Certification of Alternative Fuel Conversions for New and Used Vehicles/Engines

Workshop

August 14, 2012

California Environmental Protection Agency
Air Resources Board

Outline

- Scope
- Regulations
  - New Vehicles/Engines Certification
  - Aftermarket Retrofit
  - OBD II
- Certification/Retrofit Procedures

Scope of Workshop

- Alternative fuel conversion of new versus used vehicles/engines
- Applicable vehicles/engines:
  - Light-duty vehicles (passenger cars, light-duty trucks, medium-duty passenger vehicles, medium-duty vehicles)
  - Heavy-duty vehicles/engines

Scope of Workshop
(continued)

- Applicable alternate fuels:
  - Dedicated alternative fuel
    - Compressed Natural Gas (CNG)
    - Liquefied Natural gas (LNG)
    - Liquefied Petroleum Gas (LPG or Propane)
  - Dual-fuel (e.g., gasoline or CNG operation solely)
  - Bi-fuel (e.g., diesel and CNG together)

New versus Used in California

- New vehicle:
  - vehicle whose equitable or legal title has never been transferred to an ultimate purchaser
- Used vehicle:
  - vehicle whose equitable or legal title has been transferred to an ultimate purchaser
- New engine:
  - engine or engine/vehicle whose equitable or legal title has never been transferred to an ultimate purchaser
- Used engine:
  - engine or engine/vehicle whose equitable or legal title has been transferred to an ultimate purchaser

Ultimate Purchaser in California

- Ultimate Purchaser is the first person to purchase a new motor vehicle/engine for purposes other than resale
- The transfer of the equitable or legal title, and not the actual vehicle, to the ultimate purchaser makes the vehicle no longer a new vehicle

Certified for Sale in California

- No vehicle/engine may be sold in CA before it has been certified by ARB
- Vehicle/engine may be sold and operated in California if built in all material respects as described by the manufacturer and approved by ARB

No Modifications to Certified Vehicles/Engines

- Emission-related modifications to vehicles/engines causing them to no longer be in their certified configuration are considered tampering
- The modifier must obtain California certification to sell the vehicles/engines

Alternative Fuel Vehicle/Engine Conversion Paths

- New Vehicle/Engine
  - The manufacturer of the alternative fuel conversion will be considered the OEM and must comply with all new vehicle/engine requirements
  - The OEM may receive an Executive Order to sell new converted vehicle/engine in CA
- Used Vehicle/Engine
  - The manufacturer of the alternative fuel conversion kit must comply with the aftermarket alternative fuel procedures
  - The alternative fuel conversion manufacturer may receive an Executive Order to sell conversion kits in CA

New Vehicle/Engine Regulations

- 13 CCR § 1961
  - Exhaust Emission Standards and Test Procedures - 2004 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles.
- 13 CCR § 1956.8
  - Exhaust Emissions Standards and Test Procedures -1985 and Subsequent Model Heavy-Duty Engines and Vehicles.
- 13 CCR § 1976
  - Standards and Test Procedures for Motor Vehicle Fuel Evaporative Emissions.
- 13 CCR § 1968.2
  - Malfunction and Diagnostic System Requirements -2004 and Subsequent Model-Year Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles and Engines.
- 13 CCR § 1971
  - Engine Manufacturer Diagnostic System Requirements -2007 and Subsequent Model-Year Heavy-Duty Engines.
- 13 CCR § 1971.1
  - On-Board Diagnostic System Requirements -2010 and Subsequent Model-Year Heavy-Duty Engines.

New Vehicle/Engine Certification Requirements

- Submit an application and update it for changes
- Meet the applicable emission standards and adhere to the appropriate test procedures
- Demonstrate durability
- Meet the applicable labeling requirements
- Provide emissions warranty to the ultimate purchaser
- Identify all makes and models
- OBD II

New Vehicle/Engine Certification Requirements

- Identify all makes and models
  - Manufacturer's name and its own model names, or
  - With permission from base vehicle/engine OEM, manufacturer may use the OEM's make and model names

Exhaust and Evaporative Requirements

- Vehicles/engines must adhere to applicable tailpipe exhaust emissions requirements
- Vehicles must adhere to applicable evaporative emissions requirements
  - SHED testing for light-duty vehicles
  - SHED testing or engineering evaluation for heavy-duty vehicles
  - Fuel tank, fuel lines, canister, etc.

