US LIGHT DUTY OBD PROGRAM UPDATE

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California Air Resources Board

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SAE INTERNATIONAL

California Environmental Protection Agency
Air Resources Board

Outline

- **Rulemaking Timeline**
- **Update on Proposed Changes**
- **Case Study: Monitor Calibration**
- **Case Study: OBD in SmogCheck**

Regulatory Update Schedule

45-Day Notice Package

- Publication date: August 4, 2015
  - Includes notice, staff report, and proposed regulatory language

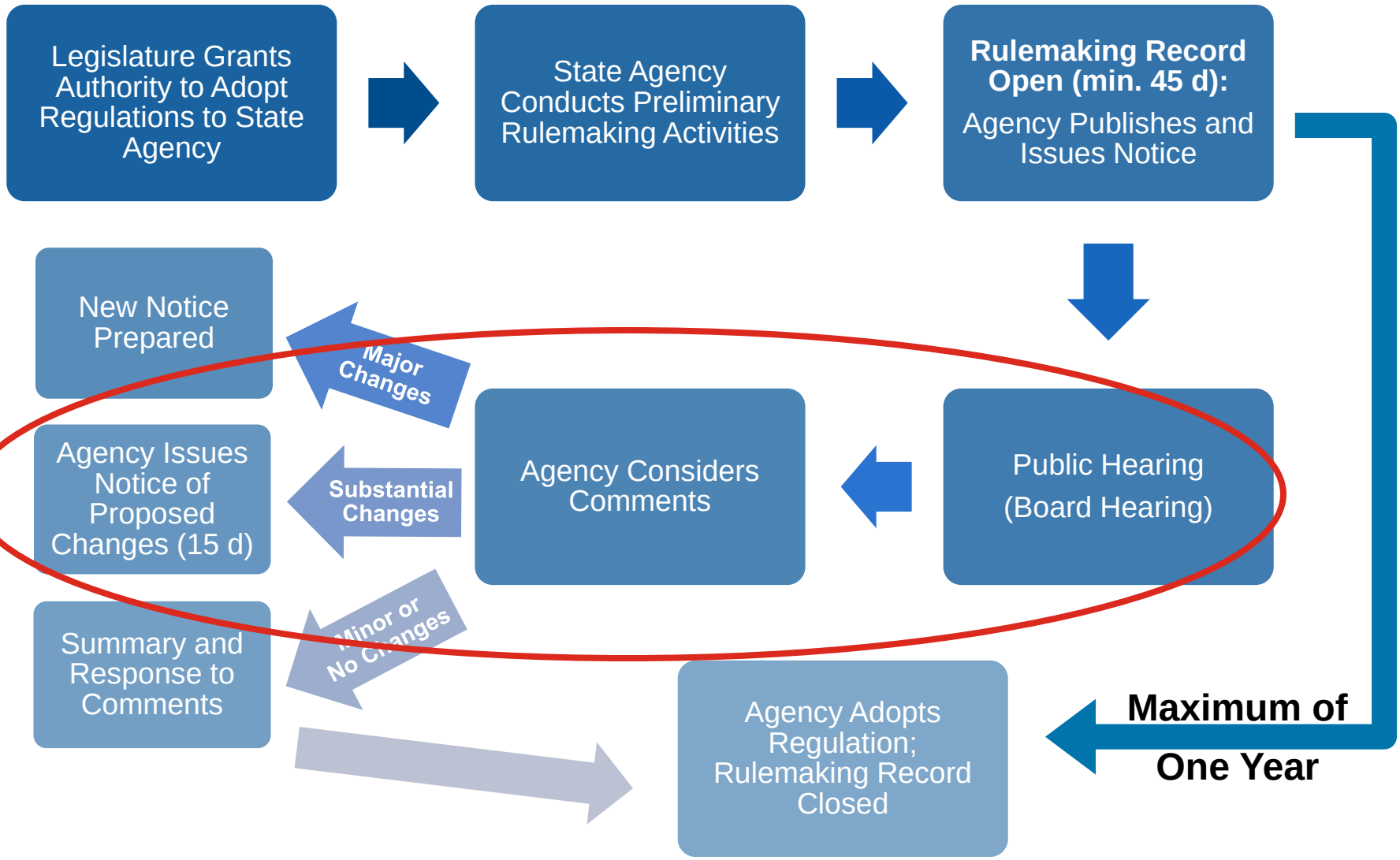
Board Hearing

- Scheduled date: September 24-25, 2015
- Location: Sacramento (change from Diamond Bar)
  - Staff will propose 15 day changes in response to stakeholder concerns

