



***A Comprehensive Study of Manufacturers In-Use Testing Data
Collected from Heavy-Duty Diesel Engines Using Portable
Emissions Measurement System (PEMS)***



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Authors: Fakhri Hamady, Allen Duncan

Presented by: Allen Duncan

Office of Transportation and Air Quality

U.S. EPA

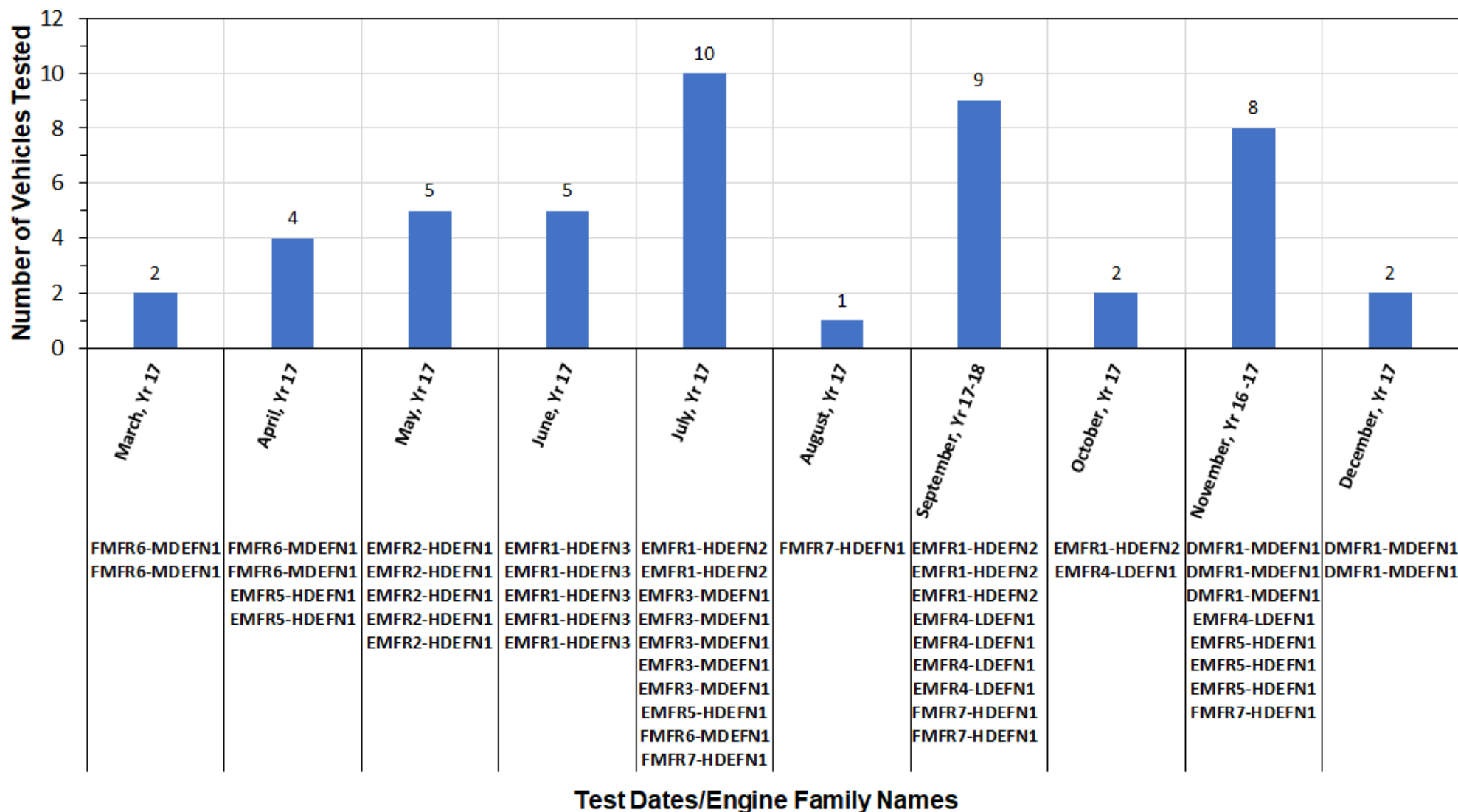
Overview

- ❑ **Manufacturer-Run In-Use Testing Program - Established in 2005**
 - ❑ **Manufacturers (MFRs) Test Order Selection of Engine Families**
 - ❑ **How Does This Program Work?**
- ❑ **In-Use Data Processing and Statistical Analyses to Determine:**
 - ❑ **Vehicle Testing Dates**
 - ❑ **Not-To-Exceed (NTE) Control Area**
 - ❑ **Vehicle Operation**
 - ❑ **Valid NTE Events, and Vehicle-Pass Ratio**
 - ❑ **Overall Average Emissions**
 - ❑ **Heavy-Duty In-Use Testing Details**
- ❑ **Data Summary**
- ❑ **Conclusions and Recommendations**
- ❑ **APPENDIX**

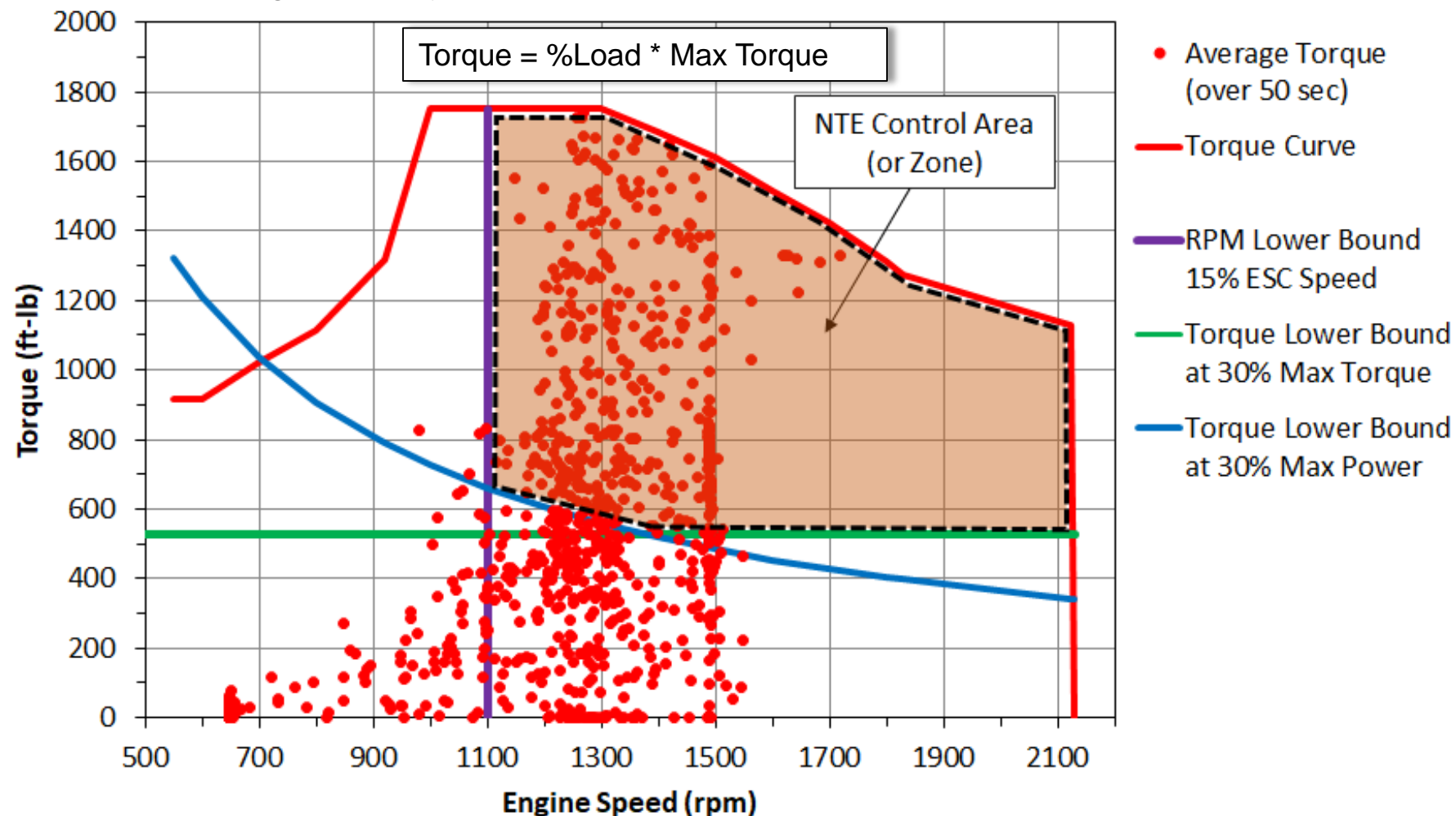
Manufacturers Test Order Selection of Engine Families

