



California Environmental Protection Agency

 **Air Resources Board**

Selective Catalytic Reduction Workshop

July 20, 2010

Workshop Agenda

- Introductions
- Opening Statements
- EPA/ARB Presentations
 - Categories/Timing
 - Reductant Level
 - Reductant Quality
 - Tampering
 - Repeat Offenses
 - Self Healing
 - Delegated Assembly
 - Maintenance Intervals
 - Freeze Protection
 - Infrastructure
 - Unregulated Pollutants/Toxic Air Contaminants
- ARB –Off-Road and LDV/MDV Session



Categories/Timing

WHAT

- EPA – heavy-duty highway engines
- ARB
 - On-road medium-duty engines (MDE)
 - On-road heavy-duty engines (HDDE)
 - Others (HD hybrids and special cases)

WHEN

- EPA – calendar year, with most changes effective January 1, 2011
- ARB - model year, with most changes effective MY2011



Reductant Level

GOAL: Minimal engine operation when SCR system is no longer able to dose

KEY POINTS:

- Need indication of reductant level for the operator
- Initiate inducement early enough so that final inducement is engaged prior to noncompliance due to low reductant
- Any driver inducement should account for safety concerns
- Notify operator of low level at least 2 times prior to final inducement



Reductant Level

INDUCEMENTS

- Strategy specifics – manufacturer's discretion
- Warn operator prior to any inducement
- Final inducement
 - 5 mph limit or
 - No power or
 - Idle only
 - Should allow for diagnostics and restart after refill
- If inducement is phased in, initiate another warning prior to final inducement



ARB - Reductant Level

Inducements Example 1

STEP 1: When there is about 15% reductant or 100 miles worth of reductant left in the tank, warning signals consisting of a reductant light and audible chimes would begin to alert driver of low level of reductant remaining

STEP 2: When there is about 10% reductant left in the reductant tank, a noticeable engine derate would begin and continue until next trigger is reached.

ARB - Reductant Level

Inducements Example 1 – cont'd

STEP 3:

WHEN

- The tank reads empty to the operator
- About 5% reductant remains in the reductant tank,
- A more significant derate of about 40% occurs

THEN

- The vehicle speed is limited to 5 mph, when one of the following conditions is triggered:
 - Diesel Fuel Refueling (must define)
 - Vehicle Parked/Idled (must define)
 - Vehicle Restarted
- No longer than an hour of an empty reductant tank

ARB - Reductant Level

Inducements Example 2

STEP 1: When there is about 15% reductant or 100 miles worth of reductant left in the tank, warning signals consisting of a reductant light and audible chimes would begin to alert driver of low level of reductant remaining

STEP 2: When there is about 12% reductant left in the reductant tank a noticeable engine derate would begin and continue until next trigger is reached.

ARB - Reductant Level

Inducements Example 2 – cont'd

STEP 3: When there is about 6% reductant left in the reductant tank (driver display reductant gauge may be showing 3%), a second more severe engine derate begins or engine / vehicle top speed limiter begins.

STEP 4: When there is about 3% reductant left in the reductant tank (driver display reductant gauge may be showing 0%) final inducements triggered when:

- Diesel Fuel Refueling (must define)
- Vehicle Parked/Idled (must define)
- Vehicle Restarted

Reductant Quality

GOAL: Detect poor reductant quality as quickly and accurately as possible

KEY POINTS:

- Need quality or NOx sensor system capable of detecting poor reductant quality that causes noncompliance
- Be able to detect noncompliance within 1 hour and notify operator immediately
- Final inducement with driver warning initiated within 4 hours of detecting noncompliance
- Any driver inducement should account for safety concerns
- EPA -- 2012
- ARB – 2011



Reductant Quality

INDUCEMENTS

- Strategy specifics – manufacturer's discretion
- Notify operator when noncompliance is detected
- Warn operator prior to any inducement
- Final inducement
 - 5 mph limit or
 - No power or
 - Idle only
 - Should allow for diagnostics and restart after refill
- If inducement is phased in, initiate another warning prior to final inducement



ARB - Reductant Quality

Inducements Example 1

STEP 1: Once poor quality reductant is detected, the engine will have about 25% derate and the warning lamp is illuminated. The engine is allowed to operate for up to 1 hour at this derated level

After the initial hour and poor quality reductant is still detected:

STEP 2: A more significant derate of about 40% occurs. The engine will only operate at this second significant derated level for no longer than necessary to confirm self-healing, for example no more than four hours.

ARB - Reductant Quality

Inducements Example 1 – cont'd

STEP 3: During the second derate, if noncompliance is determined the vehicle speed is limited to 5 mph when one of the following conditions is triggered:

- Diesel Fuel Refueling (must define)
- Vehicle Parked/Idled (must define)
- Vehicle Restarted

ARB - Reductant Quality

Inducements Example 2

STEP 1: Once poor quality reductant is detected, the warning lamp and chimes are activated to warn the operator that engine derate will occur, the engine begins ramped derate about 1% per minute for 40 minutes (total 40% derate)

After the initial period and poor quality reductant is still detected:

STEP 2: A more significant derate about 60% occurs. The engine will only operate at this second significant derated level for no longer than necessary to confirm self-healing, for example no more than four hours.