In-Use Vehicle/Engine Warranty Reporting

- New alternative fuel vehicle/engine OEMs are required to report failed emission-related parts
  - 3 years for light-duty vehicles
  - 5 years for high cost parts
  - 12 years for PZEV (10 years for HEV battery pack)
  - 5 years for heavy-duty engines

Aftermarket

- No aftermarket part that alters or modifies the design or function of the original emission control system may be sold or installed on a vehicle/engine unless the part has been approved by ARB

Aftermarket Regulations

- Applicable to used vehicles/engines
- Statutory authority: HSC 43006
- Regulations contained in:
  - Sections 2030 & 2031 Title 13, CCR
  - "California Certification and Installation Procedures for Alternative Fuel Retrofit Systems for Motor Vehicles Certified for 1994 and Subsequent Model Years and for All Model Year Motor Vehicle Retrofit Systems Certified for Emission Reduction Credit," last amended September 25, 1997
  - http://www.arb.ca.gov/msprog/aftermkt/altfuel/altfuel.htm

Aftermarket Certification Requirements

- Compliance with base vehicle/engine certification emission standards or more stringent standards
- Testing based on engine family
- Durability demonstration
- On-Board Diagnostic II compliance
- Evaluation of impact on auxiliary emission control devices
- Supplemental emission control information label
- Manufacturer and installer warranty
- Installation inspection
- In-use enforcement testing

New Vehicle/Engine Certification Process

Major Steps for Certification

1. (New Mfrs.) Register with U.S. EPA and ARB.
2. Group vehicles/engines into test groups/engine families.
3. Demonstrate service accumulation durability & emissions compliance for each test group/engine family.
4. Submit Applications to ARB via the Document Management System (DMS).

Major Steps for Certification

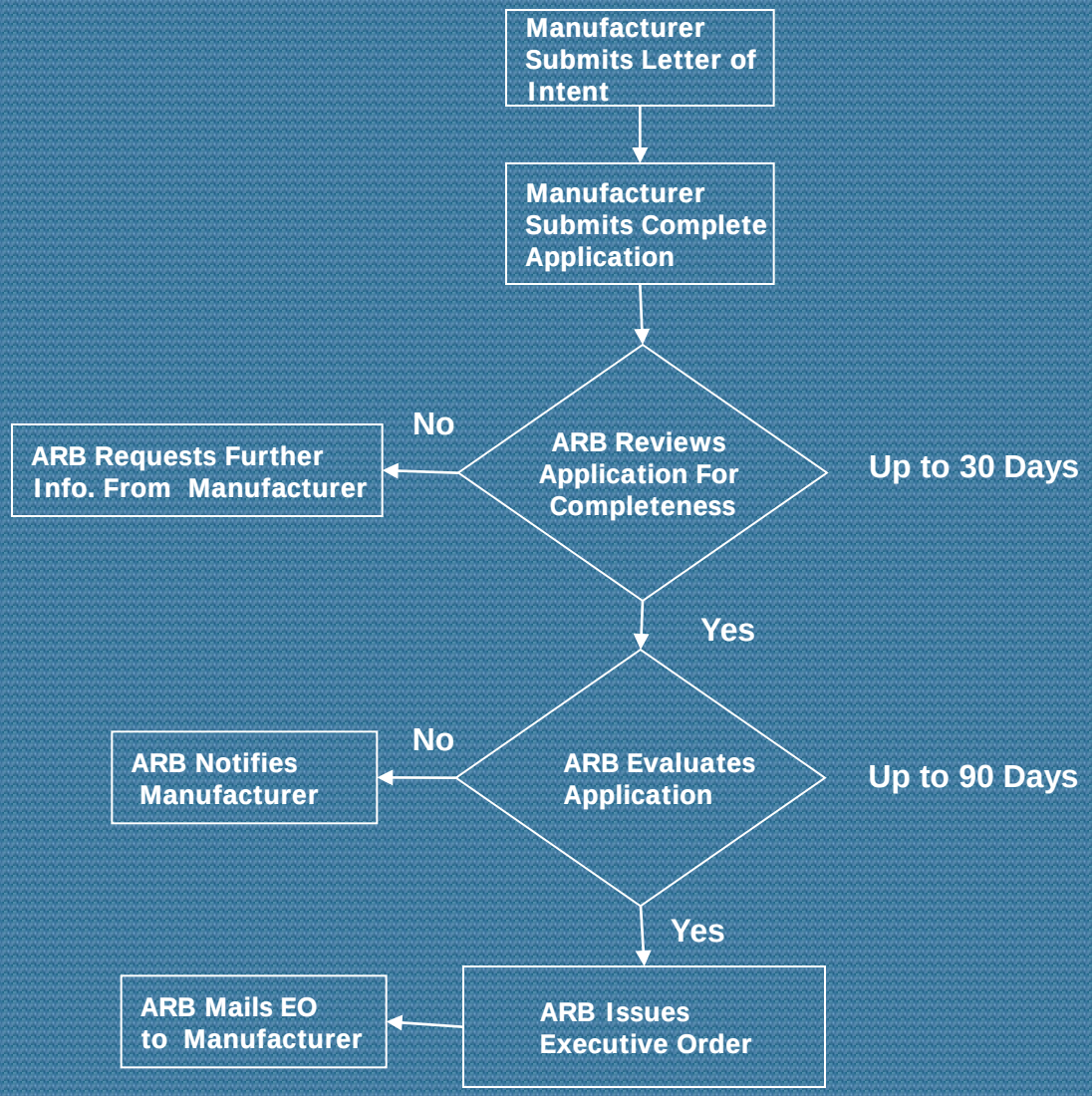
(continued)

