

OBD II Workshop

Proposed changes

Mobile Source Control Division
California Air Resources Board

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Discussion Points

- New technical requirements
 - Catalyst
 - Misfire
 - Evaporative leak check
 - Secondary Air and Cold Start Strategy
 - Air Conditioning system
 - Variable Valve Timing
 - DOR
 - Diesel Catalyst and PM trap

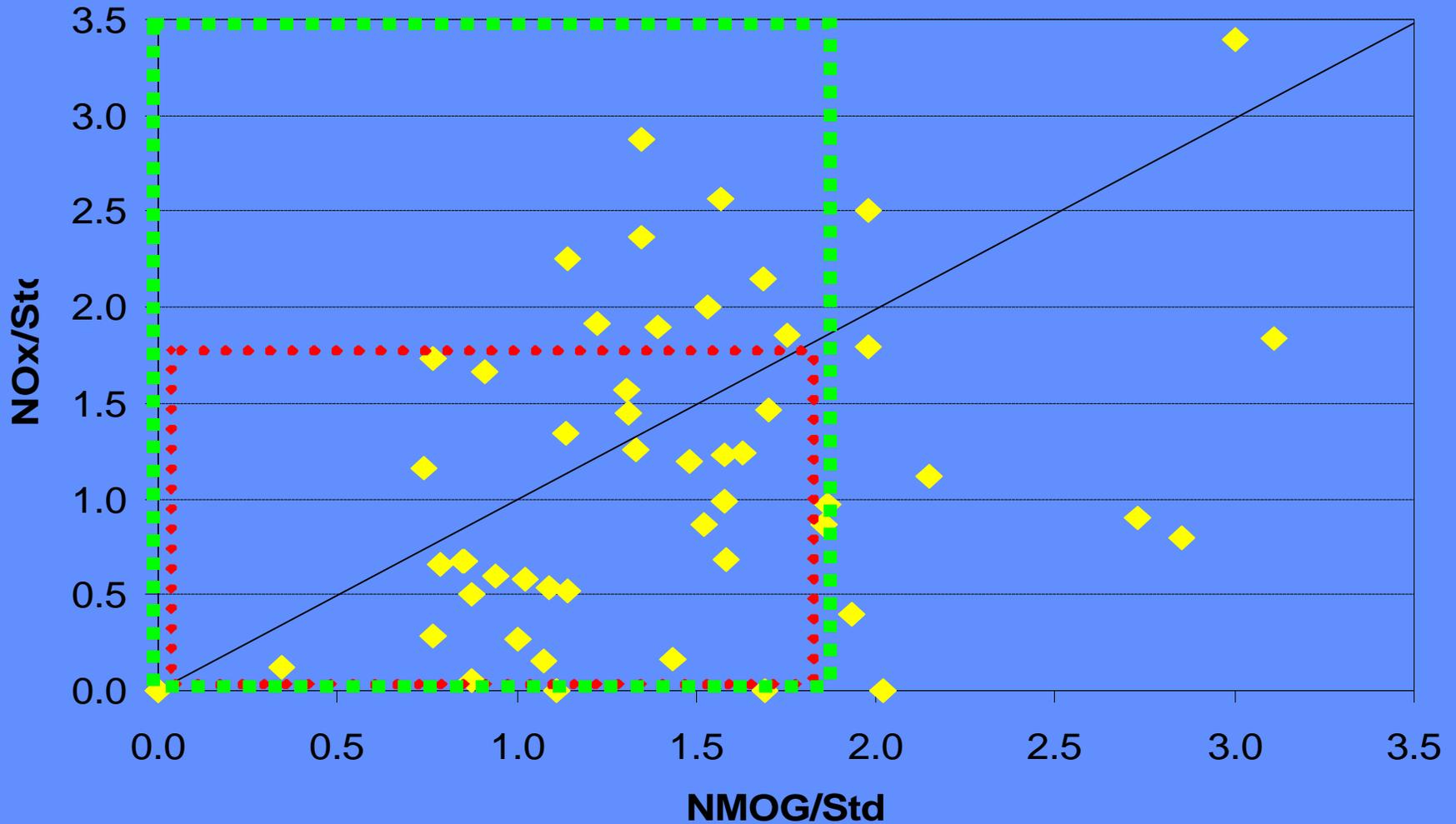
Discussion Points

- Standardization items for I/M and service technicians
- DDV Testing
- Production Vehicle Testing
- Rate-based monitoring
- Deficiencies
- Enforcement Provisions