- ❑ **Over any four-year period, EPA will not select more than the average number of engine families that manufacturers have certified over that four-year period. Manufacturers are notified in writing by June 30 of the applicable calendar year about the Test Order, and have 18 months to complete their testing and report results to EPA.**
- ❑ **Selection of engine families is a cooperative effort between EPA and CARB staff, and it's based on information collected from engine certification data, compliance reports, previous in-use testing, and defect and recall reports, etc..**
- ❑ **How does this program work? 40 CFR part 86, Subpart T, provides detailed on manufacturer run in-use testing program.**

Vehicle, Engine Family and Testing Dates for Manufacturers 2016 Test Order



NTE Control Area - Engine Family Name: EMFR1-HDEFN3, Vocational Truck



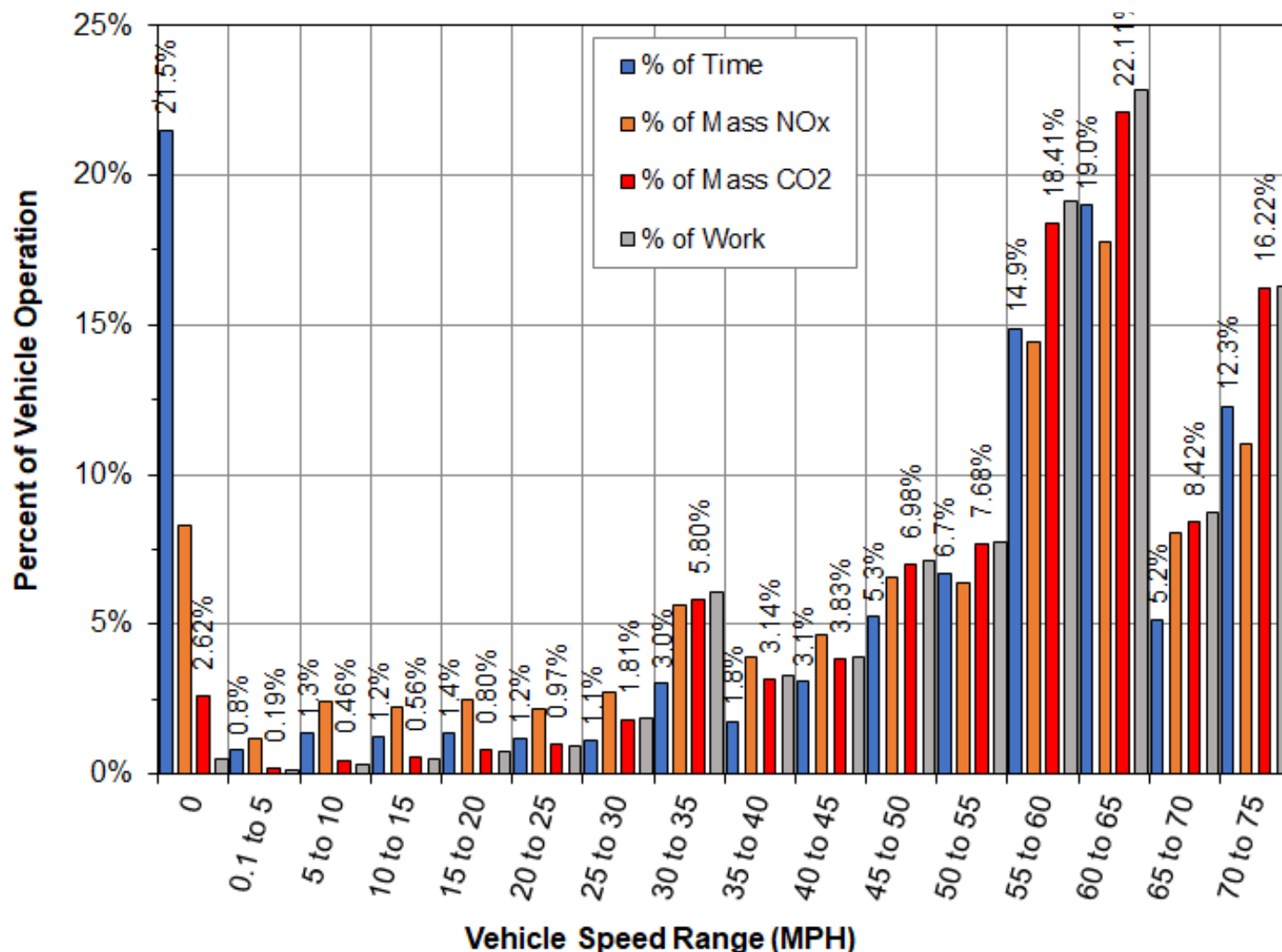
Valid NTE event duration is at least 30 seconds of vehicle continuous operation in the NTE zone with all exclusion set in the current regulation are applied

Each Vehicle has a Distinctive Operation Profile – Engine Family Name: EMFR1-HDEFN3, Vocational Truck

- Test Time = 13 hr.
- Mass NO_x = 340 g
- Mass of CO₂ = 873917 g
- Diesel Fuel = 85.85 gallons
- Work = 1727 hp-hr

For 0 - 50 MPH:

- Mass of NO_x is about 42%
- Mass of CO₂ is about 27%
- Work is about 25%



Valid NTE Events and Vehicle-Pass Ratio - Engine Family Name: EMFR1-HDEFN3, Vocational Truck

- ❑ Calculated and MFR reported Vehicle-Pass Ratios with all exclusions applied as set in the current EPA regulation.
- ❑ Percent of emissions, work and diesel fuel inside and outside the NTE control area.