Final Statement of Reasons

- Will include final 15 day changes (minimum 15 day public comment period)
- Must be submitted to OAL within one year from 45 day notice publication

Rulemaking Process



Proposed LEV III Thresholds for Gasoline

Exhaust Standards		Monitor Thresholds (except catalyst monitor)				Catalyst Monitor Threshold
Vehicle Type	**Vehicle Emission Category**	**NMOG + NOx Mult.**	**CO Mult.**	**PM Mult.**	**PM THD (mg/mi)**	**NMOG + NOx Mult.**
Passenger Cars, Light-Duty Trucks, and Chassis Certified Medium-Duty Passenger Vehicles	LEV160	1.50	1.50	N/A	17.50[1]	1.75
	ULEV125					
	ULEV70	2.00[4]				2.00[4]
	ULEV50					
	SULEV30	2.50[5]	2.50			2.50
	SULEV20					
Chassis Certified Medium-Duty Vehicles (except Medium-Duty Passenger Vehicles)	All Medium-Duty Vehicle Emission Categories	1.50	1.50	1.50[2]	17.50[3]	1.75

1. Applies to 2019+MY LEV III vehicles
2. Applies to 2019+MY LEV III vehicles not included in the phase-in of the PM standards set forth in title 13, CCR section 1961.2(a)(2)(B)2
3. Applies to 2019+MY LEV III vehicles included in the phase-in of the PM standards set forth in title 13, CCR section 1961.2(a)(2)(B)2
4. Have an interim in-use threshold of 2.50 the first three years a ULEV50 or ULEV70 is certified through 2019MY.
5. SULEV20 vehicles may use a 3.25 threshold for the first 3 years a vehicle is certified up to the 2025MY.

Proposed LEV III Thresholds for Chassis Certified Diesels

Exhaust Standards		Monitor Thresholds[1]			Aftertreatment Monitor Thresholds[2]			DPF Filtering Performance Monitor Threshold			
Vehicle Type	Vehicle Emission Category	NMOG + NOx Mult.	CO Mult.	PM Mult.	NMOG + NOx Mult.	CO Mult.[3]	PM Mult.	NMOG + NOx Mult.[3]	CO Mult.[3]	PM Mult.	PM THD (mg/mi)
Passenger Cars, Light-Duty Trucks, and Chassis Certified Medium-Duty Passenger Vehicles	LEV160	1.50	1.50	2.00	1.75	1.50	2.00[3]	1.50	1.50	N/A	17.50
	ULEV125										
	ULEV70	2.00[6]			2.00[6]			2.00[6]			
	ULEV50										
	SULEV30	2.50[7]	2.50		2.50[7]	2.50		2.50[7]	2.50		
	SULEV20										
2016MY-2018MY Chassis Certified Medium-Duty Vehicles (except Medium-Duty Passenger Vehicles)	All Medium-Duty Vehicle Emission Categories	1.50	1.50	2.00	1.75	N/A	N/A	N/A	N/A	1.75[4]	17.50[5]
2019+MY Chassis Certified Medium-Duty Vehicles (except Medium-Duty Passenger Vehicles)	All Medium-Duty Vehicle Emission Categories	1.50	1.50	1.50[4] or 2.00[5]	1.75	1.50	1.50[4] or 2.00[5]	1.50	1.50	1.50[4]	17.50[5]

1. Applies to (f)(3.2.5), (f)(4)-(f)(7), (f)(9.2.2), (f)(12)-(f)(13)
2. Applies to (f)(1)-(f)(2), (f)(8), and (f)(9.2.4)(A)
3. Applies to 2019+MY LEV III Vehicles
4. Applies to vehicles not included in the phase-in of the PM standards set forth in title 13, CCR section 1961.2(a)(2)(B)2
5. Applies to vehicles included in the phase-in of the PM standards set forth in title 13, CCR section 1961.2(a)(2)(B)2
6. Have an interim in-use threshold of 2.50 the first three years a ULEV50 or ULEV70 is certified through 2019MY.
7. SULEV20 vehicles may use a 3.25 threshold for the first 3 years a vehicle is certified up to the 2025MY.