5. Receive Certificate of Conformity from U.S. EPA and Executive Order from ARB.
6. Produce and label each vehicle/engine according to specifications described in applications.
7. Do not introduce vehicles/engines into commerce in CA until certified.
8. Receive U.S. EPA and ARB approval for any emissions-related production running changes.

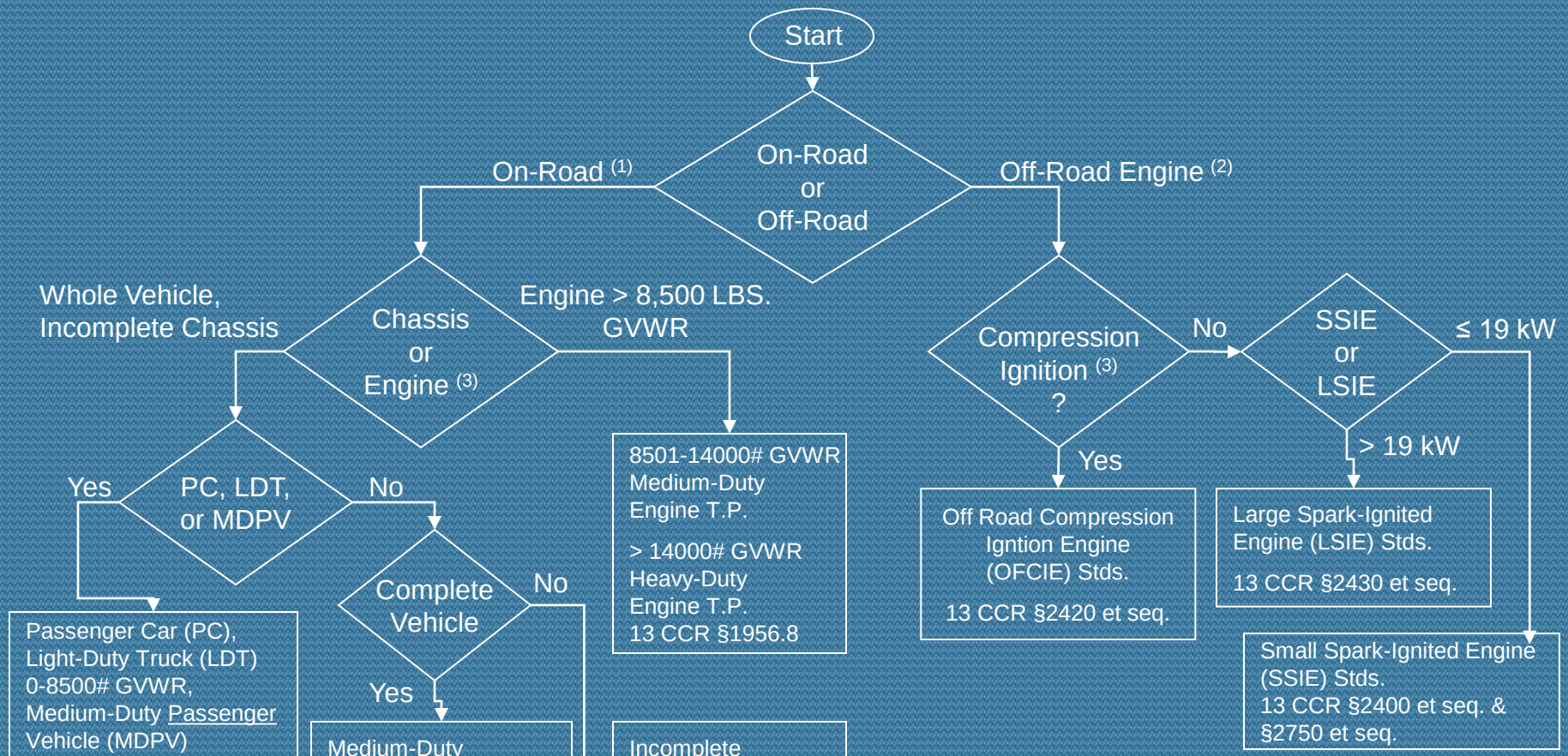
New MFR Must be Registered

- Register with U.S. EPA as a manufacturer.
- Submit to ARB via regular mail a hard copy "Letter of Intent" to certify vehicles in CA.
  - Name, address, e-mail, Mfr.'s name, EPA-assigned Mfr.'s code, types of vehicles/engines to be certified.
- ARB assigns unique ARB Mfr.'s code to enable access to Document Management System (DMS).
- ARB issues its Executive Orders (EOs) to the vehicle/engine manufacturer.

Certification Process Flowchart



Identify Vehicle or Engine CA Emissions Class



(1) & (2) "Highway Motorcycle" & "Off-Highway Recreational Vehicle" (e.g. OFMC, ATV) are not listed, and "Spark-Ignited Marine Engines" are not listed due to lack of interest to convert these vehicles to CNG.

(3) Spark ignited otto-cycle engines which have horsepower and torque characteristics of a HD diesel engine may be certified per HD diesel standards & test procedures.

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Certification Application Submittal

- Letter of Intent
- Cover letter/Statements of Compliance
- Application
  - Certification summary
  - Supplemental Information
- Emission Control Label
- Warranty Statement
- Tamper Resistance Compliance
- Durability Plan
- OBD II Documentation
- Confirmatory Test data
- NMOG, VEC, ABT Plan (if applicable)

Post-Certification

- NMOG, VEC Fleet Average or ABT (Averaging, Banking, Trading) Reports
- Manufacturer-Run In-Use Testing (LD)
- Running Changes
  - Submit new application if changes are made during the model year
- Field Fixes
- Carryover Applications
  - May carry over emission data to the next model year
  - Must submit an application each year

