Heavy Duty On-Board Diagnostics

California Air Resources Board
Mobile Source Control Division

July 21, 2005
Sacramento, California

Today's Presentation

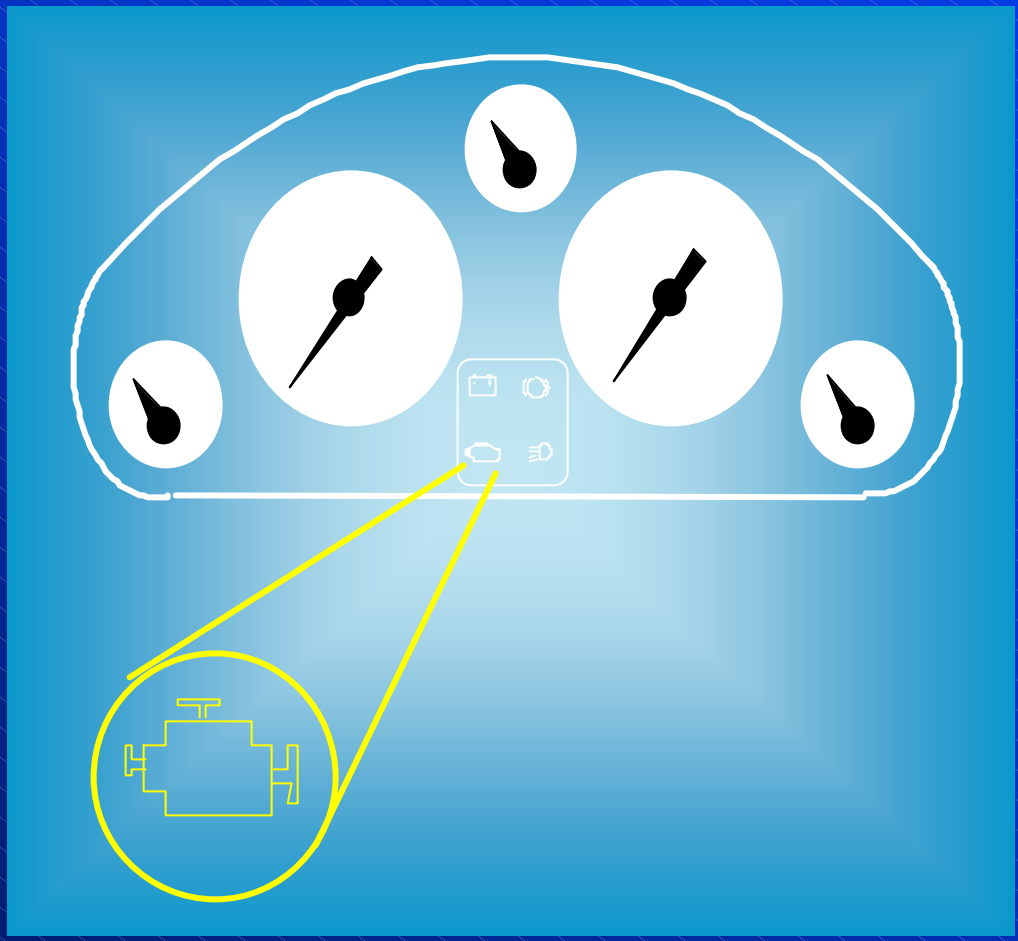
- Background
- Proposed OBD Monitoring Requirements
- Costs and Emission Impacts
- Summary

What is On-Board Diagnostics?

- A system in the engine's on-board computer that monitors the performance of emission-related components for malfunctions
- Uses information from sensors
- Mostly software that runs diagnostics in the background

Malfunction Indicator Light (MIL)

- Should a malfunction be detected, a warning light will appear on the vehicle's instrument panel to alert the driver



Standardized Information

- When a malfunction is detected, information about the malfunctioning component is stored
- Technicians can download the information with a “scan tool”
- Information is communicated in a standardized format so one tool works with all vehicles

How Does OBD Work?

- Uses information from sensors to judge the performance of the emission controls
- These sensors do not directly measure emissions

Example of how OBD works

- Fuel system pressure control
- Fuel pressure sensor measures how well pressure is controlled
- Manufacturer correlates pressure control error to corresponding emission increase
- OBD system is calibrated to turn on MIL when pressure is outside limits

Benefits of OBD

- Encourages design of durable emission control systems
- Aids diagnosis and repair of complex electronic engine controls
- Helps keep emissions low by identifying emission controls in need of repair
- Works for life of the vehicle

What vehicles have OBD today?