Proposed LEV III Thresholds

Other amendments related to thresholds

- ULEV70 and ULEV50 have an interim in-use threshold of 2.50 for the first three years a ULEV70 or ULEV50 vehicle is certified through 2019MY
- SULEV20 vehicles may use a 3.25 threshold for the first 3 years a vehicle is certified up to the 2025MY
- Proposing to require manufacturers to provide CO emission data with all gasoline catalyst monitor demonstration data starting with the 2017MY
- Proposing to starting in 2017MY gasoline vehicles to include PM emission data for all OBD demonstration tests.
  - 2017-2018MY gasoline vehicles meeting the LEVIII 3 mg/mi PM standard
  - All 2019MY+ gasoline vehicles

Proposed LEV III Thresholds

Recent Developments

- EPA Tier 3 program allows the interim BIN110 and BIN85 through 2019.
- ARB proposed 15-day change:

LEV III Gasoline BIN110 and BIN85 OBD Thresholds			
	(NMOG + NOx)	CO	PM THD
Monitors (ex. Catalyst)	1.85x	1.5x	17.5 g/mi[1]
Catalyst Monitor	2.0x	N/A	N/A

LEV III Diesel BIN110 and BIN85 OBD Thresholds			
	(NMOG + NOx)	CO	PM THD
Monitors (ex. Aftertreatment)	1.85x	1.5x	2.0x
Aftertreatment Monitors (ex. DPF Filtering Performance Monitor)	2.0x	1.5x[1]	2.0x[1]
DPF Filtering Performance Monitor	1.85x[1]	1.5x[1]	17.5 g/mi

1. Applies to 2019MY LEV III BIN110 and BIN85 Vehicles

Proposed Data Parameters

Categories

- Portable Emission Measurement (PEMS)/certification
- PHEV
- GHG

PEMS/certification

- Engine Reference torque (PID $63/SPN 544)
- Friction Losses (PID $8E/SPN 514)
- Parasitic losses (PID $?/SPN 2978)
- Actual Engine Percent torque (PID $62/SPN 513)…*already in regulation*
- DEF dosing status *%Duty Cycle* (PID/SPN ?)
- DEF dosing rate in ml/sec (PID/SPN ?)
- Cylinder fuel rate in mg/stroke (PID $A2/SPN ?)
- Engine fuel rate in g/s (PID $9D/SPN ?)
- Vehicle fuel rate in g/s (PID $9D/SPN ?)
- NOx sensor correction in ppm (PID $A1/SPN ?)

Proposed Data Parameters

Proposed PHEV Data Parameters

- Cumulative distance traveled in charge depleting operation with engine on
- Cumulative distance traveled in charge increasing operation
- Cumulative fuel consumed in charge depleting operation
- Cumulative fuel consumed in charge increasing operation
- Cumulative grid energy consumed in charge depleting operation with engine off
- Cumulative grid energy consumed in charge depleting operation with engine on
- Cumulative distance traveled in charge depleting operation with engine off

Proposed Data Parameters

GHG Parameters

- Total engine run time
- Total idle run time
- Cumulative distance traveled
- Cumulative fuel consumed by the vehicle
- Cumulative positive kinetic energy
- Cumulative calculated engine output torque
- Cumulative propulsion system active time
- Cumulative idle propulsion system active time ($\leq$ 1 mph)
- Cumulative city propulsion system active time ($\geq$ 40 mph)
- Off cycle technologies (activation time, activations, successful occurrences)