Passenger Car, Light-Duty Truck, Medium-Duty Passenger Vehicle

Examples: car, pick-up, SUV, passenger van

Testing Requirements:

- FTP (NMOG, CO, CO_2, NO_X, PM, HCHO); HWFET (NO_X, CO_2); 50°F FTP[1] (NMOG, CO, NO_X, HCHO); 20°F FTP (CO)
- Evaporative: Diurnal (3-day & 2-day), Hot Soak, Running Loss, ORVR

  - Dedicated CNG and LNG fueled vehicles are exempt

  - MDPVs are ORVR exempt

[1] LPG is subject to the 50°F test; CNG is exempt.

Medium-Duty Vehicle Complete Vehicle – Chassis Certified

Examples: full size pick-up, cargo van

Testing Requirements:

- FTP NMOG, CO, NO_X, HCHO; HWFET NO_X
- Evaporative: Diurnal, Hot Soak, Running Loss
  - Dedicated CNG and LNG fueled vehicles are exempt

LEV-II Regs. Webpage:
http://www.arb.ca.gov/msprog/levprog/test_proc.htm

Medium & Heavy-Duty Vehicle Incomplete Chassis

Examples: truck chassis, van chassis

Testing Requirements:

- Evaporative: Diurnal, Hot Soak, Running Loss

  - HD chassis, compliance by engineering analysis

  - Dedicated CNG and LNG fueled vehicles are exempt

Evaporative Emissions Regs. Webpage:

http://www.arb.ca.gov/msprog/evap/evap.htm

Medium & Heavy-Duty Engine

Examples: heavy-duty truck, bus

Testing Requirements:

- HD Otto or Diesel cycle engine test procedures; THC/NMHC, CO, NO_X, HCHO, PM
- Engines intended for HD vehicle applications, e.g., urban bus, must adhere to heavy heavy-duty diesel standards & test procedures

Heavy-Duty Engine Regs. Webpage:

http://www.arb.ca.gov/msprog/onroadhd/onroadhd.htm

Emission Standards & Test Procedures, CA vs. U.S. EPA

When certifying to a CA standards ***all*** CA test procedures must be followed

- Example: CA vehicles > 8,500 lbs. GVWR are tested with dynamometer loading set at adjusted loaded vehicle weight (ALVW or (curb weight+GVWR)÷2, whereas federal medium-duty passenger vehicles are tested at loaded vehicle weight (curb weight+300 lbs.))
- When certifying to the "Cleaner Federal Vehicle" or "BIN" standard, the test vehicle's weight follows EPA's test procedures

On-Road Vehicles (PC, LDT, MDV, MDE, HDV/E)