NOx Catalyst Monitoring

- Currently, only HC conversion efficiency required to be monitored
- However, recent tailpipe standard reductions primarily target NOx (e.g. LEV II program)
- Current data indicates NOx emissions can vary from $< 1x$ to $> 3x$ standard when HC conversion efficiency threshold is reached

DDV data with "threshold" NMOG catalyst



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NOx Catalyst Monitoring Original Proposal

- Staff proposal would require 2007 and subsequent LEV II program vehicles to indicate a catalyst malfunction before HC or NOx conversion efficiency reaches 1.75x standard (2.5x for SULEVs)
- 2005 and 2006 LEV II program vehicles would use an interim threshold of 3.5x NOx standard
- Expect most manufacturers to meet requirement with refinement of existing oxygen storage monitoring method

NOx Catalyst Monitoring Revised Proposal

- Staff proposal would require 2007 and subsequent LEV II program vehicles to indicate a catalyst malfunction before HC or NOx conversion efficiency reaches 1.75x standard (2.5x for SULEVs)
- 30% of 2005 and 60% of 2006 ~~LEV II program~~ vehicles would use an interim threshold of 3.5x NOx standard
- Expect most manufacturers to meet requirement with refinement of existing oxygen storage monitoring method

Other Catalyst Changes

- Changes would require aging of both monitored and unmonitored catalysts when developing “threshold” catalyst calibrations on 2005 and subsequent LEV II program vehicles not using fuel shut-off during misfire
- Changes would allow monitored catalyst volume to have lower than 50% conversion efficiency if packaged/replaced with additional catalyst volume that, in total, exceeds 50% conversion efficiency



Misfire Monitoring

- Changes would identify more specifically what type of disablements are generally approved by ARB
- Changes would identify what type of disablements will no longer be allowed in 2005 and subsequent model years
 - (A/C compressor cycling, A/T gear shifts, idle to off-idle transitions, load or speed transients less severe than US06 cycle, etc.)

Misfire Monitoring (cont.)

- Clarify for 2005 and subsequent vehicles, conditions when individual vs. multiple cylinder fault codes should be stored
- Allow disablement at engine start for no longer than 2 crankshaft revolutions after meeting the engine start definition
- Set minimums of 1% and 5% for FTP and catalyst damage misfire levels, respectively
- Allow down to 75% probability of detection during cold start strategy operation



Evaporative System Monitoring

- Currently, purge valve functional check, 0.040” leak detection, and 0.020” leak detection required on all 2003 model year vehicles
- Engine-off diagnostics that do not meet a conventional “two-in-a-row” definition not accounted for very well.

Evaporative System Monitoring (cont.)

- Proposal would more explicitly allow non-conventional (e.g., engine-off) diagnostics
- Proposal would provide further specification on the shape of the orifice
- Intent of proposal to allow manufacturers with frequent 0.020" monitors to conduct "gross leak" (>0.090") in lieu of 0.040" monitoring

Evaporative System Monitoring (cont.)

- Regarding frequency of 0.020" monitor, many manufacturers have made tremendous improvements from the 2000 to 2002 model year
- While very restrictive enable conditions were originally necessary, further refinements now appear to allow much broader conditions
- Accordingly, proposal does not account for as severely constrained monitoring conditions as originally adopted in 1996

Evaporative System Monitoring (cont.)

Proposal:

- Detect 0.040" in two weeks
- Detect 0.020" in three weeks
- Perform 0.090" in lieu of 0.040" if and only if:
 - Detect 0.020" in two weeks
 - Detect 0.090" in one week





Secondary Air and Cold Start Strategy Monitoring

- Vast majority of emissions occur at cold start
- Many emission control components and strategies focused on accelerating catalyst warm-up
- Currently, these components are generally monitored for proper performance only after the vehicle is warmed-up

Secondary Air System Original Proposal

- Changes would require 2007 and subsequent LEV II program vehicles to monitor the secondary air flow rate during cold start for malfunctions that cause emissions to exceed 1.5x standard (2.5x for SULEV)
- 2005 and 2006 LEV II program vehicles would be required to perform a functional check (e.g., flow or no flow) during cold start and a 1.5x standard flow rate check later in the same driving cycle
- Most likely monitoring method appears to use a wide-range A/F sensor (in lieu of a conventional O₂ sensor)