Freeze Frame Proposal

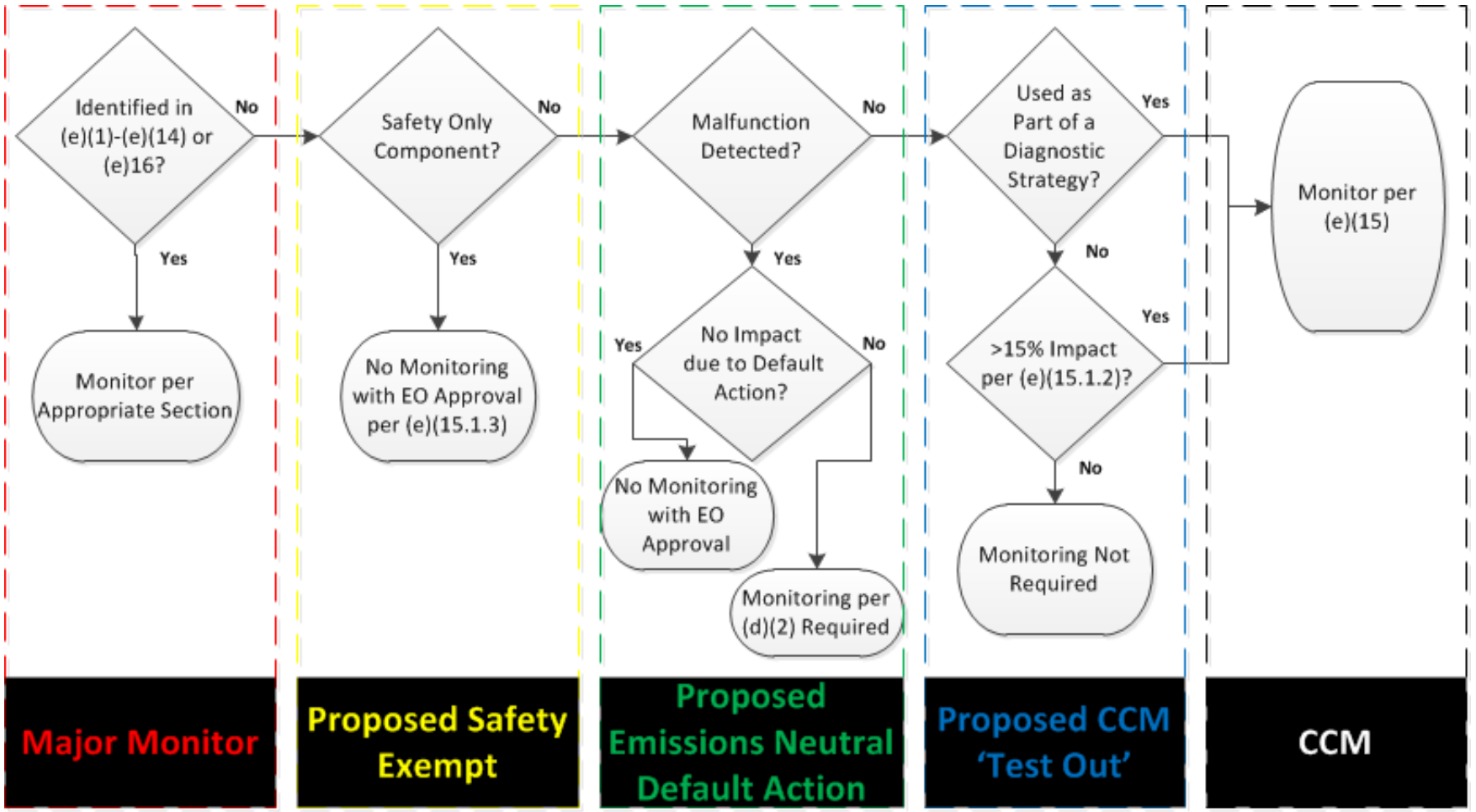
Gasoline

- Only one set of freeze frame information required to be stored
- If freeze frame currently stored for a fault, it may not be replaced with those of a subsequently detected fault unless that subsequent fault is for misfire or fuel system

Diesel

- Aligning with gasoline: diesel misfire freeze frame can only replace currently stored freeze frame if the data stored are not for a diesel misfire fault or diesel fuel system fault

Proposed Changes to Requirements/Exceptions to OBD Monitoring/MIL Illumination



Comprehensive Component Monitoring Test Out Proposal

Test out proposal

- Consider emission impact on FTP, US06, SC03, highway, Unified cycle, and 50 degF FTP
  - Provide data for FTP and worst case of other cycles
- Test out if difference between mean of 3 tests in baseline and mean of 3 tests in worst case malfunction is less than 15% of the applicable standard

Questions

- I tested out years ago, do I have to ‘test out’ again?
  - If in doubt, ‘test out’
  - Data doesn’t expire, additional testing not necessarily required
  - Written justification required to use data from a different or prior test group
  - Manufacturers ***must meet the current ‘test out’ requirements if tested by you or ARB***
  - Proposed 15 day change: LEVII vehicles may continue use old criteria
- Do I need to ‘test out’ for every single unmonitored component on every single vehicle?
  - No. Only those components that may reasonably be expected to affect emissions require monitoring or ‘test out’ data.