Pass Ratios NTEE Min. Time = 30 sec and at 30% Max. Power	Macro Calculated	MFR/XML Reported
NMHC Pass Ratio:	1.00	1.00
CO Pass Ratio:	1.00	1.00
NOx Pass Ratio:	1.00	1.00
NOx & NMHC Pass Ratio:	N/A	N/A
PM pass ratio:	1.00	1.00
# of NTE Events:	37	38

Emissions Summary NTEE Min. Time = 30 sec, at 30% Max. Power	Total Emissions (g)							Total Work (hp-hr)	Gallon of Diesel Fuel
	Time (sec)	Time (%)	NOx	NMHC	CO	CO2	PM	Work	Fuel
Total Throughout Test:	47,471	100.0%	340.33	5.90	626.85	873,916.64	2.45	1,727.03	85.85
Percent of Total Emissions and Work									
Percent of:	Time (sec)	Time (%)	NOx	NMHC	CO	CO2	PM	Work	Fuel
Total outside of "Basic" NTE Control Area:	30,080	63.4%	27.3%	64.9%	36.2%	20.6%	63.8%	15.3%	17.65
Total in "Basic" NTE Control Area (w/o exclusions):	17,391	36.6%	72.7%	35.1%	63.8%	79.4%	36.2%	84.7%	68.20
Exclusion 6 (Deficiency):	0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Exclusion 7 (EMD/OBD):	0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Exclusion 8 (EGR/Cold Temp Operation):	11,563	24.4%	50.9%	18.7%	39.3%	50.3%	17.1%	53.7%	43.15
Exclusion 9 (Aftertreatment/Low Temp Operation):	2,522	5.3%	24.6%	16.8%	8.3%	9.6%	1.7%	10.2%	8.22
Exclusion 10 (Altitude/Amb Temp):	0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Exclusion 11 (Zero Check):	0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Total in NTE Control Area (w/ exclusions applied):	5,270	11.1%	13.4%	4.2%	22.5%	26.9%	17.9%	28.6%	23.10
Total in NTE Control Area with LTR flag:	0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Total in "Basic" NTE w/o excl with Regen flag:	0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Total of Valid NTE Events in NTE Control Area:	2,431	5.1%	7.3%	0.7%	10.8%	14.4%	10.3%	15.3%	12.40

Valid NTE Events and Vehicle-Pass Ratio - Engine Family Name: EMFR1-HDEFN3, Vocational Truck

Effect of EGR Cold Temperature (Exclusion) on Valid NTE Events (Turning "off" the EGR Cold Temperature Exclusion):

- EGR cold temperature operation is defined as engine meeting either of the following:
 - Intake Manifold Temp IMT (°F) ≤ IMT defined in $IMP (bars) = 0.0875 \times IMT - 7.75$, or
 - Engine Coolant Temp ECT (°F) ≤ ECT defined in $IMP (bars) = 0.0778 \times ECT - 9.8889$

Pass Ratios - No EGR/Cold Temp Operation NTEE Min. Time = 30 sec and at 30% Max. Power	Macro Calculated	MFR/XML Reported
NMHC Pass Ratio:	1.00	1.00
CO Pass Ratio:	1.00	1.00
NOx Pass Ratio:	0.98	1.00
NOx & NMHC Pass Ratio:	N/A	N/A
PM pass ratio:	1.00	1.00
# of NTE Events:	152	38

Emissions Summary - No EGR/Cold Temp Operation NTEE Min. Time = 30 sec and at 30% Max. Power	Total Emissions (g)							Total Work (hp-hr)	Gallon of Diesel Fuel
	Time (sec)	Time (%)	NOx	NMHC	CO	CO2	PM	Work	Fuel
Total Throughout Test:	47,471	100.0%	340.33	5.90	626.85	873,916.64	2.45	1,727.03	85.85
Percent of Total Emissions, Work and Diesel Fuel									
Percent of:	Time (sec)	Time (%)	NOx	NMHC	CO	CO2	PM	Work	
Total outside of "Basic" NTE Control Area:	30,080	63.4%	27.3%	64.9%	36.2%	20.6%	63.8%	15.3%	17.65
Total in "Basic" NTE Control Area (w/o exclusions):	17,391	36.6%	72.7%	35.1%	63.8%	79.4%	36.2%	84.7%	68.20
Exclusion 6 (Deficiency):	0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Exclusion 7 (EMD/OBD):	0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Exclusion 8 (EGR/Cold Temp Operation):	0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Exclusion 9 (Aftertreatment/Low Temp Operation):	2,522	5.3%	24.6%	16.8%	8.3%	9.6%	1.7%	10.2%	8.22
Exclusion 10 (Altitude/Amb Temp):	0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Exclusion 11 (Zero Check):	0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Total in NTE Control Area (w/o exclusions applied):	14,869	31.3%	48.1%	18.3%	55.5%	69.9%	34.5%	74.5%	59.98
Total in NTE Control Area with LTR flag:	0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Total in "Basic" NTE w/o excl with Regen flag:	0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Total of Valid NTE Events in NTE Control Area:	8,825	18.6%	31.5%	8.7%	33.5%	45.8%	23.9%	48.8%	39.28

Vehicle In-Use Test Information - Engine Family Name: EMFR1-HDEFN3, Vocational Truck

Vehicle Test Information and Average Emission Results					
Test Date = June 6, 2017	Average Valid NTEE NOx = 0.09 g/bhp-hr				
Vocaltional Truck Engine Family Name = EMFR1-HDEFN3	Average NOx = 0.19 g/bhp-hr				
Test Identification Code = 191	Average NOx (non-idle) = 0.17 g/bhp-hr				
Start Odometer = 361511 mi	Average NOx outside NTE = 0.20 g/bhp-hr				
End Odometer = 362102 mi	Average Cold NOx = 1.79 g/bhp-hr				
Covered Mileage = 591 mi	Average Idle NOx = 19.5 g/hr				
Shift Day Testing = 13.19 hr	Total Mass NO _x = 340.33 g				
Ambient Temp Range = 53.8 to 82.4 °F	Total Work = 1727 hp-hr				
Average Ambient Temp = 65.93 °F	Gallon of Diesel Fuel = 85.85 gallons				
MFR Reported Standard/FEL, Multiplier, Accuracy Margin, and NTE Threshold	NOx	NMHC	CO	NOx+NMHC	PM
Standard/FEL	0.31	0.14	15.5	N/A	0.01
Multiplier	1.5	1.5	1.25	N/A	1.5
In use Margin	N/A	N/A	N/A	N/A	N/A
Accuracy Margin	0.15	0.01	0.15	N/A	0.01
Threshold(g/bhp-hr)	0.62	0.22	19.5	N/A	0.03