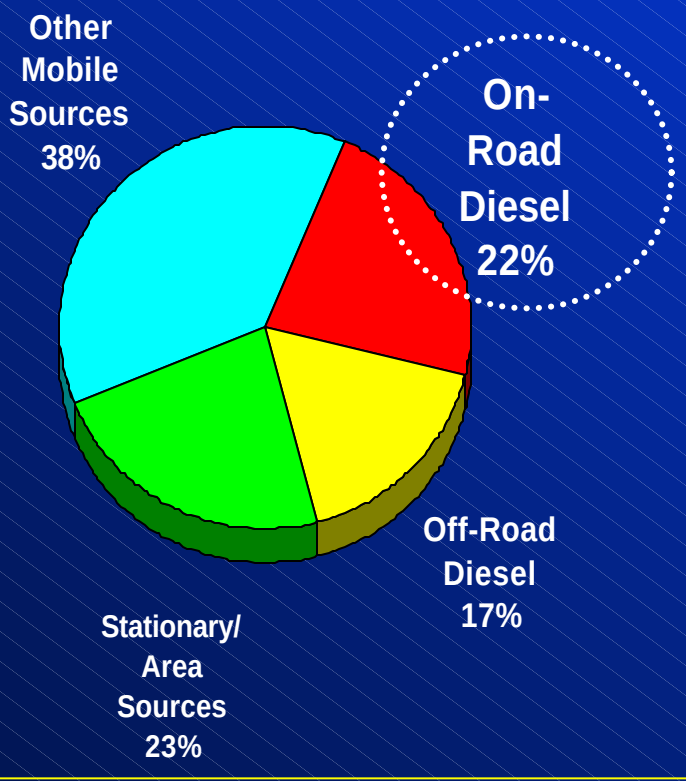
- All passenger cars, SUVs, and small trucks
  - Started in 1996 for gasoline and 1997 for diesel
- Over 120 million OBD II-equipped vehicles operating in the United States today

Why OBD for Heavy-Duty Vehicles?

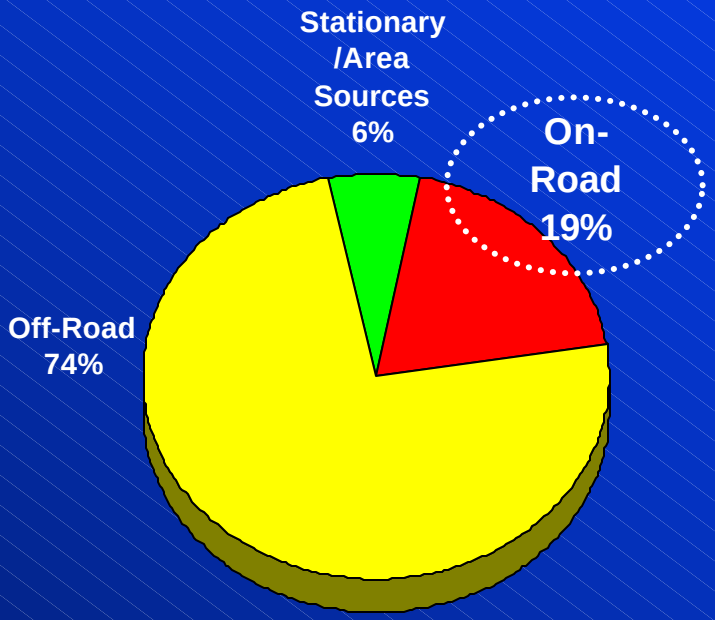
- Substantial source of emissions
- Engine is computer-controlled
- Emission controls complex, numerous
- Engines last a million miles