Certification Requirements:

- Labeling
  - Vehicle Emission Control Information (VECI) / Engine Label
    - Under hood or affixed onto the engine block, permanent
    - Identifies engine & evaporative family
    - Identifies CA, 50-state, 49-state certification status
    - Vacuum hose routing diagram, if applicable
    - EPA Conversion Label (mileage & date of conversion) must be separate from VECI / engine label
  - Environmental Performance (EP) Label
    - Applies to PC, LDT, MDPV
    - Smog Score from cert. std.
    - Global Warming Score from CO_2-equivalent emissions
    - OK to use Federal Fuel Economy and Environment Label

Group Vehicles/Engines into Exhaust Families

- Characteristics of Test Groups/Engine Families
  - Displacement, number of cylinders, cylinder configuration
  - Emission control systems, i.e., catalytic converter number & location, EGR, SCR or DPF
  - Fuel system, i.e., carburetor, TBI, MFI, SFI
  - Cooling Mechanism, i.e., liquid vs. air

[Ref. 40 CFR §86.1827-01]

Group Vehicles into Evaporative Families
LP and Dual Fuel with Gasoline

- Characteristics of Evaporative Families
  - Vapor Storage Device design, i.e., canister housing material & working capacity
  - Fuel Tank design, i.e., metal vs. plastic, vented vs. unvented
  - Fuel System, i.e., carburetor, TBI, MFI, SFI
  - Purge strategy, i.e., uncontrolled vs. controlled

[Ref. 40 CFR §86.1821-01]

Carryover Data

- Must submit certification application for each model year
- May carry over emission data from the previous model year, as long as, no changes to the engine or emission control system
- May carry across emission data from one engine family to another, if representative
- Subject to ARB Approval

Certification 101

A new vehicle or engine must comply with exhaust and evaporative standards. For PC, LDV, complete MDV, and MDPV, the whole vehicle, not the engine by itself, is certified.

- Chassis or engine dyno testing for exhaust emissions
- **S**ealed **H**ousing for **E**vaporative **D**etermination (SHED) testing for evaporative emissions
- **O**n-board **R**efueling **V**apor **R**ecovery (ORVR) testing for refueling emissions

Demonstrate UL Durability & Emissions Compliance

Chassis-based durability used here for illustration. Engine dynamometer-based durability follows similar requirements.

1. a. Durability Demonstration

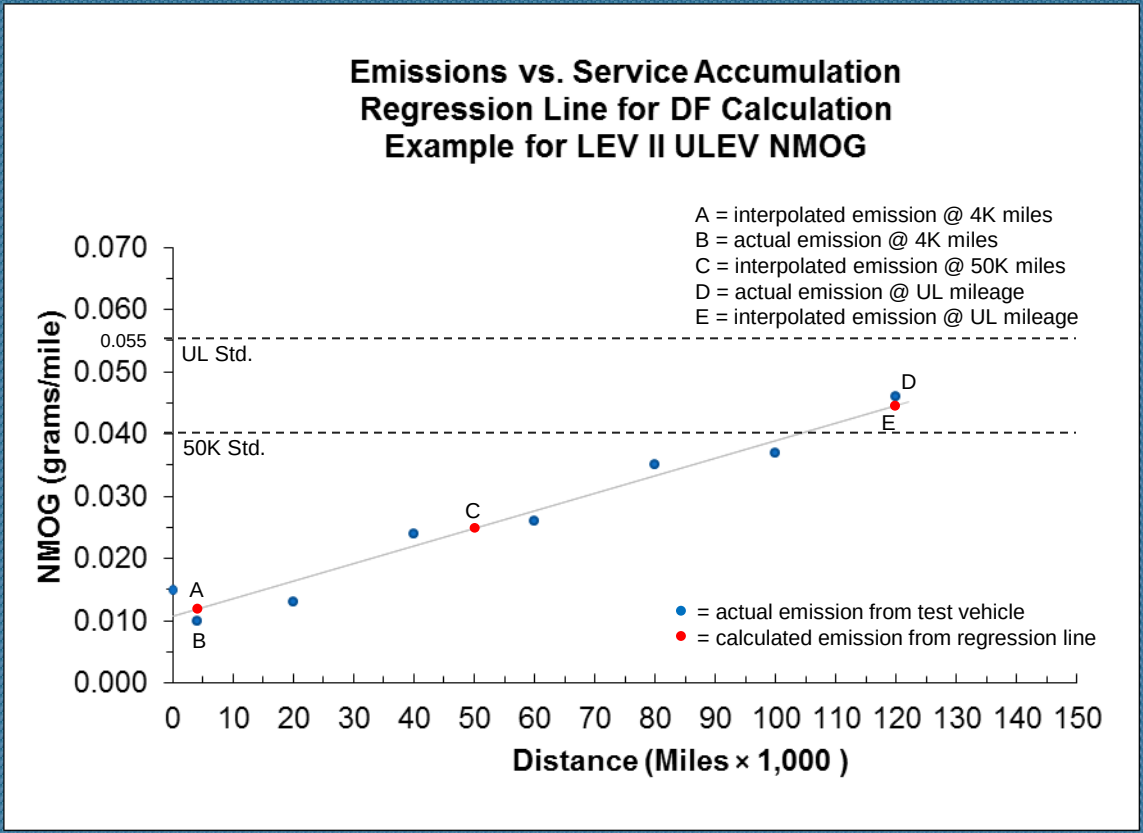
- Accumulate mileage on a prototype test vehicle.
- Mileage or service accumulation cycle is set forth in 40 CFR, §1823-01 for PC/LDT/chassis-certified MDV.
- Conduct periodic exhaust & evaporative emission tests during mileage accumulation per restrictions in 40 CFR, §1834-01 for PC/LDT/chassis-certified MDV.