In-Use Testing Data Statistics – Average Values Calculated from Tested Vehicles

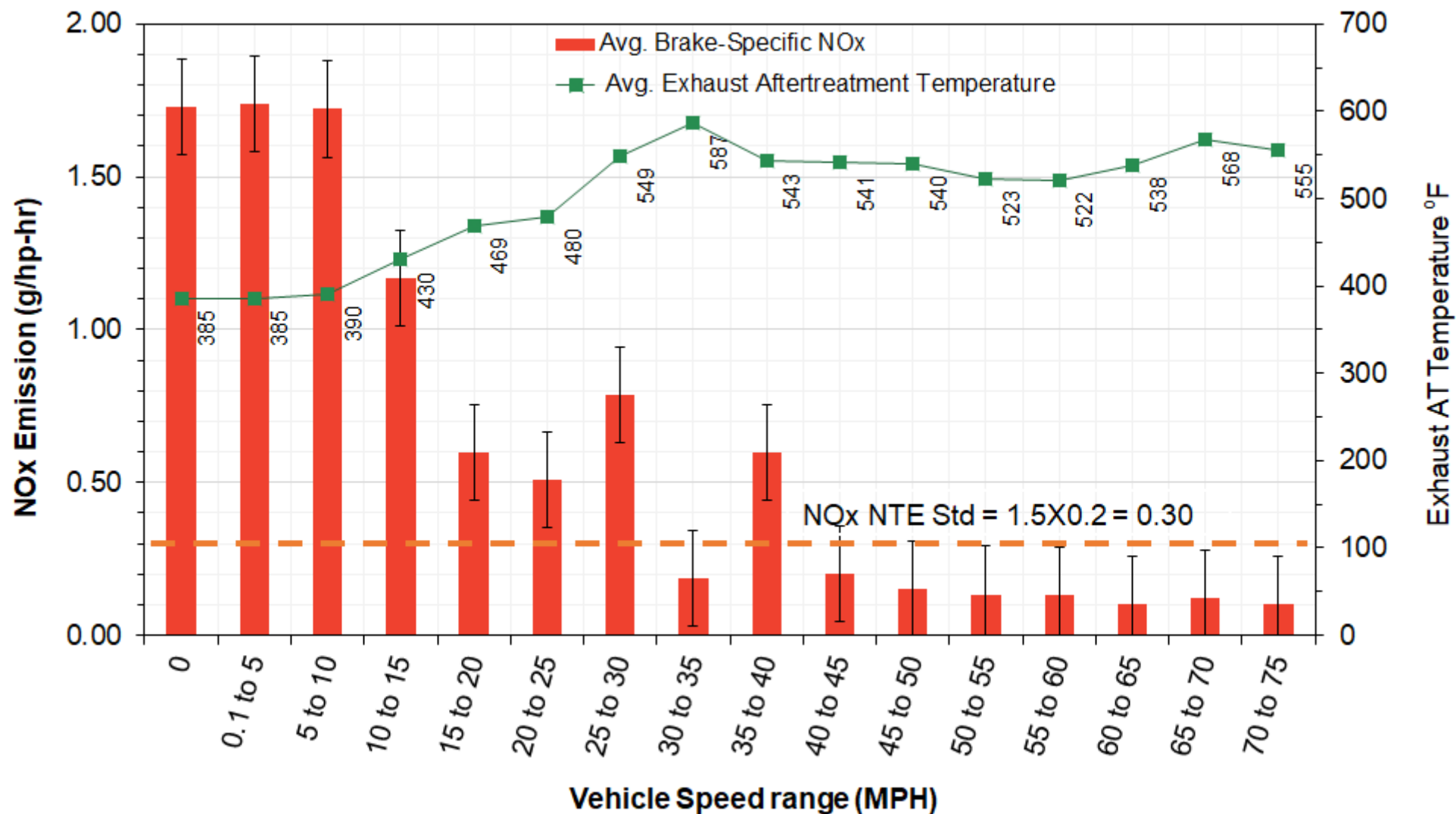
Summary Staistics	Calculated Values
Average Pass Ratio (NOx)	0.98
Max Pass Ratio (NOx)	1
Min Pass Ratio (NOx)	0.84
Number of Vehicles Failed in 2016 Test order	2
Average NOx of Valid NTE Events (g/bhp-hr)	0.10
Average NOx (g/bhp-hr)	0.44
Average NOx Outside NTE Control Zone (g/bhp-hr)	0.66
Average Cold NOx (g/bhp-hr)	2.52
Average NOx (g/mile)	1.04
Total Mass NOx per Test Day (g)	10024
Average Test Duration (hr)	8
Average Covered Mileage (mile)	303
Total Mileage (mile)	13328
Percent Time and Work Outside NTE Zone	67% and 24%
Percent Time and Work in NTE Zone w/o Exclusions	33% and 76%
Percent Time and Work in NTE Zone w/ Exclusions	17% and 39%
Percent Time and Work of Valid NTE Events in NTE Zone	7% and 16%

Overall NTE NO_x Emission and Average Mass NO_x Per Shift Day Calculated from Tested Vehicles

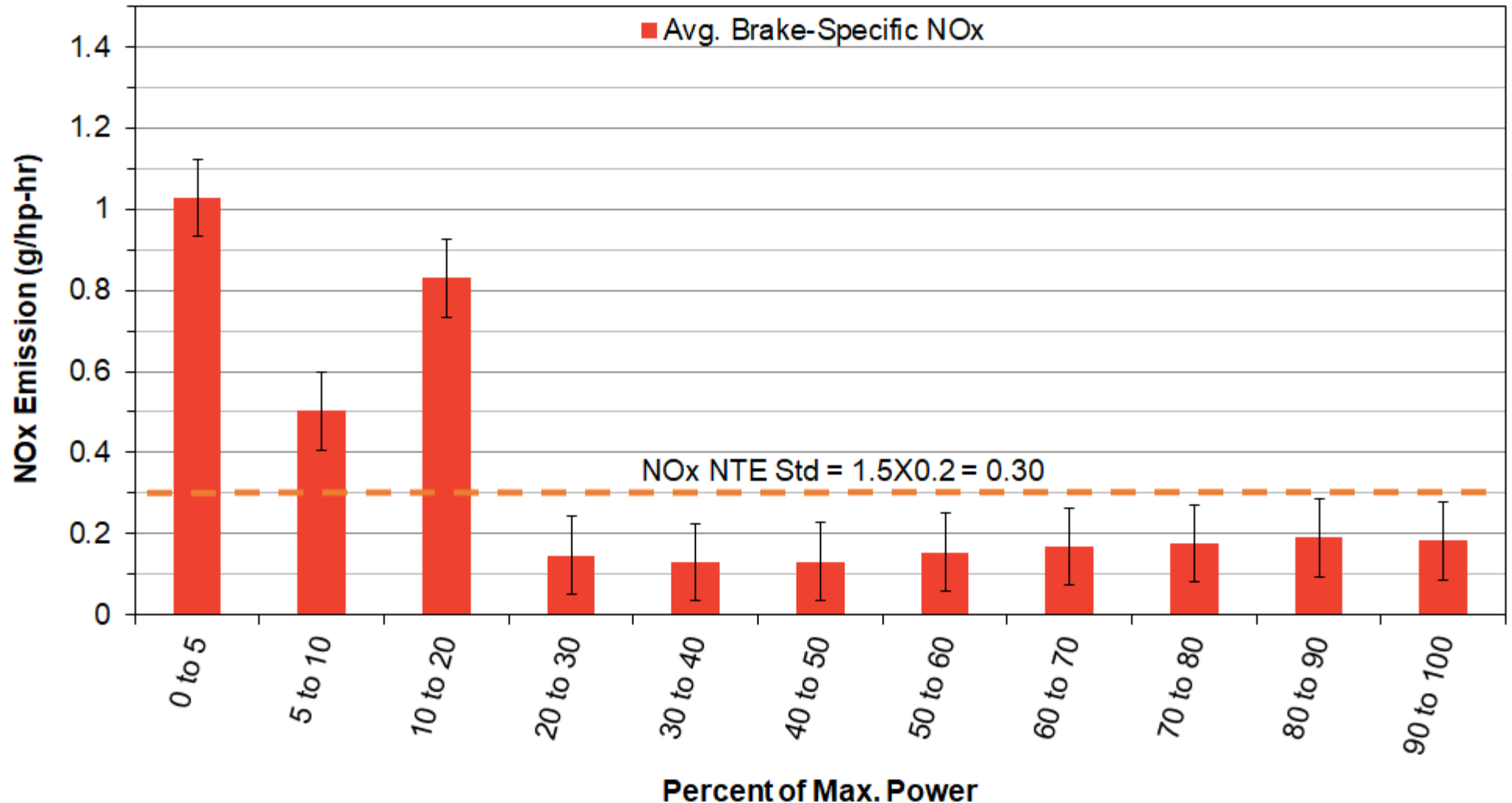
- ❑ Average NO_x emissions from valid NTE sampling events are lower than the Standard/FEL NO_x
- ❑ Average cold NO_x is always higher than the NTE NO_x