Variable Valve Timing, Lift, and/or Control Proposal

Requirements have been interpreted to mean only variable timing, or cam phasing

- Some issues not identified during ARB/manufacturer review
- Inconsistent implementation
- All systems including cylinder deactivation and load control through variable lift require detection of faults exceeding thresholds

Proposed language for clarification:

- All systems with variable control require complete FMEA for hydraulic and mechanical failures within the system
- Systems with discrete states require detection of failures exceeding thresholds
- Systems with continuously variable positioning or timing require detection before exceeding thresholds

Summary of Other Proposed 15 Day Changes

PCV Monitoring Requirements

- Fresh air line on n/a vehicles does not have to be monitored
- All other external lines have to be monitored for disconnections and breaks

Evaporative System Purge Monitoring Requirements

- Lower high-load purge monitor IUMPR to 0.336
- Interim high-load purge monitor enforcement IUMPR of 0.100 for first 3 years through the 2023 model year

NMHC Converting Catalyst Feedgas Monitoring Requirements

- Increase test-out criteria to 20% for ULEV70 and ULEV50, and to 25% for SULEV30 and SULEV20

Case Study: Monitor Robustness versus Frequency

What must to be achieved in monitor design?

1) **Make good decisions**
   - (d)(3.1) '…define monitoring conditions that are technically necessary to ensure robust detection of malfunctions'
2) **Meet in-use monitoring frequency**
   - (d)(3.2) '…define monitoring conditions that yield an in-use performance ratio that meets or exceeds the minimum required ratio,' (e.g., 0.336) *and* should only increment when monitor is capable of detecting a failure

Both of the above need to hold true simultaneously

Case Study: Monitor Robustness versus Frequency

- Demonstration data observations (“red flags”)
  - Monitor does not consistently fail during demonstration testing
  - Test results do not show consistent failing values with failed part installed
  - Numerator increment when falsely passing
- Confirmatory testing observations
  - Fail on demo cycle, pass off cycle (e.g., on road)

Case Study: Monitor Robustness versus Frequency

Example

- Application: exhaust gas sensor slow response
  - Based on enable conditions and thresholds listed in summary table, monitor should run under broad in-use driving conditions
    - Summary table specifically indicated that the min/max speed-load criteria were calibrated to enable monitor at road load in multiple gears
- Confirmatory testing
  - Staff conducted on-road verification testing after successful FTP demo
    - After code clear, monitor passed on first drive cycle; failed after that
    - Driving conditions when pending code was recorded were 3-4th gear, 35-40 mph
    - Staff questioned manufacturer about filtering or averaging
    - Manufacturer response: Failure threshold was calibrated to prohibit failing the monitor in real world driving conditions
- <u>The monitor was deemed non compliant</u>

Case Study: Monitor Robustness versus Frequency

Malfunction criteria table: possible to calibrate entire engine map

Engine Load \ Engine Speed	1000	1500	2000	2500	3000	3500	4000	4500	5000
20	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25	n/a	n/a	0.5	0.5	0.5	0.5	0.7	0.7	n/a
30	n/a	n/a	0.5	0.5	0.5	0.5	0.7	0.7	n/a
35	n/a	n/a	0.5	0.5	0.5	0.5	0.7	0.7	n/a
40	n/a	n/a	0.5	0.5	0.5	0.5	0.7	0.7	n/a
45	n/a	n/a	0.5	0.5	0.5	0.5	0.7	0.7	n/a
50	n/a	n/a	0.5	0.5	0.5	0.5	0.7	0.7	n/a
55	n/a	n/a	0.5	0.5	0.5	0.5	0.7	0.7	n/a
60	n/a	n/a	0.5	0.7	0.7	0.7	0.7	0.7	n/a
65	n/a	n/a	0.5	0.7	3.0	3.0	3.0	3.0	n/a
70	n/a	n/a	0.5	0.7	3.0	3.0	3.0	3.0	n/a
80	n/a	n/a	0.7	0.7	3.0	3.0	3.0	3.0	n/a
90	n/a	n/a	0.7	0.7	3.0	3.0	3.0	3.0	n/a
100	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Case Study: Monitor Robustness versus Frequency

