



# **Examples of Heavy-Duty Diesel and Off-Road Diesel Engine Deterioration Factor Validation for CARB and US EPA Approval**

Compliance Workshop

July 8, 2020

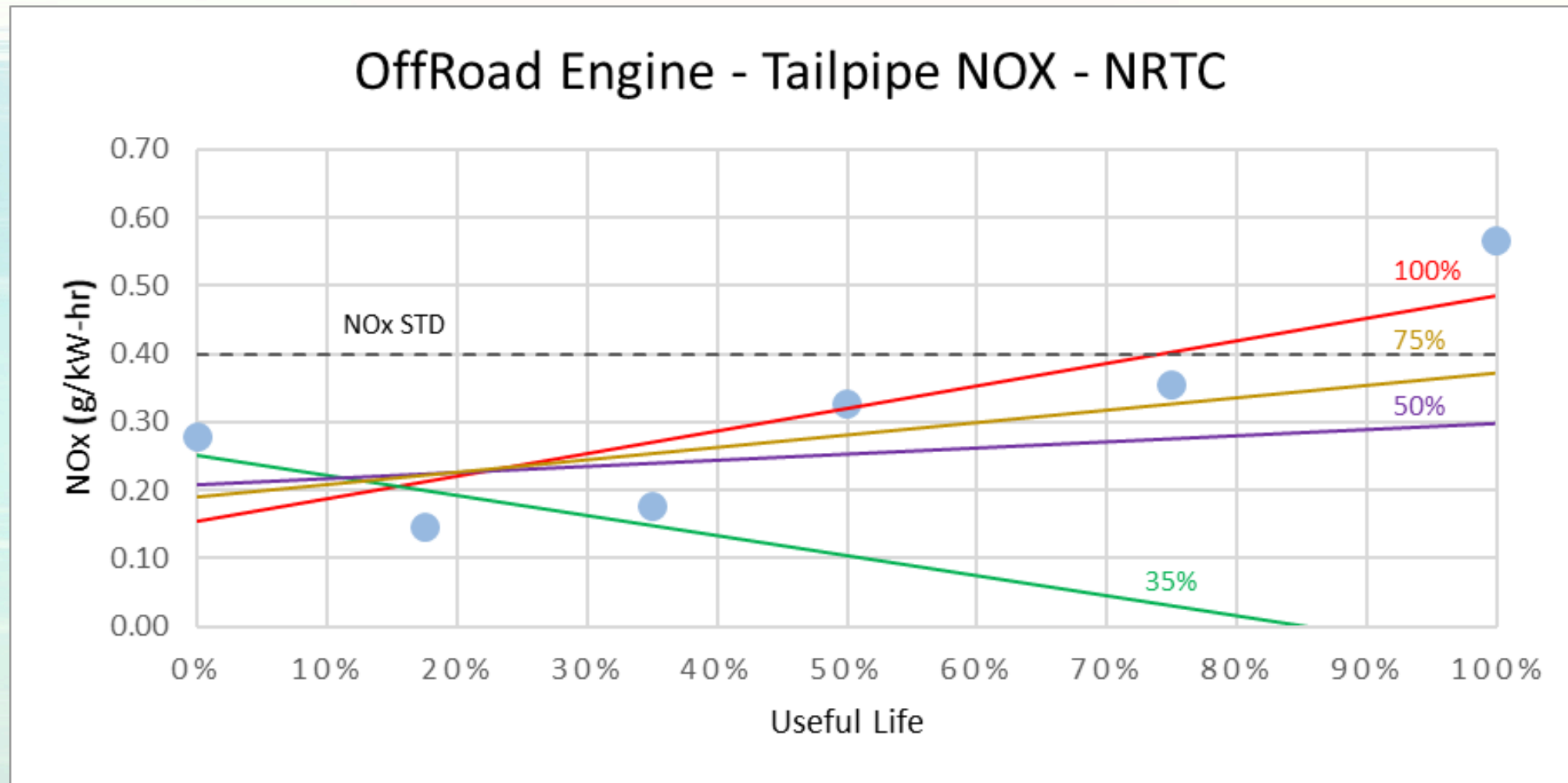
# Overview

- Manufacturers of heavy-duty on- and off-road diesel engines establish deterioration factors (DF) to estimate emissions at the end of useful life
- Testing has shown that emissions rates on engines with SCR are increasing faster than DF's indicate
- CARB/EPA are asking manufacturers to validate existing DFs to continue using them for future model years
- Examples of acceptable methods to validate DFs are provided

# Background

- Data from EMA DF test program and OBD MST program useful for evaluating DF accuracy
- Engine deterioration
  - Engine-out emissions are fairly stable throughout the UL
- Tailpipe-out
  - Tailpipe-out emissions higher at the end of UL when compared to DF's extrapolated from 35%, 50% or 75% of UL
  - DF increases with inclusion of more data out to UL

# EMA DF Program Showed Mixed Results SCR Engines



# Applicability

- DF validation program applicable to new and carryover MY2021+ certification of diesel engines with SCR after-treatment systems
  - On-road / Highway SCR-equipped engines
  - Off-road / Non-road SCR-equipped engines

# 2021 Model Year

- No new data required to carryover DFs, when appropriate
- With MY2021 applications (new and carry over engine families)
  - Manufacturers need to submit acknowledgment that agency approval of a plan to establish MY2022+ DFs will be required
  - Manufacturers may begin testing upon plan approval by CARB and US EPA

# 2022 – 2023 Model Years

- Manufacturers need to submit DF validation data prior to receiving their 2022 MY EOs/CoC
- Previous model year DF's need to be validated in order to be carried over
  - New and 1<sup>st</sup> year of carryover: no validation is needed
  - 2<sup>nd</sup> year of carryover and beyond: validation data required