ARB - Reductant Quality

Inducements Example 2 – cont'd

STEP 3: During the second derate, if noncompliance is determined the vehicle speed is limited to 5 mph when one of the following conditions is triggered:

- Vehicle speed is < 5mph
- Vehicle Parked/Idled (must define)
- Vehicle Restarted

Tampering

GOAL: Systems should be designed to be tamper resistant to reduce the likelihood of circumvention

KEY POINTS:

- Be able to detect tampering related malfunctions within 1 hour and notify operator immediately
- Final inducement with driver warning initiated within 4 hours of detecting tampering related malfunction
- Any driver inducement should account for safety concerns



Tampering - continued

- At a minimum the following tampering related malfunctions should be considered
 - Disconnected reductant level sensor
 - Blocked reductant line or dosing valve
 - Disconnected reductant dosing valve
 - Disconnected reductant pump
 - Disconnected SCR wiring harness
 - Disconnected NOx sensor (that is incorporated with the SCR system)
 - Disconnected reductant quality sensor
 - Disconnected exhaust temperature sensor
 - Disconnected reductant temperature sensor



ARB - Tampering

Example 1

STEP 1: Once tampering is detected, the engine would have about 25% derate and the warning lamp and chime are illuminated. The engine is allowed to operate for up to 1 hour at this derated level.

STEP 2: After an hour of the engine operating with the initial derate, a more significant derate about 40% would occur. The engine will only operate at this second significant derated level for no longer than necessary to confirm disconnection, for example no more than four (4) hours.

ARB - Tampering

Example 1 – cont'd

STEP 3: During the second derate, if noncompliance is determined the vehicle speed is limited to 5 mph when one of the following conditions is triggered :

- Diesel Fuel Refueling (must define)
- Vehicle Parked/Idled (must define)
- Vehicle Restarted

ARB - Tampering

Example 2

STEP 1: Once the tamper is confirmed, the engine is immediately derated (e.g., ramped derate about 1% per minutes for 25 minutes) and allowed to operate for up to 1 hour at this derated level.

ARB - Tampering

Example 2 – cont'd

STEP 2: After an hour of the engine operating with the initial derate, a more significant derate of about 40% would occur. The engine will only operate at this second significant derated level for example no more than four hours.

ARB - Tampering

Example 2 – cont'd

STEP 3: During the second derate, if noncompliance is determined the engine is derated (e.g., ramped derate about 1% per minute) such that the vehicle's final speed is limited to 5 mph when one of the following conditions is triggered:

- Vehicle speed is < 5mph
- Vehicle Parked/Idled (must define)
- Vehicle Restarted

Repeat Offenses

GOAL: Discourage repeat tampering and repeat use of poor quality reductant

KEY POINTS:

- System should monitor for repeat faults for a minimum of 40 engine hours
- Return to final inducement for repeat offense within
 - EPA – 30 minutes
 - ARB – 60 minutes
- Repeat offense
 - EPA – same offense
 - ARB - any 2nd offense



ARB - Repeated Offenses

Example 1

STEP 1: Upon detecting subsequent repeated offenses which occurs within 40 engine hours of the previous offense, the system warns operator and derate occurs for one hour

STEP 2: The vehicle speed is limited to 5 mph maximum when one of the previously discussed triggers is reached

STEP 3: Normal engine operation inhibited, reset to normal mode by factory or dealership tools

Self Healing

GOAL: Systems should be able to restart after action that triggers inducement is corrected

KEY POINTS:

- Use of generic scan tool to clear inducement not acceptable



Delegated Assembly

GOAL: All system components designed to comply and installed in certified configuration

KEY POINTS:

- Components to be considered in addition to other devices:
 - Reductant storage (configuration and volume)
 - Freeze protection system



Maintenance Intervals

GOAL: Technological necessity for any maintenance intervals shorter than prescribed in regulations

KEY POINTS:

- Petition for shorter interval needed for each manufacturer per model year (multiple MYs and manufacturers can be covered by a single submission)
- Petition may be needed for refill interval AND SCR filter maintenance



Freeze Protection

GOAL: Systems should be designed to dose as soon as possible after freezing event and continue to dose in cold temperatures

KEY POINTS:

- Test procedure can be used to show system capable of dosing within 70 minutes
- By 2011, show that reductant won't refreeze during operation
- Show that system is capable of dosing within 40 minutes
 - EPA – 2012
 - ARB – 2011



Freeze Protection – cont'd

Test Procedure for Performance of Reductant Dosing Freeze Protection Systems:

- **Prior to Procedure:**
 - Temperature: Reductant at 20°F (maximum)
- **Soak Conditions:**
 - Temperature: 0°F (maximum)
 - Time: 72 hours or solid reductant (whichever occurs first)
- **Test Duty Cycle:**
 - Temperature: 0°F (maximum)
 - Time: 70 minutes (or 40 minutes) (maximum)
 - Start engine and idle with no engine load for 20 minutes
 - Operate engine at no more than 40% load at rated speed for up to 50 minutes (or 20 minutes)



Infrastructure

GOAL: Reducing agent widely available and readily accessible

KEY POINTS:

- Reductant available at dealerships
- Reductant available through a back up plan
- Reductant available through appropriate 3rd party locations



Unregulated Pollutants/ Toxic Air Contaminants

GOAL: No SCR systems shall cause or contribute to an unreasonable risk to public health, welfare or safety

KEY POINTS:

- NH_3 – below 10 PPM average over useful life
- Dioxins – systems with Cu-Zeolite catalysts represented by EPA testing
- Vanadium Oxides (ARB) – Manufacturers must discuss strategy with ARB



Questions?

Audience Presentations

Please limit
presentations to 10
minutes

Break / Lunch

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Proposals Only – Not Final Agency Decisions

Other Industries Using SCR

Off Road CI Products

Light-Duty Vehicle (LDV) / Medium-Duty Vehicle (MDV) Chassis Products

Thank You!