Secondary Air System Revised Proposal

- Changes would require ~~2007~~ 2008 and subsequent ~~LEV II~~ program vehicles to monitor the secondary air flow rate during cold start for malfunctions that cause emissions to exceed 1.5x standard (2.5x for SULEV)
- ~~2005 and 2006~~ and 2007 LEV II program vehicles would be required to perform a functional check (e.g., flow or no flow) during cold start and a 1.5x standard flow rate check later in the same driving cycle

Cold Start Strategy Monitoring Original Proposal

- Changes would require 2005 and subsequent LEV II program vehicles to monitor the key control and feedback parameters during cold start for malfunctions that cause emissions to exceed 1.5x standard (2.5x for SULEV)
- Most likely monitored parameters are engine speed, idle air mass flow, and commanded spark timing

Cold Start Strategy Monitoring Revised Proposal

- Changes would require ~~2005 and subsequent LEV II program~~ 30/60/100% in 2006/07/08 vehicles to monitor the key control and feedback parameters during cold start for malfunctions that cause emissions to exceed 1.5x standard (2.5x for SULEV)

Cold Start Strategy Monitoring (cont.)

- Only requires malfunction detection when a single component malfunction or deterioration can cause emissions to exceed 1.5x standard (as opposed to a total system monitor).
- Allows manufacturers to calibrate to 1.5x standard on a “representative” vehicle and carry-over the thresholds to other vehicles (reducing calibration burden).



Air Conditioning System Component Monitoring

- Currently, all electronic powertrain components required to be monitored under comprehensive components
- Some are concerned this may currently include some A/C components
- In general, staff does not believe it should be necessary to monitor A/C components under the OBD II requirements

Air Conditioning System Component Monitoring (cont.)

- Proposal would exclude electronic A/C components from monitoring unless:
 - Failure causes emissions to exceed 1.5x applicable standard (FTP for A/C physically off malfunctions, SC03 for A/C physically on malfunctions), or
 - Failure effectively disables any other OBD II monitor
- Based on experience to date, it appears unlikely that any A/C system components will require monitoring
- 30/60/100% phase-in in 2006/07/08 vehicles



Variable Valve Timing (VVT) System Monitoring

- Increasing trend in industry to use some form of VVT system for improved performance without emission increase
- Essentially performs as an EGR system
- Currently, the individual VVT components are monitored but the overall system performance is not monitored to a tailpipe emission level

Variable Valve Timing (VVT) Proposal

- Changes would require 2005 and subsequent LEV II program vehicles to monitor system performance to 1.5x standards (2.5x SULEV)
- Position errors and slow response malfunctions would need to be detected
- Most systems already monitored for these failure modes but may need to be recalibrated to meet the emission thresholds



Direct Ozone Reduction (DOR) System Monitoring

- Some new emission reduction technologies have evolved that directly reduce ozone
- Examples include specially coated radiators, etc. (e.g., PremAir®)
- Requires unique solution because component does not directly affect vehicle tailpipe or evaporative emissions nor any other OBD II system monitors

Direct Ozone Reduction (DOR) System Monitoring (cont.)

- CARB policy was formalized in MAC No. 99-06 which outlined emission credits and monitoring requirements
- Assigns different levels of emission credit (or “offset”) depending on monitoring capability (i.e., functional vs. performance)
- Optical, resistance, and ozone sensor monitoring technologies are fairly far into development

Direct Ozone Reduction (DOR) System Monitoring (cont.)

- Changes would simply incorporate MAC policy officially into regulation
- Would also allow “half-credit” for 2003 and 2004 without any monitoring
- Uniqueness of component (e.g., deterioration does not affect tailpipe/evaporative emissions or other monitors) merits special handling
- “Offset” would also be carried over to other HC-based standards (e.g., 1.5x HC std + “offset”)



Monitoring Thresholds

- Many OBD II monitors calibrated to 1.5x FTP emission levels
- As the industry transitions to lower emission levels in the LEV II program, some have questioned the need for revisions to the 1.5x threshold

Monitoring Thresholds (cont.)