MFR Name	MFR Engine Family	Production Volume for Corresponding	Average Mass NO _x per Shift Day	Estimated NO _x Production per Shift Day	Standard/FEL NO _x	Average NO _x	Average NO _x of Valid NTEE	Average NO _x Outside NTE Zone	Average NO _x (Non-Idle)	Average NO _x (Idle)	Average Cold NO _x	Distance Specific NO _x
			(g)	(Metric ton)	(g/bhp-hr)	(g/bhp-hr)	(g/bhp-hr)	(g/bhp-hr)	(g/bhp-hr)	(g/hr)	(g/bhp-hr)	(g/mile)
Manufacturer 1 MY2013	DMFR1-MDEFN1	45973	120.52	5.54	0.20	0.67	0.13	0.88	0.59	7.07	1.82	2.28
Manufacturer 1 MY2014	EMFR1-HDEFN2	3178	232.54	0.74	0.20	0.28	0.12	0.59	0.1	43.73	3.87	0.85
Manufacturer 1 MY2014	EMFR1-HDEFN3	42329	450.61	19.07	0.31	0.38	0.07	0.41	0.34	16.67	1.69	1.02
Manufacturer 2 MY2014	EMFR2-HDEFN1	32279	132.23	4.27	0.20	0.25	0.04	0.29	0.12	23	2.81	0.57
Manufacturer 3 MY2014	EMFR3-MDEFN1	2911	104.06	0.30	0.20	0.31	0.08	0.57	0.26	38.81	1.47	0.5
Manufacturer 4 MY2014	EMFR4-LDEFN1	12071	109.23	1.32	0.20	0.56	0.2	0.48	0.34	37.34	2.02	0.52
Manufacturer 5 MY2014	EMFR5-HDEFN1	34196	368.17	12.59	0.20	0.38	0.12	0.54	0.3	73.61	4.05	1.17
Manufacturer 6 MY2015	FMFR6-MDEFN1	7744	110.03	0.85	0.50	0.53	0.08	0.63	0.34	19.31	1.72	0.67
Manufacturer 7 MY2015	FMFR7-HDEFN1	4081	322.82	1.32	0.20	0.61	0.02	1.55	0.13	30.13	3.25	1.78

Urban Brake-Specific NO_x Emissions are About 3-5 X NTE Standard – Engine Family Name: EMFR1-HDEFN3, Vocational Truck

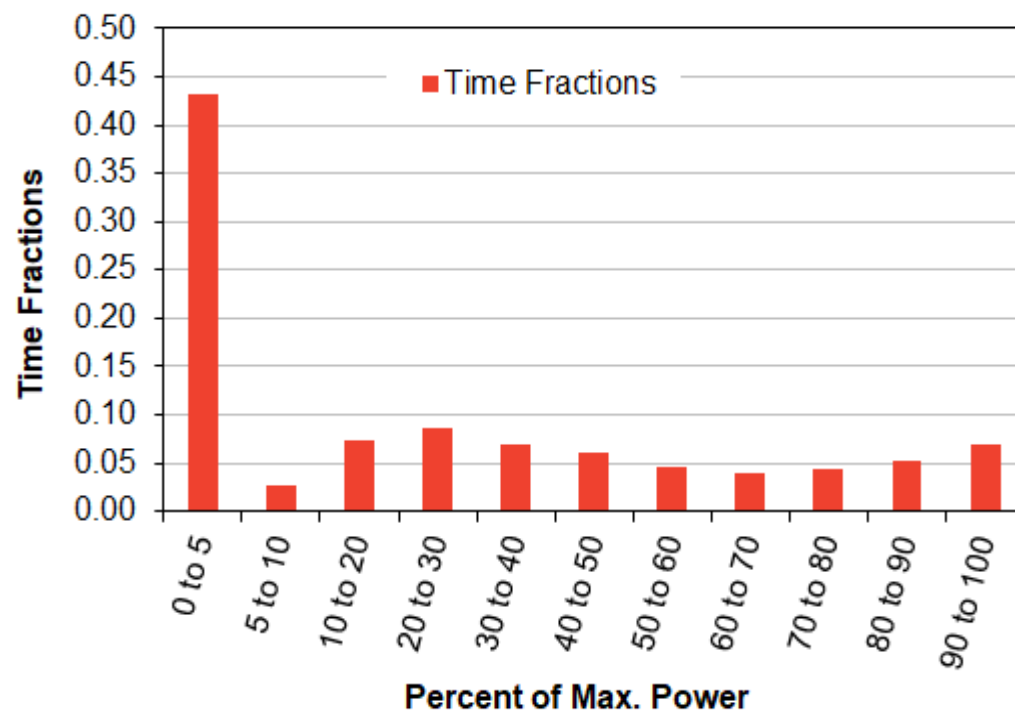
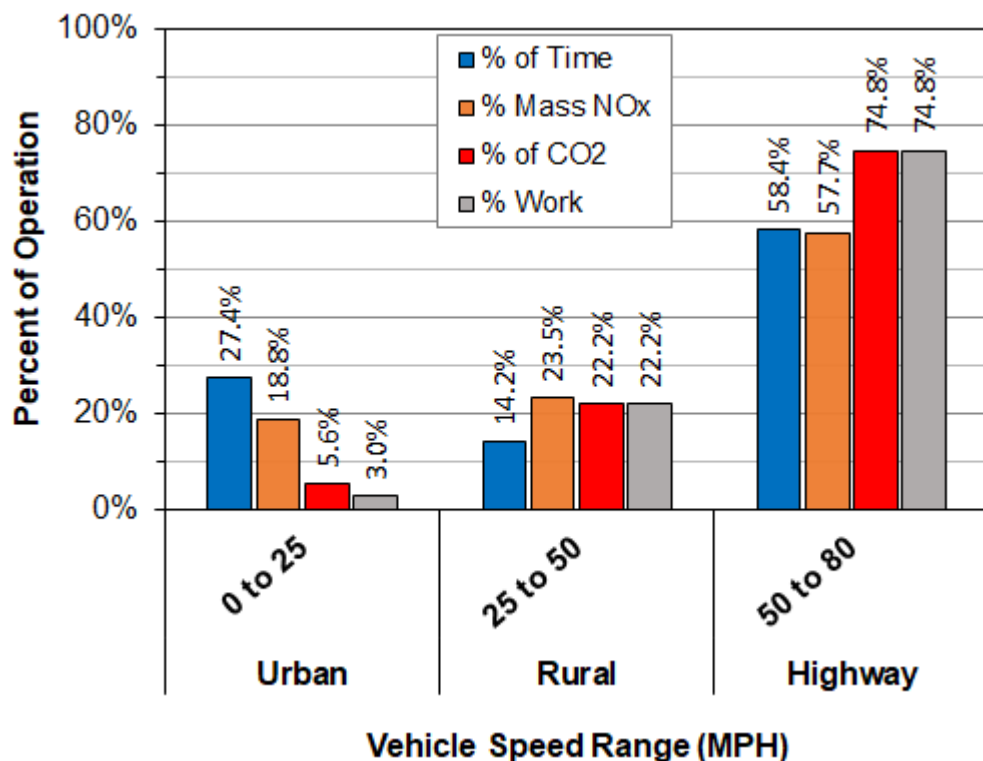


Average Brake-Specific NOx Emissions Increase at Lower Power Especially below 30% of Max Power -
 Engine Family Name: EMFR1-HDEFN3, Vocational Truck