Heavy-Duty Diesel Emissions are Substantial

NOx

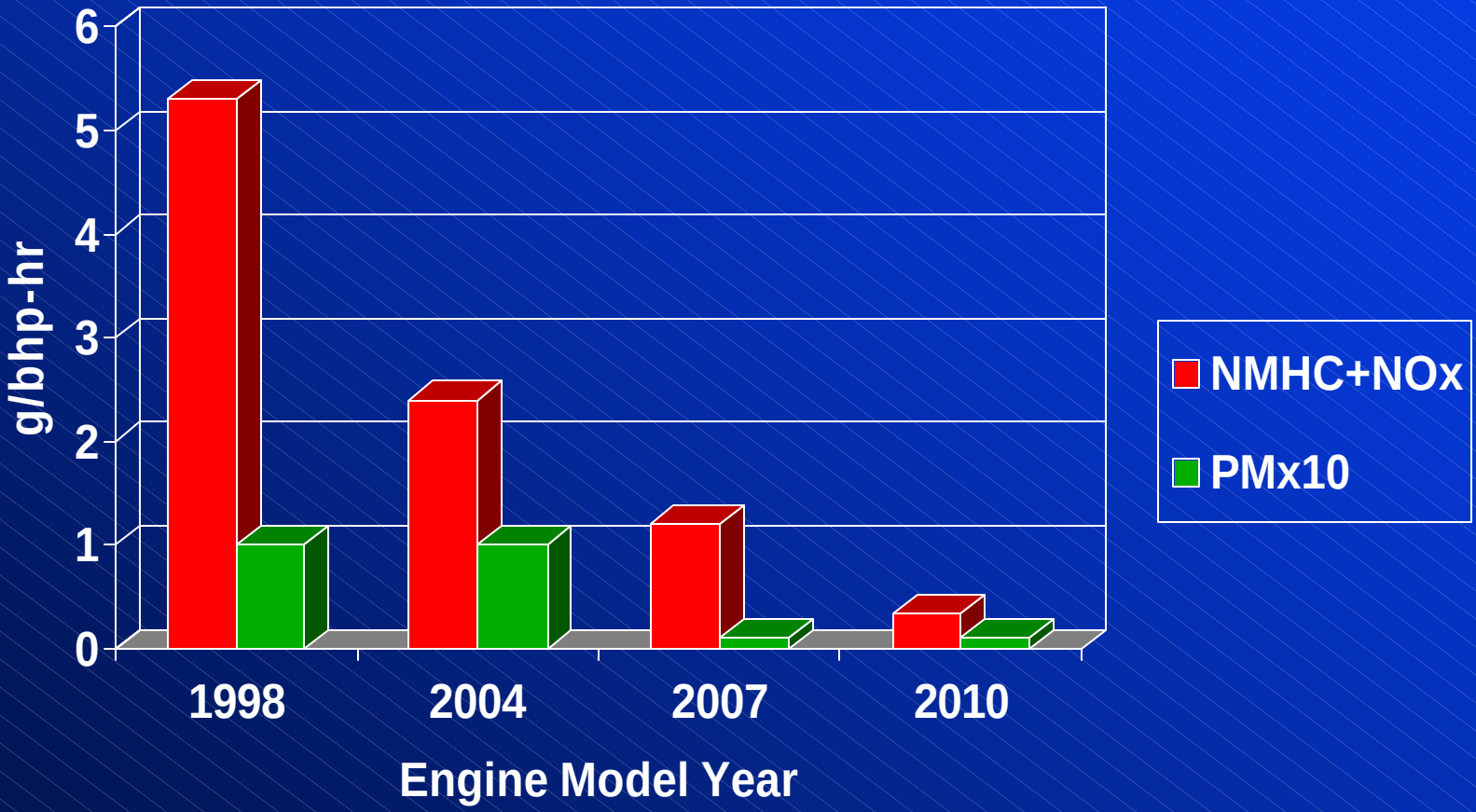


Diesel PM



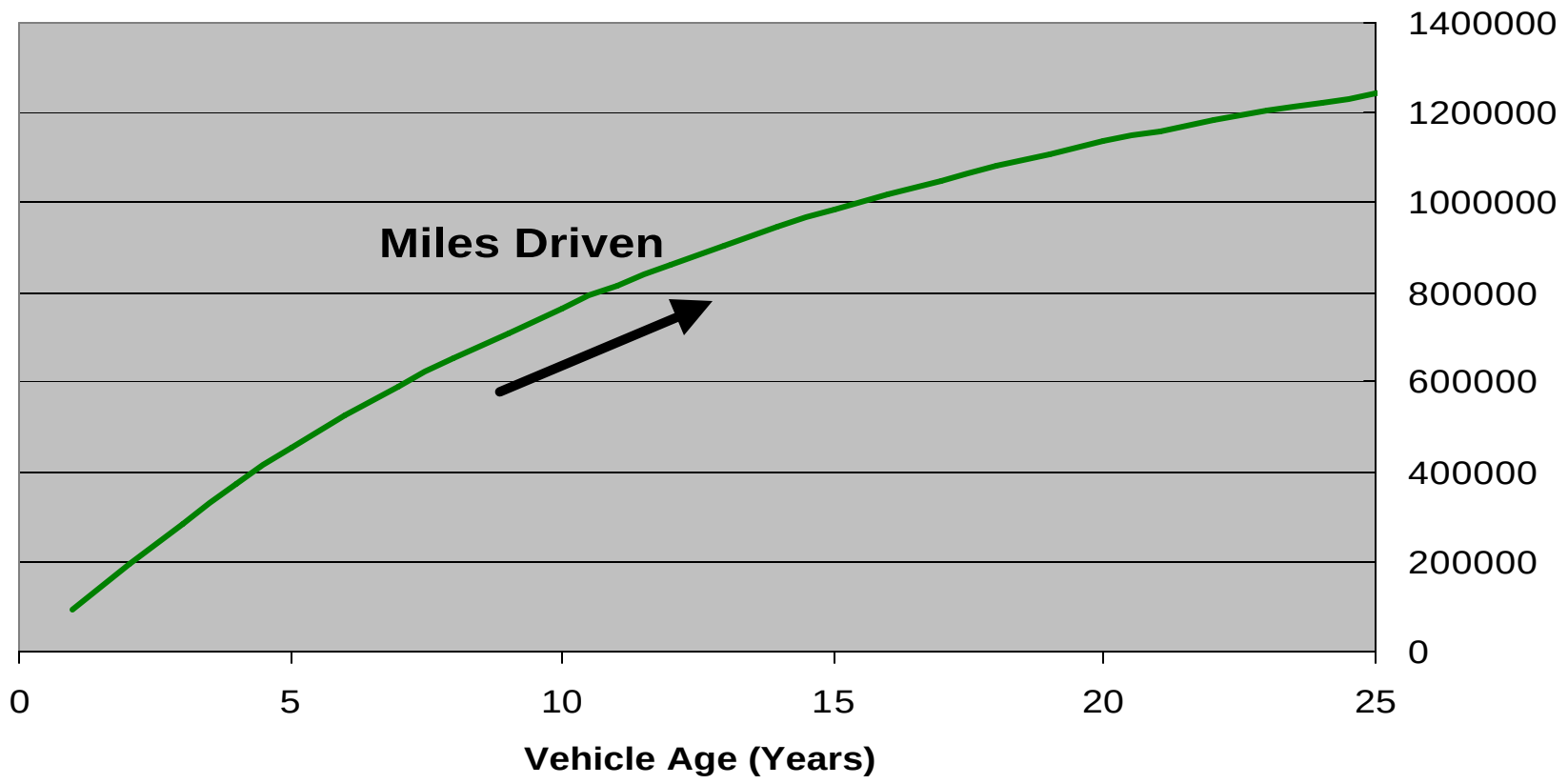