Demonstrate UL Durability & Emissions Compliance (cont'd)

1. b. Durability Demonstration – Evaporative System
   - Evaporative emission control system component bench aging, See Mail-out 93-23, or request assigned deterioration factor
1. c. Test vehicle = worst case configuration in test group having greatest probability of exceeding the standards
1. d. Unscheduled maintenance must be approved by ARB
1. e. All test data and projected emissions must be below applicable standard
1. f. Calculate deterioration factors (DF) for all pollutants

Demonstrate UL Durability & Emissions Compliance (cont'd)

2. a. DF calculated from **least squares linear regression** of emission test data. Plot separate regression lines for NMOG, NO_X, CO, HCHO, PM, Evap and ORVR as applicable.



Demonstrate UL Durability & Emissions Compliance (cont'd)

2. b. Determine multiplicative DFs.

$$DF_{50K} = \frac{C}{A} = \frac{\text{Projected emissions @ 50K miles}}{\text{Interpolated emissions @ 4k miles}}$$

$$DF_{UL} = \frac{E}{A} = \frac{\text{Projected emissions @ UL mileage}}{\text{Interpolated emissions @ 4K miles}}$$

Determine additive DFs:

$DF_{50K} = C - A$

$DF_{UL} = E - A$

Demonstrate UL Durability & Emissions Compliance (cont'd)

3. Determine certification level for all pollutants. All certification levels must be ≤ the applicable certification standard

4. Retain test vehicle for possible confirmatory testing at ARB and for testing future production running changes

Other Ways to Demonstrate UL Durability

- Carry across DFs from OEM
  - Good engineering practice, i.e., vehicle/engine operating on alternate fuel causes less deterioration to emission control system than gasoline operation
  - Obtain permission from OEM to use their durability data.
- Accelerated mileage accumulation or engine dyno accumulation
- Bench aged catalysts & other emission control devices
- Assigned DFs
  - Not automatic
  - Must make a showing of durability of fuel and emission control system

Auxiliary Emission Control Devices (AECDs)

1. AECD: Any element of design which senses temperature, vehicle speed, engine RPM, transmission gear, manifold vacuum, or any other parameters for the purpose of activating, modulating, delaying, or deactivating the operation of any part of the emission control system

Auxiliary Emission Control Devices (AECDs) (cont'd)

2. All AECDs must be described in the application and approved by ARB

3. Unapproved AECDs may be deemed a defeat device – a violation of certification

   [Ref. 40 CFR, §86.1809-01 for PC/LDT/chassis certified MDV]

   [Ref. 40 CFR, §86-004-16 for MDE/HDE/HDV]

Model Year

- New Vehicles/Engines are certified and EOs are issued on a model year basis
- A model year generally runs from Jan. **2** of the previous calendar year for which the model year is named to Dec. 31 of the calendar year for which the model year is named, e.g., a 2012 model year vehicle/engine may be produced from Jan. 2, 2011 through Dec. 31, 2012
- A model year "X" vehicle/engine cannot be produced after Dec. 31 of calendar year "X"

Model Year (Cont'd)

A manufacturer may certify an alternate fuel conversion using the previous model year base vehicle/engine (e.g., a 2013 CNG vehicle using a 2012 base gasoline vehicle) provided that from one model year to the next:

