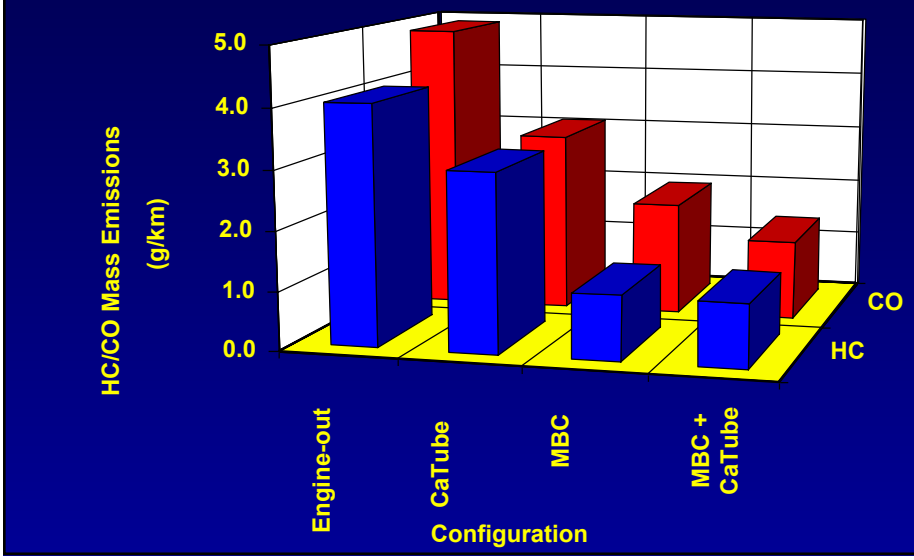



## Catalytic Aftertreatment Configurations

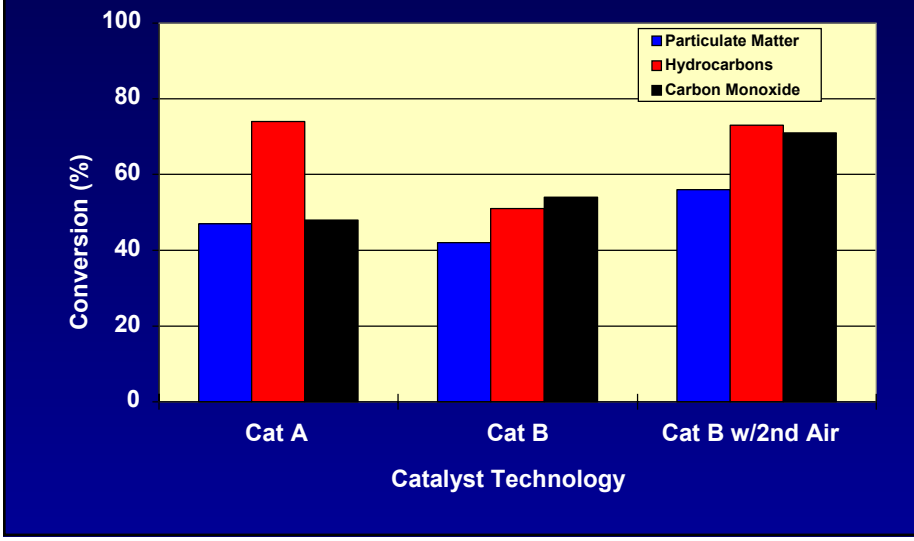
- Monolithic Catalysts with CaTubes (tubes)
  - Moderate to high reductions
  - Heat management
  - Extended monolithic catalyst durability
  - Oxygen limitations are possible



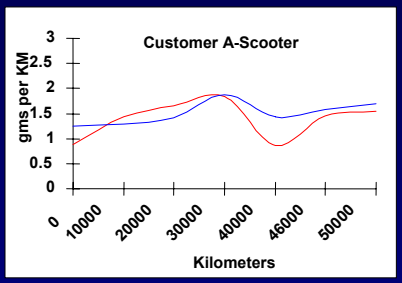
## Advanced Catalyst Configurations Give Low Tailpipe HC and CO Emissions and Improved Catalyst Durability

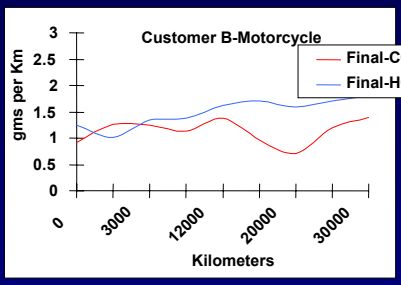


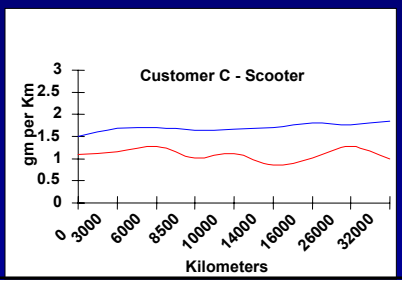

## A Benefit is Also Realized for Particulate Matter Emissions

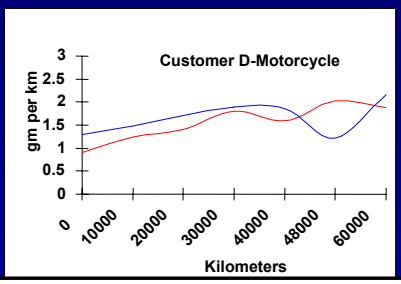


## Durability Results



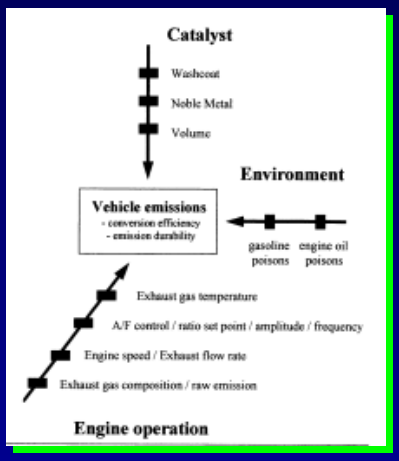




## Catalytic Aftertreatment Provides the Opportunity to Significantly Reduce Undesirable Emissions

- Effective Pollution Abatement
- Proven Technology
- Flexible Application
- Little or no impact on vehicle features
- Cost Effective
- Attainment of stringent standards

## Factors Impacting Automotive Emissions




## Significant Potential Exposure to Exhaust-borne Poisons

- **Chemical Poisons - React with Noble Metals**
  - Lead and halide scavengers in leaded fuels
  - Sulfur dioxide
- **Physical Poisons - Mark and Cover Noble Metals**
  - Phosphorus, zinc, and calcium from oil
  - Silicon (gasket materials and recycled cleaning fluids)
  - Manganese (MMT additive)

## 2- and 4- Stroke Motorcycle Engines Have Much Lower Combustion Efficiency Than Stoichiometric Car Engines

| | 2-stroke | 4-stroke | Car |
|---|---|---|---|
| HC | 3.3% | 0.6% | 1700 ppm |
| CO | 2.8% | 4.8% | 0.7% |
| NOx | Very little | 500 ppm | 1800 ppm |
| $O_2$ | 4.2% | 1.2% | Exhaust 0.6% |
| Overall A/F ratio | Richer | Rich | Stoichiometric |