Source: EMFAC state-wide projection for 2010

Emission Standards Becoming More Stringent



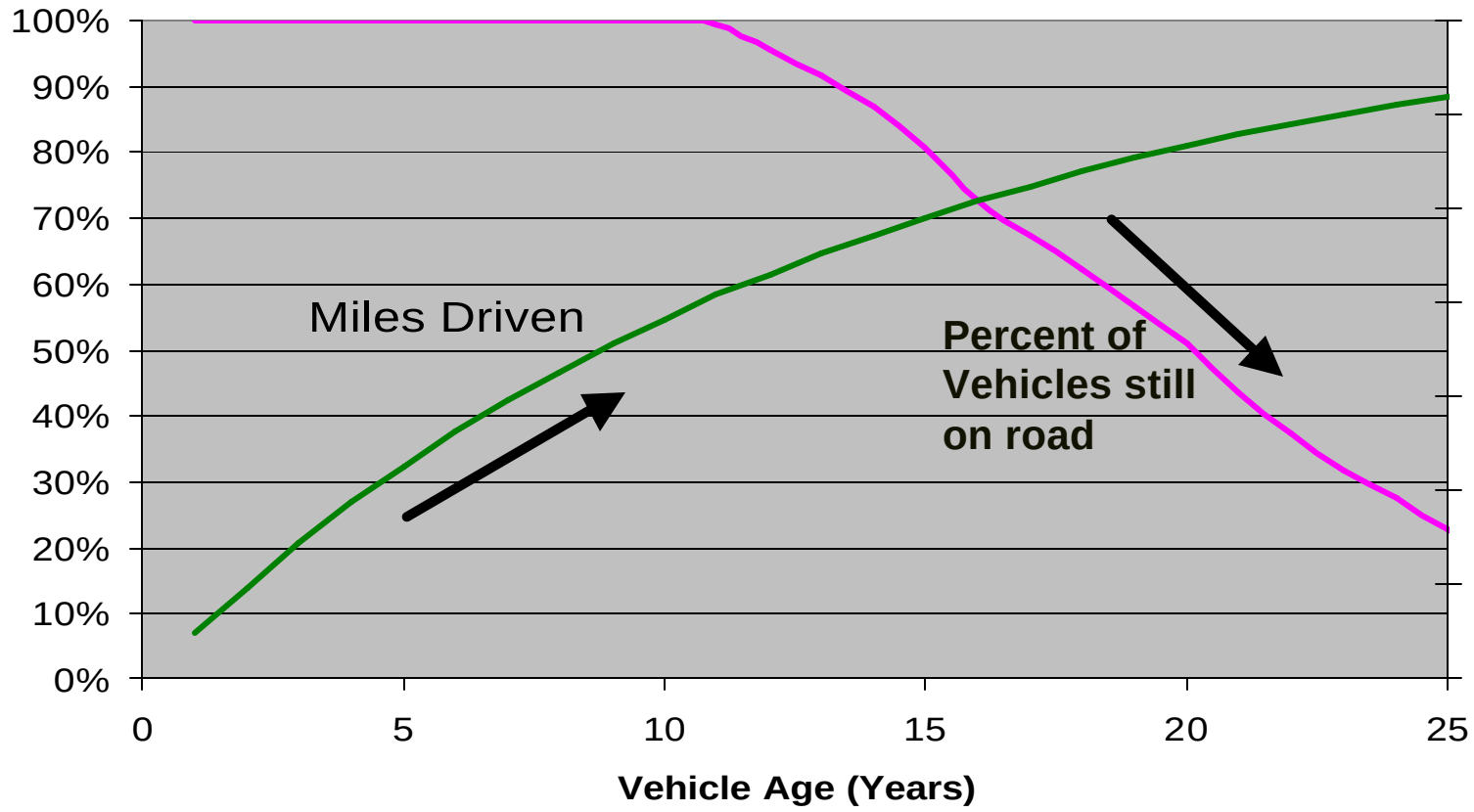
Heavy-duty diesel engines remain in the fleet a long time