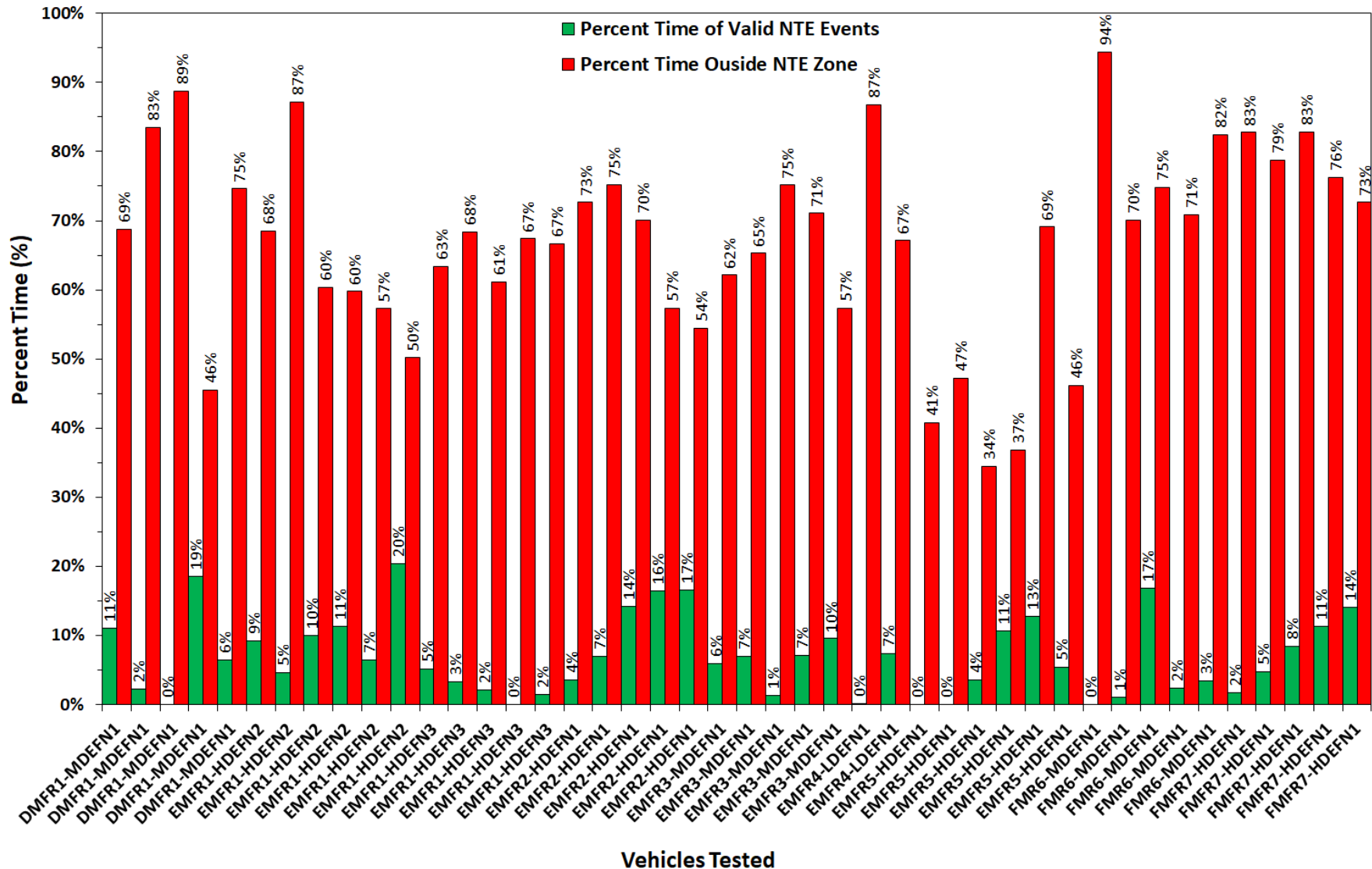


Percent of Time Spent in Urban Driving and Idling - Engine Family Name: EMFR1-HDEFN3, Vocational Truck

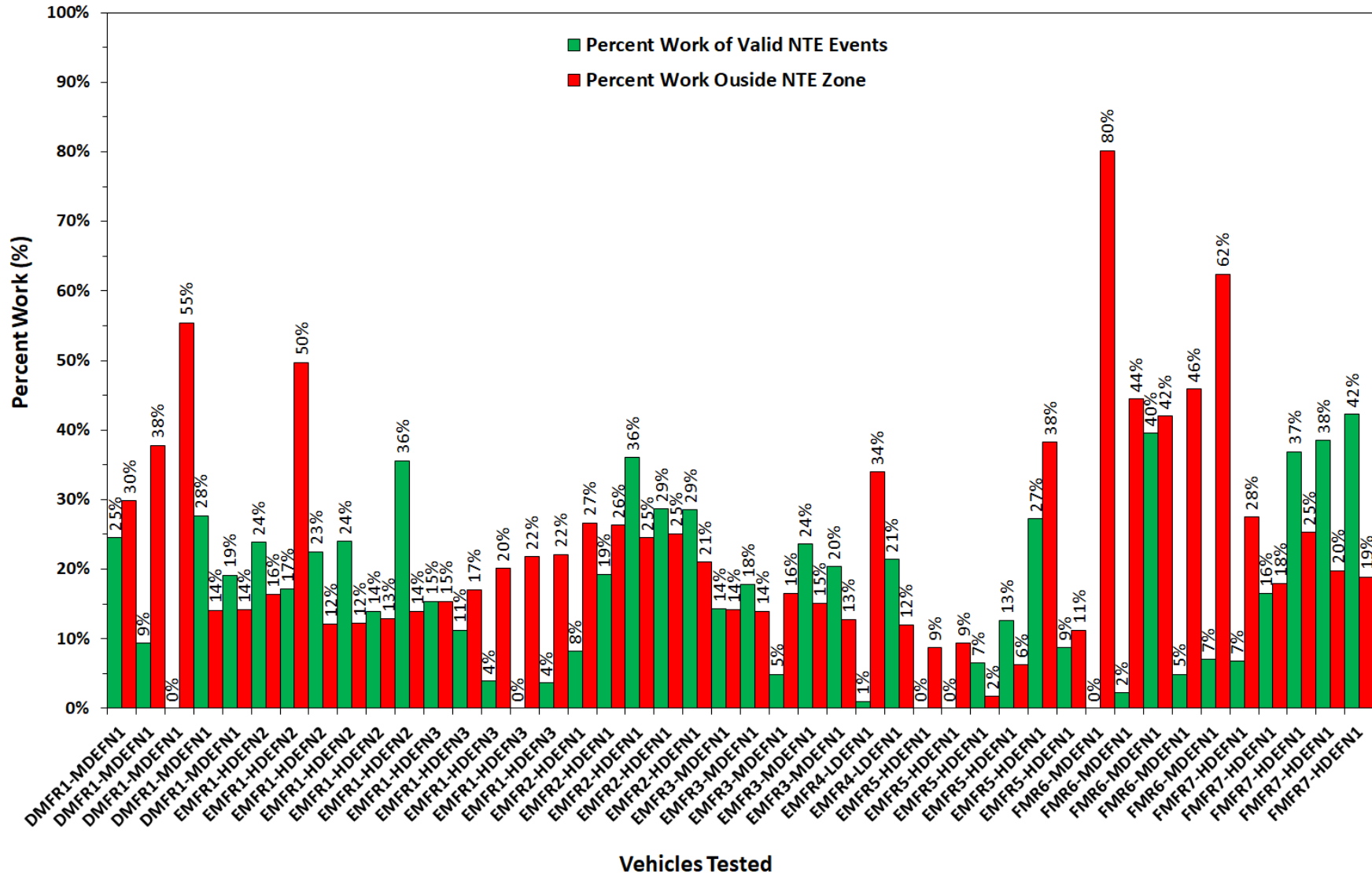
- Urban + rural driving represent over 40% of the HD NOx emissions time from vehicles
- In real driving low speed and idling are major part of the duty cycles even for line haul and delivery vehicles



