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
Re ductant 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.
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.
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

Proposal Only – Not Final Agency Decisions
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.
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.
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.
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 is 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
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
Other Industries Using SCR

Off Road CI Products

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