Mileage accumulation of a 2010 MY HDD Truck



Heavy-duty diesel engines remain in the fleet a long time

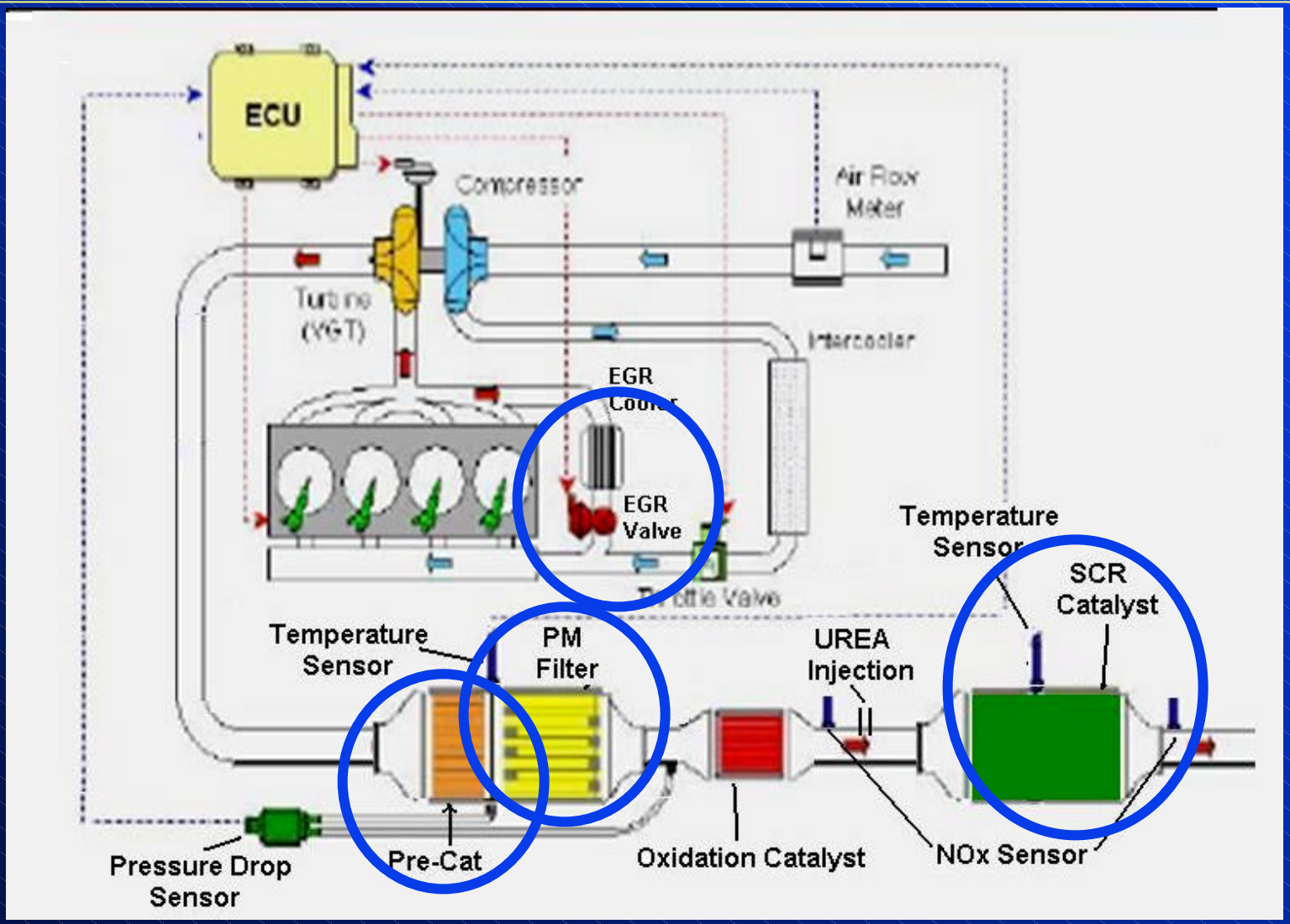
Life of the 2010 MY HDD Truck Fleet



Why wasn't OBD required for Heavy-Duty before now?

- Heavy-duty engines lag in using electronic engine controls and aftertreatment
- More stringent emission standards starting in 2007-2010 are changing that

Potential Technologies for HD Diesel Engines in 2010



Status of OBD for Heavy-Duty Engines

- First step taken by the Board in 2004
  - Requires Engine Manufacturer Diagnostic (EMD) system starting in 2007
  - Basic system not tied to emissions
- Staff directed to come back in 2005 with a comprehensive OBD proposal
- Today's proposal is for comprehensive OBD