Monitor enable range is a subset of entire speed load map

Engine Load \ Engine Speed	1000	1500	2000	2500	3000	3500	4000	4500	5000
20	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25	n/a	n/a	0.5	0.5	0.5	0.5	0.7	0.7	n/a
30	n/a	n/a	0.5	0.5	0.5	0.5	0.7	0.7	n/a
35	n/a	n/a	0.5	0.5	0.5	0.5	0.7	0.7	n/a
40	n/a	n/a	0.5	0.5	0.5	0.5	0.7	0.7	n/a
45	n/a	n/a	0.5	0.5	0.5	0.5	0.7	0.7	n/a
50	n/a	n/a	0.5	0.5	0.5	0.5	0.7	0.7	n/a
55	n/a	n/a	0.5	0.5	0.5	0.5	0.7	0.7	n/a
60	n/a	n/a	0.5	0.7	0.7	0.7	0.7	0.7	n/a
65	n/a	n/a	0.5	0.7	3.0	3.0	3.0	3.0	n/a
70	n/a	n/a	0.5	0.7	3.0	3.0	3.0	3.0	n/a
80	n/a	n/a	0.7	0.7	3.0	3.0	3.0	3.0	n/a
90	n/a	n/a	0.7	0.7	3.0	3.0	3.0	3.0	n/a
100	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Case Study: Monitor Robustness versus Frequency

Demonstration on certification cycle occurs in limited range

Engine Load \ Engine Speed	1000	1500	2000	2500	3000	3500	4000	4500	5000
20	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25	n/a	n/a	0.5	0.5	0.5	0.5	0.7	0.7	n/a
30	n/a	n/a	**0.5**	**0.5**	**0.5**	0.5	0.7	0.7	n/a
35	n/a	n/a	**0.5**	**0.5**	**0.5**	0.5	0.7	0.7	n/a
40	n/a	n/a	0.5	0.5	0.5	0.5	0.7	0.7	n/a
45	n/a	n/a	0.5	0.5	0.5	0.5	0.7	0.7	n/a
50	n/a	n/a	0.5	0.5	0.5	0.5	0.7	0.7	n/a
55	n/a	n/a	0.5	0.5	0.5	0.5	0.7	0.7	n/a
60	n/a	n/a	0.5	0.7	0.7	0.7	0.7	0.7	n/a
65	n/a	n/a	0.5	0.7	3.0	3.0	3.0	3.0	n/a
70	n/a	n/a	0.5	0.7	3.0	3.0	3.0	3.0	n/a
80	n/a	n/a	0.7	0.7	3.0	3.0	3.0	3.0	n/a
90	n/a	n/a	0.7	0.7	3.0	3.0	3.0	3.0	n/a
100	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Case Study: Monitor Robustness versus Frequency

Same failed part demonstrated on the road results in a false-pass since on-road conditions use different malfunction criteria

Engine Load	Engine Speed								
	1000	1500	2000	2500	3000	3500	4000	4500	5000
20	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25	n/a	n/a	0.5	0.5	0.5	0.5	0.7	0.7	n/a
30	n/a	n/a	0.5	0.5	0.5	0.5	0.7	0.7	n/a
35	n/a	n/a	0.5	0.5	0.5	0.5	0.7	0.7	n/a
40	n/a	n/a	0.5	0.5	0.5	0.5	0.7	0.7	n/a
45	n/a	n/a	0.5	0.5	0.5	0.5	0.7	0.7	n/a
50	n/a	n/a	0.5	0.5	0.5	0.5	0.7	0.7	n/a
55	n/a	n/a	0.5	0.5	0.5	0.5	0.7	0.7	n/a
60	n/a	n/a	0.5	0.7	0.7	0.7	0.7	0.7	n/a
65	n/a	n/a	0.5	0.7	**3.0**	**3.0**	**3.0**	**3.0**	n/a
70	n/a	n/a	0.5	0.7	**3.0**	**3.0**	**3.0**	**3.0**	n/a
80	n/a	n/a	0.7	0.7	**3.0**	**3.0**	**3.0**	**3.0**	n/a
90	n/a	n/a	0.7	0.7	**3.0**	**3.0**	**3.0**	**3.0**	n/a
100	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Case Study: Monitor Robustness versus Frequency