- Based on systems certified to date, staff does not believe LEV II and ULEV II standards necessitate special thresholds
 - LEV II/ULEV II have identical HC and CO standards as LEV I/ULEV I and only have lower NO_x
 - NO_x is generally only the limiting pollutant for EGR, fuel system, and potentially O₂ sensor response
- Proposed regulation does, however, retain flexibility to revise the thresholds if later found to be necessary

SULEV Monitoring Thresholds

- Proposed revisions do increase the threshold for SULEV vehicles to 2.5x standard in lieu of 1.5x standard
 - Accounts for increased uncertainty of today's emission measurement technology at SULEV levels
 - And, based on currently certified systems, appears to allow essentially identical levels of individual component deterioration as ULEV I levels.



Diesel Vehicle Monitoring Changes

- Currently, diesel vehicles <14,000 lbs GVWR required to have OBD II systems but no catalyst or particulate matter (PM) trap monitoring required
- Trend in industry towards SUV diesel engines
- Lower future tailpipe and fuel standards will increase reliance on proper performance of catalysts and PM traps

Diesel Catalyst Monitoring for MDVs

- Changes would require 2007 and subsequent MDVs to monitor catalysts for 1.5x standard failures of HC, NO_x, or PM
- If failure of component cannot cause 1.5x standard emission levels, functional monitoring required
- However, low efficiency catalysts (<30%) would not require any monitoring until 2009
- NO_x sensor looks like primary monitoring technology

Diesel Catalyst Monitoring for MDVs Interim Proposal

- 2005 and 2006 MDVs only required to detect 1.5x standard NOx or PM failures (not HC)
- If failure of component cannot cause 1.5x standard emission levels, no monitoring required (instead of functional monitoring)

Diesel PM Trap Monitoring for MDVs

- Changes would require 2007 and subsequent MDVs to monitor PM traps for 1.5x standard failures
- If failure of component cannot cause 1.5x standard emission levels, only functional monitoring required
- Exhaust backpressure sensor appears to be likely monitoring technology
- Consistent with OBD regs [(a)(1.10)] that currently require “other emission control devices” to be monitored

Diesel Catalyst Monitoring for LDVs

- Changes would require 2004 and subsequent LDVs to monitor catalysts for 1.5x standard failures of HC, NOx, or PM
- If failure of component cannot cause 1.5x standard emission levels, functional monitoring required
- However, low efficiency catalysts (<30%) would not require monitoring at all until 2009
- NOx sensor looks like primary monitoring technology

Diesel PM Trap Monitoring for LDVs

- Changes would require 2004 and subsequent LDVs to monitor PM traps for 1.5x standard failures
- If failure of component cannot cause 1.5x standard emission levels, only functional monitoring required
- Exhaust backpressure sensor appears to be likely monitoring technology
- Consistent with OBD regs [(a)(1.10)] that currently require “other emission control devices” to be monitored



Standardization changes

- An essential part of OBD II is the standardization requirements
- Includes items like scan tool communication, connector, fault codes, etc.
- Based on feedback from the field and I/M programs, global standards, and technology improvements, updates to current standardization requirements are warranted.

Changes to help I/M programs

- EPA recently modified the requirements for state I/M programs
- Inspection of the OBD II system a necessary element and can be done in-lieu of any tailpipe emission testing
- Accordingly, increasing focus on the performance of OBD II systems and ease of incorporation into an I/M program

Modifications to help I/M programs (cont.)

- EPA's decision considered the results of several test programs across the nation
- While the decision supports the performance of the OBD II system in identifying vehicles in need of emission repairs, plenty of room for improvement was identified in areas to ease implementation into an I/M program

Readiness Status

- One area for improvement identified was readiness status/codes
- Conceived primarily to identify recent attempts to erase the fault memory of the vehicle
- Field experience has shown a higher than expected number of vehicles that indicate one or more monitors has not run

Readiness Status (cont.)

- Vehicles not ready due to:
 - Incorrect or overly restrictive software logic
 - Recent repairs
 - Overly restrictive monitoring conditions
 - Driver habits
 - Ambient conditions

Readiness Status (cont.)