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Proposed Regulation: Who is Affected & When?

- On-road heavy-duty engines
  - Delivery, trash trucks, buses, line haul, etc
  - Diesel and gasoline
- Starts in 2010
  - Fully phased-in 2016

Proposed Requirements

- Threshold monitoring
  - Warning light on when emissions increase X%
  - 8-10 per engine
- Non-threshold monitoring
  - Functional, rational, electrical
  - 75-100 checks per engine
- OBD testing and validation
  - Pre- and post-production; by engine manufacturer

Threshold Monitoring

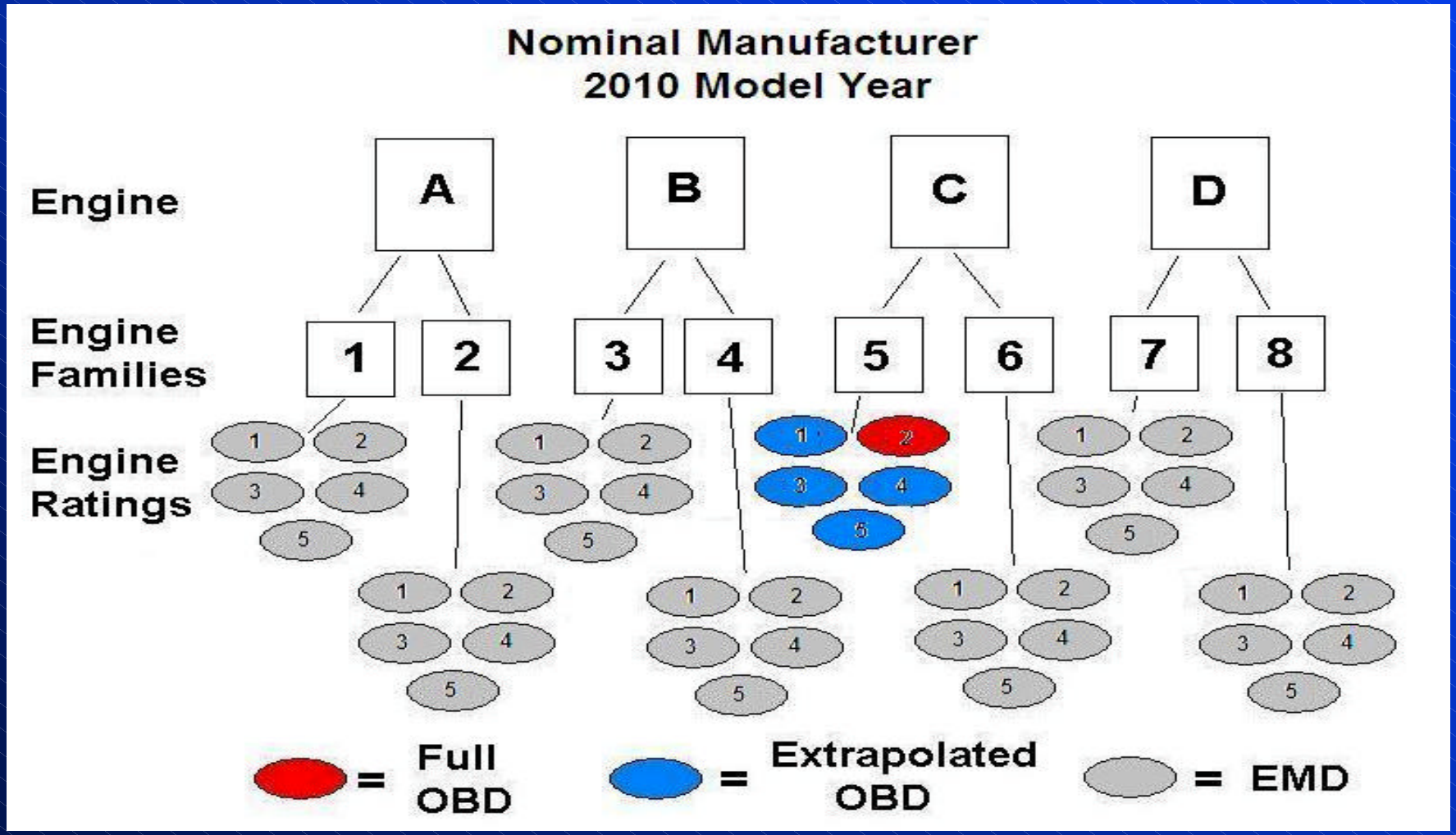
- Most important systems (8-10), e.g.
  - PM filter
  - EGR
  - NOx catalyst
  - Fuel System
- Thresholds (‘light on’) set at multiples of emission standard, e.g.