- The emission control system remains the same
- The emission standards remain the same
- Phase-in requirements (e.g., emission standards, OBD II monitoring) are met
- OBD II deficiencies are addressed or remedied
- Advance planning is key to successful carry-over of previous model year's data

Additional Requirements

- Assembly Line End-Of-Line Test (PC, LDT,& chassis-certified MDV only)
  - Functional check of the emission control system
  - Usually entails interrogating the OBD II system
  - Required on 100% of all CA vehicles
- Identify locations of all assembly plants and distribution centers (upon request)
- Identify special procedures and tools used in the conversion process
- ARB personnel is allowed access to assembly plants, distribution facilities, and test facilities for the purpose of vehicle selection (for confirmatory/audit testing) and for observing emission tests

Aftermarket Retrofit Certification Process

Retrofit System Certification Process

- Manufacturer submits certification plan
- ARB approves durability and emission testing plan
- Manufacturer conducts testing per ARB approved plan
- Manufacturer submits certification application
- ARB evaluates the application and issues the Executive Order upon approval

Test Requirements
On-Road Retrofit System

- Emission testing and durability
- Test procedures based on vehicle category
  - Category I: PC, LDT, MDV certified to chassis dynamometer-based standards
  - Category II: GVWR $\leq$ 14,000 lbs. certified to engine dynamometer-based standards
  - Category III: GVWR > 14,000 lbs. certified to engine dynamometer-based standards

Test Requirements - Category I

- Actual mileage accumulation
  - Emission test at 4,000 miles
  - Mileage accumulation to useful life
  - Emission test after mileage accumulation
  - Show compliance with certification standards & determine deterioration factors (DF)
- Bench aging
  - Emission test at 4,000 miles
  - Remove retrofit system and bench age retrofit system to useful life
  - Re-install bench aged system and emission test
  - Show compliance with certification standards & determine DFs

Test Requirements - Category I (Continued)

- Alternate test procedure (ARB MAC 95-10)
  - Emission test at 4,000 miles
  - Apply DFs and show compliance with certification standards
  - Qualify DFs prior to certification and validate DFs within two years of certification
  - Emission test at end of durability testing and validate DFs

Test Requirements - Category I (continued)

- To use derived or U.S. EPA-assigned DFs:

  Submit DF qualification data & DF validation plan prior to certification
- Submit DF qualification data
  - Base vehicle and retrofitted vehicle performance characteristics, such as air/fuel calibration control, catalyst temperature traces
  - Component durability data, such as data from previously certified system/vehicle, bench testing
- Submit DF validation plan
  - Dynamometer driving schedules/in-use mileage accumulation routes
  - Emission test mileage points up to useful life
  - Maintenance schedules

Test Requirements - Category II

- Actual mileage accumulation or bench aging
  - Establish baseline emissions - use same test procedures as Category I
  - Emission test at 4,000 miles; emissions </= 1.10 times baseline
  - Mileage accumulation or bench aging to useful life (UL)
  - Emission test at UL miles; emissions </= 1.3 times baseline

Test Requirements - Category II (continued)

- Alternate test procedure (ARB MAC 95-07) :

  Use derived or U.S. EPA-assigned (Guidance letter CCD-00-12) deterioration factors
  - Emission test at 100 hours using same test procedures used by base engine to certify when new
  - Apply deterioration factors (DF) and show compliance with certification standards
  - Qualify DFs prior to certification and validate DFs within two years of certification
  - Emission test at end of durability testing and validate DFs

Test Requirements - Category III

- Actual mileage accumulation or bench aging
  - Establish baseline emissions - use test procedures proposed by manufacturer and approved by ARB
  - Emission test at 4,000 miles; emissions </= 1.10 times baseline
  - Mileage accumulation or bench aging to 180,000-mile useful life
  - Emission test at 180,000 miles; emissions </= 1.3 times baseline

Test Requirements - Category III

- Alternate test procedure (ARB MAC 95-07):

  Use derived or U.S. EPA-assigned (Guidance letter CCD-00-12) deterioration factors
  - Emission test at 100 hours using same test procedures used by base engine to certify when new
  - Apply deterioration factors (DF) and show compliance with certification standards
  - Qualify DFs prior to certification and validate DFs within two years of certification
  - Emission test at end of durability testing and validate DFs

Test Requirements-Category II & III (continued)

- To use derived or U.S. EPA-assigned DFs:

  Submit DF qualification data and DF validation plan prior to certification
- Submit DF qualification data
  - Base engine and retrofitted engine performance characteristics, such as

    horsepower & torque curves, fuel feed curves, air/fuel calibration control, catalyst temperature traces
  - Component durability data, such as

    data from previously certified system/engine, bench testing

Test Requirements-Category II & III (continued)