- Proposal requires faster, consistent setting to complete on passing vehicles
- Additional data available via scan tool to distinguish recent fault code clearing from driver pattern or ambient condition situations
- Additional data (via scan tool and service info) to help technicians set readiness status in post-repair situations
- Allow MIL to “blink” readiness status to vehicle owner without using a scan tool



Electronic access to VIN

- One item commonly collected during an I/M check is the VIN
- Requires entry by the inspector manually or via bar code scanning
- Access to the VIN through the OBD II data connector simplifies and automates data collection
- Proposal requires access on all 2005 and newer vehicles

Connector location

- Manufacturers are currently provided abundant latitude in the location of the OBD II data link.
- Pilot I/M programs have demonstrated the need for further restrictions on connector location
- Proposal further confines connector to driver's footwell

MIL bulb check

- All I/M programs continue to use a visual MIL check as part of the inspection
- Proposed changes require MIL to remain on for a minimum of 15-20 seconds during bulb check to help technicians properly verify bulb check
- Proposal clarifies that MIL command status (via the scan tool) should be “OFF” during bulb check to avoid mistakenly failing cars in I/M

Communication Protocol Testing

- OBD II vehicles required to use one of three allowable “generic” communication protocols
- Some problems have been encountered during scan tool or I/M equipment design
- Many due to inappropriate interpretations of SAE and ISO standards or misunderstandings
- Result is some vehicles are more difficult to talk to than others

Communication Protocol Testing (cont.)

- Changes would require manufacturers to test representative vehicles at the end of the assembly line
- CARB would contract out to have custom test equipment built exactly to ISO and SAE standards
- Vehicles unable to communicate with custom test equipment would require corrective action
- Should minimize chance of future problems resulting in vehicles incompatible with I/M check

Repair Information Changes

- One consistent message received from the field is that technicians want access to more and more information for repair
- While OBD II has put more information in the hands of independent technicians than ever before, even more could be done.
- EPA, California legislators, and CARB have all taken steps to make more info available

Access to Information

- Under a separate rulemaking, CARB is adopting a service information regulation
- Will require access to service info via Internet
- Will dictate that some information be made available such as monitoring conditions, drive cycles to execute monitors, etc.
- Due to Board Hearing timing differences between service info and OBD II regulation, service info provisions must remain in OBD II with “escape” clause once service info is adopted

Additional Scan Tool Data

- Based on feedback from the field, 12-18 additional parameters proposed to aid in diagnosis and repair of vehicles
- Further specification added to two parameters (TPS and Load) to clean-up discrepancies in the way they are calculated and reported
- Proposal requires the new parameters on all 2005 and newer vehicles.

New Communication Protocol

- Allowance of a new protocol to keep pace with the developments on vehicles regarding communication between modules
- Controller Area Network (CAN) will allow faster data update rates and provide more information to technicians
- Will be allowed on 2003 and newer vehicles
- Proposed changes make it the only protocol allowed on 2008 and newer vehicles

Further Standardization

- Changes provide more direction to manufacturers for using generic (P0xxx) fault codes instead of manufacturer-specific
- Changes require consistent storing and erasing of pending fault codes on all 2005 and subsequent model year vehicles



Production Vehicle Evaluation Testing

- Essentially, three new “verification” test sequences required on production vehicles
- First verifies basic OBD II interaction with a generic scan tool (simulates an I/M OBD test)
- Second verifies, in detail, that every monitor functions as designed on a production vehicle
- Third requires the collection of in-use monitoring performance data from actual in-use cars within the first six months after production starts

Verification of Standardized Functions

- Requires manufacturer to verify basic interaction with a generic scan tool on one vehicle per representative calibration
- Would take effect one year after ARB and/or industry create a benchmark piece of software/hardware to be used by all manufacturers (likely 1-3 years from now)
- Should take less than 5 minutes to complete the test on a single vehicle

Verification of Monitors

- Required on one vehicle per DDV test group (total of 1-3 per manufacturer)
- Requires every single monitor to be “exercised” with a fault present and verify fault code is set
- Required to be completed within 120 days after production starts
- Estimates for test time range from 2-5 weeks per car.

Collection of In-use data

- Requires manufacturers to collect data from a small sample of actual in-use vehicles in the first six months
- Data required to be collected for every test group (but number of vehicles per test group could be as few as 20-30)



In-use Monitoring Conditions

- Currently, manufacturers required to seek CARB approval of the monitoring conditions
- Conditions must ensure robust monitoring, occur frequently in-use (“real world”), and generally, occur on the FTP or Unified cycle
- Manufacturers requested this flexibility to determine the conditions “case-by-case” when the regulation was originally adopted

In-use Monitoring Conditions (cont.)