– PM filter	5X initially	3X later
– NOx catalyst	2.5X “	2X “
– Others (typical)	2.5X “	2X “

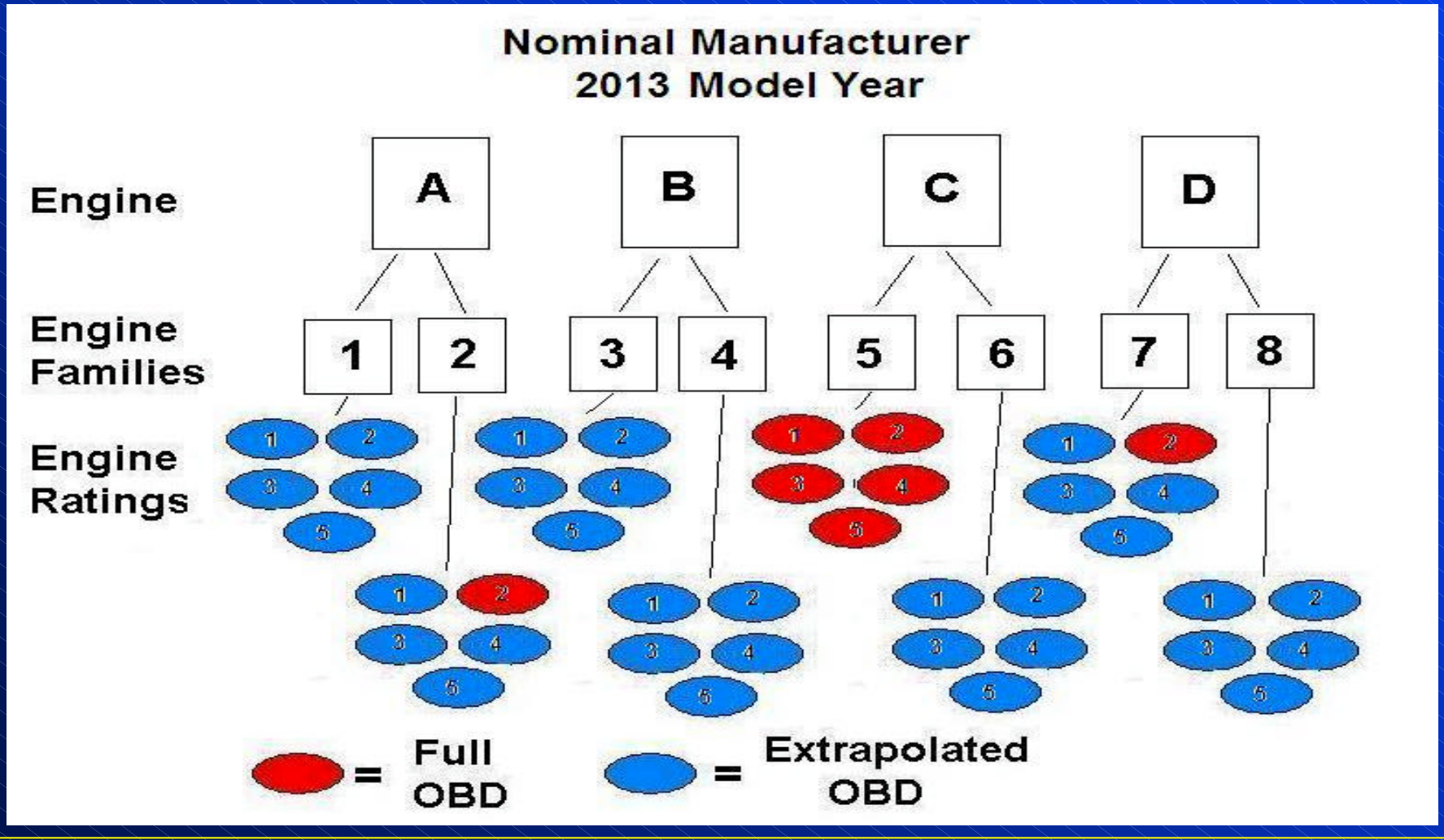
Phase-in

- Gradual, 6 year phase-in
  - Addresses workload; test facility limits
- Full system requirements
  - 2010: 1 rating of 1 engine family
  - 2013: All ratings of 2010 family, 1-2 more representative ratings
  - 2016 : All engines/ratings

Initial 2010 Phase-in of OBD



Partial 2013 Phase-in of OBD



Standardization

- Simplifies diagnosis
- Lower cost instrumentation (scan tools)
- Begins in 2013
  - –Eases implementation with truck builders

Reduced Compliance Liability (In-use)

- Extrapolated systems (no testing)
  - No penalty if threshold exceeded
- Fully compliant engines (tested)
  - No violation unless exceed double the threshold
  - Through 2018 model year
  - Example: NOx catalyst (2010): 5X standard

Gasoline Engine OBD Requirements

- Very similar to light- and medium-duty OBD II requirements
  - Similar emission control technology
- Evaporative system monitor is specific to gasoline engines

OBD Testing and Validation
Four Requirements

- Validate threshold calibration (engine emission test)
- Verify communication to scan tool (on truck)
- Verify that non-threshold monitors work (on truck)
- Verify that monitors run frequently (on truck)

Why Is Validation Testing Needed?

- OBD problems found post-production in passenger vehicles
  - Resulted in recalls, penalties
- Avoid these problems with HD OBD
  - Validation testing accomplishes this
- Volume of testing kept small
  - Spot check identifies problems

Validate threshold calibration (engine emission test)

- Problem: Threshold monitors calibrated incorrectly
- Fix: Require manufacturer to emission test engines to verify thresholds
- Proposal: Test 1-3 engines per year

Verify communication to scan tool

- Problem: Vehicles didn't comply with standardization
- Fix: Use test equipment to confirm the truck complies with the specifications
- Proposal: Test 10 different trucks per engine family per year starting in 2013

Verify that non-threshold monitors work

- Problem: Some monitors didn't work
- Fix: Spot-check a few production vehicles each year and verify each and every diagnostic works correctly