Summary

- Look for the application red flags
  - If monitor is not robust across entire range of monitoring conditions, the monitor is not compliant
- As a supplier/designer, don't offer monitoring solutions like this
- As a calibrator, don't sign off on a calibration that behaves this way
- As a manufacturer seeking certification,
  - Identify this before certification and fix it
  - Or be ready to provide a convincing explanation for a monitor that is calibrated this way in support of a deficiency request
- Non-compliances such as this that are not assigned a deficiency are handled through enforcement action

Case Study: OBD, OIS and Service Information

Bureau of Automotive Repair
OBD Inspection System

- OIS: California's new inspection system for the Smog Check Program
- OIS has the ability to collect all current standardized OBD data that is supported on the vehicle
  - Previous system (BAR97) limited to MIL status, fault codes and readiness.
- Pass/fail criteria at time of inspection have changed depending on model year
- OBD inspection data saved
  - Post processed for a number of purposes: program statistics, investigations (fraud, vehicle problems)

Case Study: OBD, OIS and Service Information

Possible OBD II failure criteria (Section 3340.42.2 of the CA Code of Regulations)

Current Fail Criteria:

- *Bulb Check:* MIL does not illuminate when the ignition is on and engine is off
- *MIL On:* MIL illuminates continuously or flashes with the engine running
- *MIL Command:* OBD system reports the MIL as commanded on
- *Communications:* OBD system does not communicate with the BAR-OIS
- *Readiness:* OBD system reports incomplete readiness based on MY criteria

Possible Additional Fail Criteria:

- OBD system data is inappropriate for the vehicle being tested
- OBD system data does not match the original equipment manufacturer or an ARB exempted OBD software configuration
- OBD system reports a permanent DTC
- OBD system data indicates the system has not yet been sufficiently operated to determine the presence or absence of a DTC

Case Study: OBD, OIS and Service Information

- Changes to Readiness Pass Criteria
  - New monitor/readiness issues are now coming to light

Table 1: OBD Test Monitor Readiness Standards
(Implemented May 4, 2015)

Model Years	Fuel Type	Number of Incomplete Monitors Allowed to Pass OBD Test
1996-1999	Gas[1]	Any one
2000 and newer	Gas[1]	Evaporative system
1998-2006	Diesel	Zero
2007 and newer	Diesel	Any two

[1] "Gas" includes gasoline, propane, natural gas (CNG, LNG, LPG)

- Fail for permanent DTC set is currently being studied
- Warm-up/distance since code clear also being studied as possible basis for readiness/PDTC failure exemption

Case Study: OBD, OIS and Service Information

Examples of recently identified readiness issues through OIS data and new inspection criteria

- Vehicle failed because couldn't set readiness for required monitor
- Service information
  - Example 1: found monitor description and enable conditions, but still could not run monitor
  - Example 2: could not find monitor descriptions and enable conditions
- No faults detected that would explain disablement
- Further review of OIS data showed a similar trend for these vehicles
- Requested manufacturer to investigate
- Outcome
  - Example 1: problem found and reflash now available
  - Example 2: still under investigation

Case Study: OBD, OIS and Service Information

Summary

- Impact on both technicians and manufacturers
- Knowledge on how to set readiness is increasingly important to technicians
- Successful use of new data depends on compliant OBD system
  - Newly discovered monitor/readiness issues need to be addressed
  - BAR/ARB are finding instances where vehicles don't properly handle warm-up/distance data and/or permanent DTCs
  - ARB is asking for corrective action in most cases
- Overall OBD and Smog Check are achieving significant air quality benefits
  - Approximately 10 million inspections per year and 28,000 per day in California alone
  - Malfunctioning cars are being identified and repaired

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