- With this flexibility, the vast majority of manufacturers have developed monitoring conditions that achieve all three requirements
- Others, however, have asked for increased clarity regarding in-use performance
- Still others have felt performance on the FTP alone should be “good enough”

In-use Monitoring Conditions (cont.)

- This demand for a more precise in-use performance standard has led to CARB consideration of two concepts:
- Standardized monitoring conditions
- “Rate-based” monitoring conditions

Standardized Monitoring Conditions

- CARB would define the precise monitoring conditions for monitors
- Would ensure consistent performance by all manufacturers, simplify approval process, and likely provide adequate in-use performance
- Would require major redesign by most manufacturers and put burden of in-use performance on CARB staff

Standardized Monitoring Conditions (cont.)

- Most significantly, this concept does not allow manufacturers much room to optimize or “tweak” monitors for each make/model.
- Development of this concept essentially halted because of inherent problems with creating common conditions across all manufacturers.

“Rate-based” Monitoring Conditions

- Manufacturers would continue to select monitoring conditions but each vehicle would contain “counters” to track monitoring frequency in-use
- Manufacturers would be held liable for maintaining a minimum in-use frequency
- Would answer the bottom line question- How often does this monitor run?

“Rate-based” Monitoring Conditions (cont.)

- Appears to be the best compromise between providing flexibility to manufacturers to optimize conditions and maintaining consistent and adequate in-use performance
- Ensures all manufacturers held to the same performance standard
- Provides an objective evaluation criteria to be used by ARB and industry

“Rate-based” Proposal

- Vehicles will keep track of “numerators” and “denominators” for catalyst, evap, O₂, EGR, and secondary air
- Numerator will keep track of how many times a particular monitor has run
- Denominator will keep track of how many times a vehicle has been operated
- Ratio of the two will indicate how often monitor is running.

Numerator Proposal

- Numerator would increment by one each time the monitor met all the conditions necessary to detect a *malfunction*

Denominator Proposal

- Denominator would increment by one each time the vehicle met certain “generic” drive cycle conditions
 - Trip > 10 minutes
 - Elevation < 8000 feet
 - Ambient temp > 20 F
 - Vehicle operation above 25 mph for > 5 minutes
 - At least one idle of \geq 30 seconds

Denominator Proposal (cont.)

- Secondary air monitor denominator would also add:
 - Secondary air commanded on for >10 secs
- Evap leak check monitor denominator would instead add:
 - $40\text{ F} \leq \text{Ambient temp} \leq 95\text{ F}$ for 10 minutes
 - Cold start defined as:
 $40\text{ F} \leq \text{ECT at start-up} \leq 95\text{ F}$ and
 $(\text{ECT at start-up} - \text{IAT at start-up}) \leq 12\text{ F}$

In-use Monitoring Performance Goals

- Design target is a MIL in two weeks for 90% of the in-use vehicles
- Staff's best estimate at this time is that a ratio (Numerator/Denominator) of ≥ 0.25 would equate to a MIL in two weeks for 90% of the vehicles

In-use Monitoring Performance Original Proposal

- Proposal required 50/75/100% phase-in of numerators/denominators in 2005/06/07 with a design goal of 0.25 for the ratio
- Proposal also required recall if ratio was <0.10 and possible recall if ratio was between 0.1 and 0.25

In-use Monitoring Performance Revised Proposal

- Proposal requires 100% phase-in of numerators/denominators in 2005 with a design goal of 0.25 for the ratio
- Proposal would eliminate recall for ratios >0.1 for 2005 and 2006 and make recalls possible (not mandatory) for ratios from 0.0 to 0.1
- From 2007 on, mandatory recall for ratios < 0.1 and possible for ratios between 0.1 and 0.25

In-use Monitoring Performance

- Obviously, proposal will likely require revisions to “fine-tune” the required ratio as data is collected in the first few years
- Ratios may need to be increased or decreased to better correlate with the design goal of MIL illumination in two weeks for 90% of the vehicles
- For instance, 0.25 for secondary air and evap monitor denominators is very likely too low and will need to be increased

In-use Monitoring Performance

California Environmental Protection Agency