- Proposal: Test 1-3 trucks per year starting in 2010

Verify that monitors run frequently

- Problem: Monitor rarely runs in-use
- Fix: Require every vehicle to track monitor frequency and require manufacturers to report that data
- Proposal: Collect and report data from 15 trucks per grouping of similar vehicles

Remaining Issues:
Raised by Engine Manufacturers

- Technical Feasibility:
  - Monitoring of all failure modes of PM filter not possible
  - Thresholds for NOx catalyst not feasible
- OBD Testing and validation
  - Testing too burdensome

PM Filter Feasibility

- EMA Issue: Monitoring for all failures of the PM filter is not technically feasible
- Staff Response: PM filter is the most important PM emission control and monitoring method has been identified by staff
  - Comparison of backpressure at various exhaust flows to modeled engine out PM levels recommended
  - Manufacturers just now developing methodology
  - Authority in regulation to revise required failure modes and thresholds

NOx Catalyst Feasibility

- EMA Issue: Thresholds for NOx catalyst monitoring are not feasible
- Staff Response: NOx catalyst is one of the technologies being considered to achieve the 2010 NOx standards but the technology is not fully matured
  - Acceptability of the technology relies on a robust NOx sensor
  - Successful NOx catalyst monitoring would follow
  - NOx sensor location could be varied to accommodate best available sensor resolution and still achieve monitoring

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Cost Effectiveness of Proposed Requirements

- Limited additional increase in engine cost calculated: $132 per engine (<2% of price of engine)
  - Uses existing sensors
- Cost-effectiveness compares favorably with other recently adopted regulations:
  - $0.05/lb of NOx+NMHC and $13.08/lb of PM
  - Emission benefit derived from repair of emission-related malfunctions
  - Cost includes added engine costs plus repair costs

Summary

- Several emission controls being added to meet the stringent 2010 heavy-duty emission standards
- Proposed OBD regulation necessary to help maintain low emissions for entire life
- OBD is feasible and necessary
- OBD is cost effective