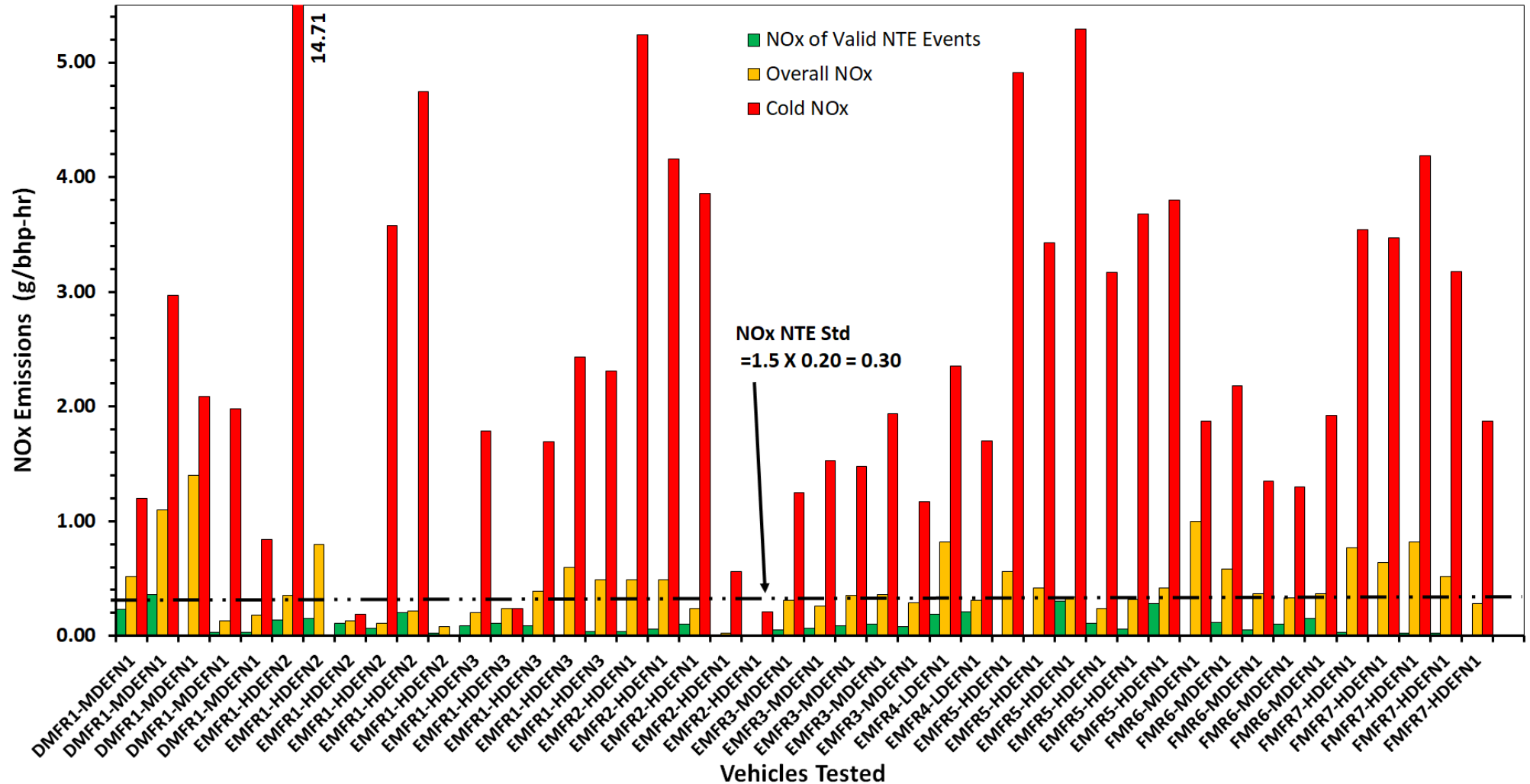
Percent Time of In-Use Testing in Valid NTE Events vs. Outside Valid NTE Events



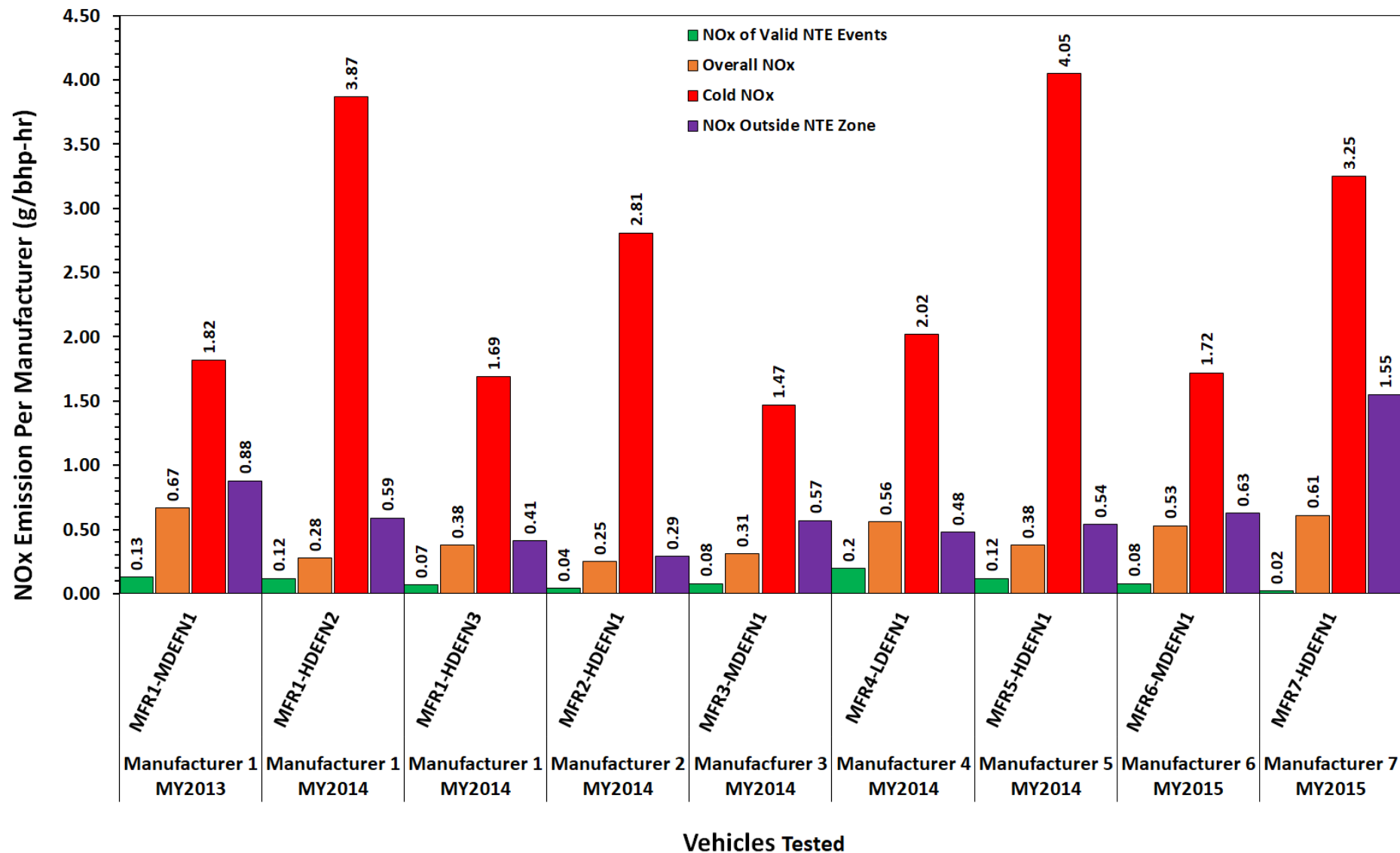
Percent Work of In-Use Testing in Valid NTE Events vs. Outside Valid NTE Events