# MY 2024 and beyond

- MY 2024 and beyond:
  - Carryover families may continue to use the processes for MY 2022 – 2023
  - New families will need to demonstrate FUL durability using some combination of bench aging and service accumulation prior to receiving certification
  - Any new emission durability regulations adopted by an agency shall supersede these guidelines for MY 2024 and later engines, as applicable



# Acceptable Methods of DF Validation

## I. In-use engines:

- a) Engine-dyno
- b) PEMS
- c) On-board NOx sensors data

## II. Compliance demonstration on FUL aged engine (i.e. no extrapolation)

- d) Engine dyno
- e) Combination of engine dyno and bench aging ATS

## III. Other methods:

- f) Upcoming procedures
- g) Alternative methods proposed by manufacturers and approved by the agencies

# Minimum Service Accumulation of In-use Engines

- Data to be collected from engines with minimum service accumulation according to the table below:

	Minimum engine service accumulation
3 <sup>rd</sup> year of production	35% of UL
4 <sup>th</sup> year of production	45% of UL
5 <sup>th</sup> year of production	55% of UL
6 <sup>th</sup> year of production	65% of UL
7 <sup>th</sup> year of production	75% of UL
8 <sup>th</sup> year of production and beyond	85% of UL

- DF validation is complete as soon as passing results are obtained from engines aged to at least 85% UL

# Engine Dyno Testing of In-use Engines

- Test at least two engines each year
- Engines must comply with all regulated criteria pollutants for the engine to pass
- If testing more than two engines, at least 70% of engines must pass

Example:   if testing 3 engines, all 3 engines must pass  
              if testing 5 engines, 4 engines must pass

# Engine Dyno Testing of In-use Engines

- Test engines on all applicable certification cycles
- Measure all regulated pollutants
- Validate IRAFs

# PEMS Testing of In-use Engines

- Test at least five engines each year
- At least four engines must comply with all regulated criteria pollutants (except for PM) for the engine to pass
- If testing more than five engines, at least 70% of engines must pass

Example: if testing 6 engines, 5 engines must pass  
if testing 7 engines, 5 engines must pass

# PEMS Testing of In-use Engines

- If DF validation using PEMS results fails, manufacturers may use Option a. (i.e., engine dyno testing of two engines) for DF validation of the same year

# On-board NOx Sensors Data from In-use Engines

- Test at least seven engines each year
- At least five engines tested annually must pass
- If testing more than seven engines, at least 70% of engines must pass

Example: if testing 9 engines, 7 engines must pass  
if testing 12 engines, 9 engines must pass



# On-board NOx Sensors Data from In-use Engines

- If DF validation using this method fails, manufacturer may use Option a. (i.e., engine dyno testing of two engines) for DF validation of the same year

# Demonstrate Compliance at FUL: Engine Dyno Aged

- Age an engine on an engine dyno to FUL based on an approved DF plan
- No extrapolation to project FUL compliance
- Compliance demonstrated at FUL point

# Demonstrate Compliance at FUL: Engine Dyno and Bench-aging ATS

- Use an approved DF plan
- Age an engine on an engine dyno to less than FUL and bench-age ATS to FUL
- No extrapolation to project FUL compliance
- Compliance demonstrated at FUL point

# Other Methods

- FUL durability demonstration using upcoming on-road procedures
- An alternate method proposed by the manufacturer and approved by the agencies

# Other Considerations

- Initially approved carry-across requests will remain valid
- DF validation must be conducted on the original DF engine family and the same rating as the initial durability demonstration

# Other Considerations

- Manufacturers shall submit all test data including passing, failing, valid, and invalid data, and justification why they deem a specific set of data invalid.
- Agencies will review requests for consideration that an unrepresentative measured criteria pollutant result (other than NO<sub>x</sub>) be excluded from consideration.

# Other Considerations

- Upon receiving and reviewing all data from a manufacturer, agencies will make a determination whether the validation, according to the manufacturer's approved plan has adequately been met
- Agencies will inform the manufacturer of the results
- Data must be compliant with the applicable standards, test procedure and other provisions of Title 40 of the CFR

# Other Considerations

- The agencies will make accommodations, on a case-by-case basis, for engine families that generally are not operated to full regulatory UL levels (i.e., low mileage/hours)
- If parent rating for a given family is not reasonably available, the agencies will work with the manufacturers to agree upon and select another family in the grouping that is available



# In Case of Failed Test Data

- Agencies will not invalidate previously issued EO's and/or CoC's based solely on manufacturers' supplied data
- Agencies may initiate further review of the already certified engine families that used the affected DFs through in-use testing or other programs

# In Case of Failed Test Data

- Carryover will be allowed for only one additional model year after the failure.
- Manufacturer will have to establish new DFs for any future EO's or CoC's

# Clarifying Example 1

- Initial durability demonstration: MY2022
- No validation data needed for MY2023
- Validation data is needed for MY2024+ in order to carryover the initial DFs
- If validation fails for MY2024, MY2022 DFs will be only allowed for certifying the MY2024 (one year), and new DFs will be needed for MY2025 and beyond

# Clarifying Example 2

- Initial durability demonstration: MY2017
- No validation data needed for MY2021
- Validation data is needed for MY2022 to carryover the MY2017 DFs (at least 65% of UL)
- If validation fails for MY2022, MY2017 DFs will be allowed for certifying the MY2022 only(one year)
- New DFs will be needed for MY2023 and beyond

# Contact Information

- Certification engineer assigned to each manufacturer
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# Questions Discussions