- Submit DF validation plan
  - Engine dynamometer schedules or in-use mileage accumulation routes representative of in-use engine operation
  - Emission test mileage points - minimum of 1,000 hours (diesel)/2,000 hours (gasoline); must show correlation between hours and miles
  - Maintenance schedules

Test Requirements - Category II & III (continued)

- To generate credits, perform actual mileage accumulation or bench aging
  - Base engine certification emission levels = baseline emissions
  - Emission test at 4,000 miles using same test procedures used by base engine to certify when new; emissions </= 1.10 times baseline emissions
  - Mileage accumulation or bench aging to 120,000- or 180,000-mile useful life (UL)
  - Emission test at UL miles; emissions </= credit standards or 1.3 times baseline emissions

Other Requirements
On-Road Retrofit System

- Dual-fuel system (utilizes an alternative fuel or a conventional fuel) tested using each fuel
- Evaporative emission test determined based on retrofit system design
- Manufacturer describes impact on AECD (auxiliary emission control devices)
- OBD compliance

Carry-Over & Carry-Across On-Road Retrofit System

- Carry-over of emission data allowed if data represent emissions from the vehicle/engine seeking certification
- Carry-over & carry-across of durability data allowed if (ARB MAC 95-05):
  - Durability data vehicle/engine shared among engine families as found in the base vehicle/engine certification application and use the same retrofit system
  - If engines do not share durability data vehicle/engine:
    - Durability data must be derived from an engine certified to same or more stringent emission standards
    - Durability data engine and engine seeking certification must have similar engine characteristics/weight category
    - Catalyst temperatures of engine seeking certification are equal to or less than those of the durability data engine (EPA Advisory Circular 17F)

Gasoline Deterioration Factors On-Road Retrofit System

- Use of gasoline DFs allowed if following conditions are met (ARB MAC 95-05):
  - One-time demonstration of retrofit system durability for:
    - Emissions, calibration, and catalyst temperature data at 4,000 miles and at useful life
  - Following the one-time durability demonstration, provide:
    - Equivalent gasoline and alternative fuel calibration (lambda, air/fuel ratio curves) at 4,000 miles
    - Equivalent gasoline and alternative fuel catalyst temperatures at 4,000 miles

On-Road Supplemental Label

- Affix adjacent to the original vehicle emission control information label
- Supplement label shall show:
  - Base vehicle/engine model year
  - Retrofit system certification Executive Order number
  - Retrofit system manufacturer name, address, phone number
  - Credit standards, if applicable
  - List of base vehicle/engine parts removed during the conversion
  - Changes to tune-up specifications required by retrofit system
  - Installer name, address, phone number
  - Date of retrofit system installation
  - Mileage and date at which retrofit system warranty expires
  - Statement that retrofitted vehicle/engine complies with California emission requirements
  - Statement that the vehicle/engine has been retrofitted to operate on a fuel other than gasoline or diesel and identify the alternative fuel

Manufacturer & Installer Warranty On-Road Retrofit System

- Manufacturers
  - Warrant retrofit system to meet California requirements for 3 years or 50,000 miles or 7 years or 70,000 miles (high cost parts), whichever first occurs, from the date of installation
  - Warranty covers costs of diagnosis, parts, and labor
- Installers
  - Warrant installation work for 3 years or 50,000 miles, whichever first occurs, from the date of installation

On-Road Installation Inspection

- Prior to releasing a retrofitted vehicle to end user, installer submits the vehicle to the Bureau of Automotive Repair (BAR) Referee Smog Check Station for inspection and testing and obtains certificate of compliance
- Alternative inspection schedule
  - Installer submits 10 vehicles with similar engine families to Referee station
  - If all ten vehicles receive a certificate of compliance, installer allowed to only submit every tenth retrofitted vehicle
  - Installer maintains records on the remaining vehicles

On-Road In-Use Enforcement Test Requirements

- Manufacturers subject to in-use enforcement testing
- Testing on no more than 20 percent of certified retrofit systems/engine family applications per year
- Emission testing on no less than 10 vehicles per certified retrofit system/engine family application selected for in-use testing
- If average emissions exceed standards, recall may be ordered

Contacts

- Mr. Duc Nguyen, Manager of the On-Road Light-Duty Certification Section

  dnguyen@arb.ca.gov
- Ms. Kimberly Pryor, Manager of the Compression-Ignition and Heavy-Duty Certification Section

  kpryor@arb.ca.gov
- Ms. Rose Castro, Manager of the Aftermarket Parts Section

  rcastro@arb.ca.gov

Question & Answer