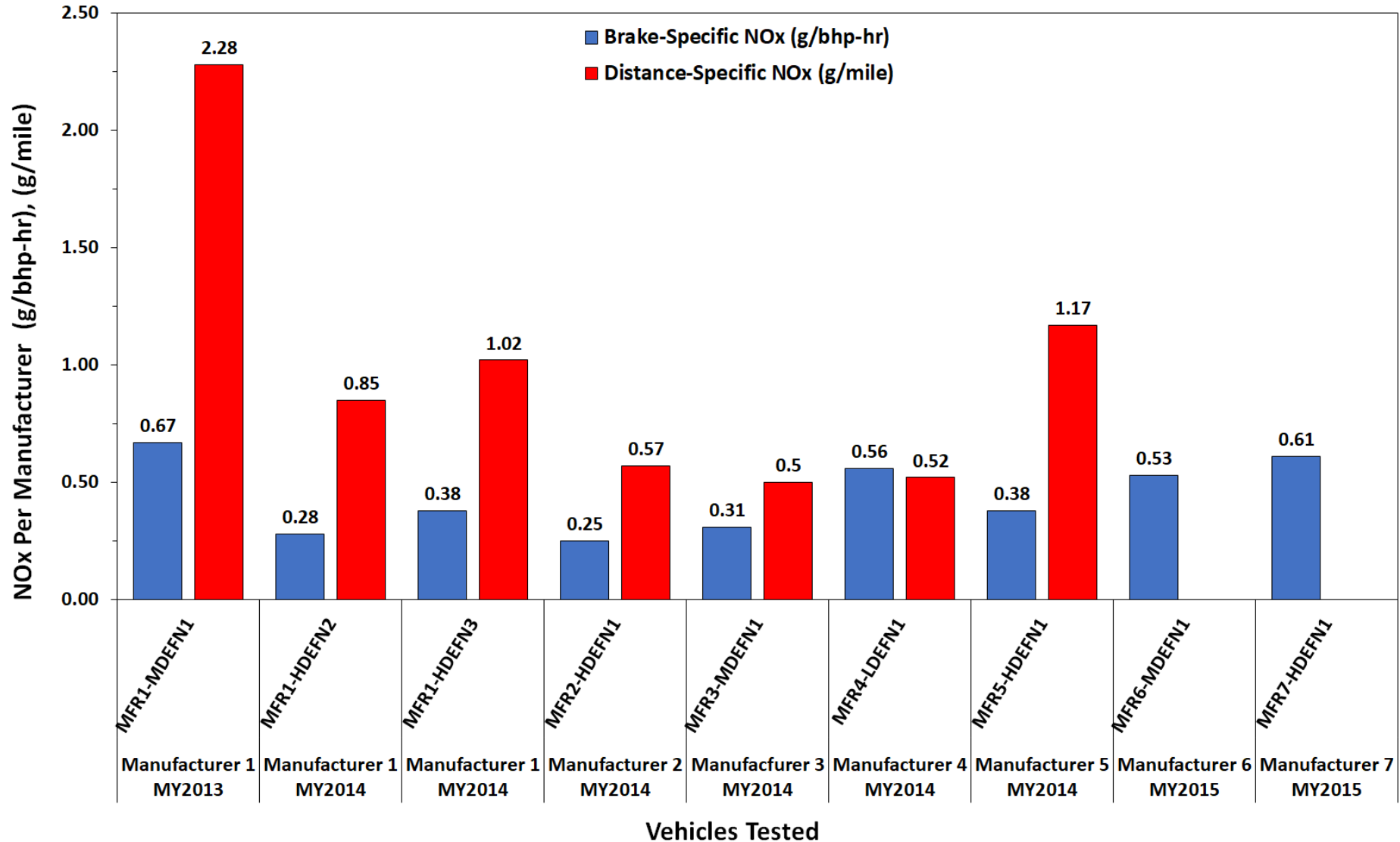
Average NOx Emissions of Valid NTE Events vs. Overall NOx and Cold NOx Emissions



Average Brake-Specific NOx Emissions per Engine Family



Average Brake-Specific vs. Distance Specific NO_x Emissions per Engine Family



Summary of Data Submitted for 2012 – 2016 Test Orders

- ❑ **Overall average vehicle pass ratios submitted since 2012.**
 - ❑ **NO_x = 0.97**
 - ❑ **PM = 0.99**
 - ❑ **CO = 1.0**

- ❑ **Percentage of tests meeting or exceeding the 0.90 vehicle-pass ratio threshold since 2012.**
 - ❑ **NO_x = 94%**
 - ❑ **PM = 100%**
 - ❑ **CO = 100%**

- ❑ **Estimated total mileage covered is greater than 200,000 miles.**

- ❑ **Manufacturer-Run In-Use Testing Program Data for Heavy-Duty Diesel Engines from 2009 – 2015 are posted on the EPA website. The data are organized by test order year and have been redacted for Confidential Business Information (CBI). Use the link below to visit the website.**

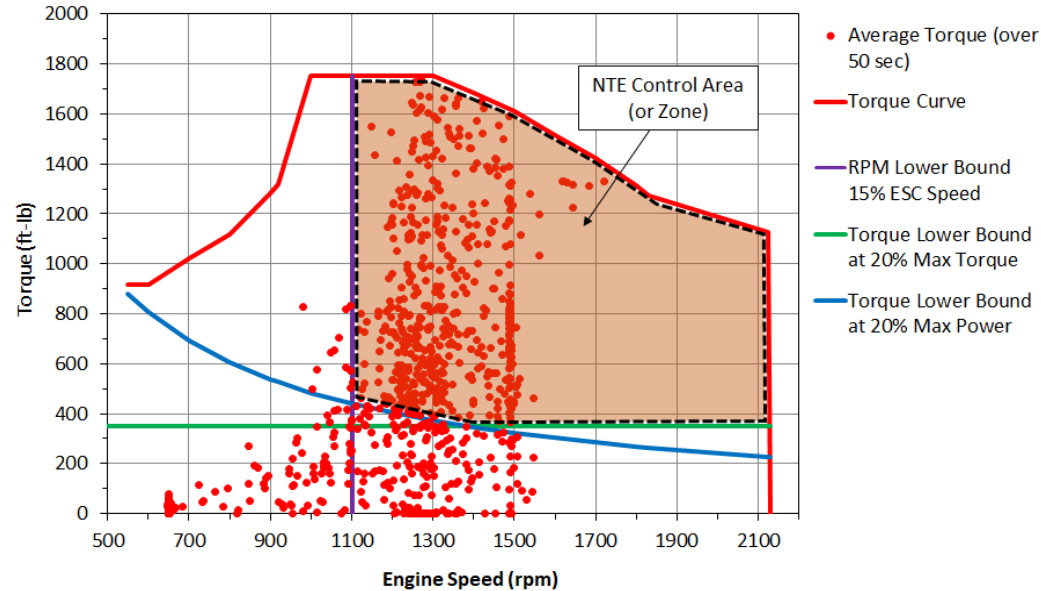
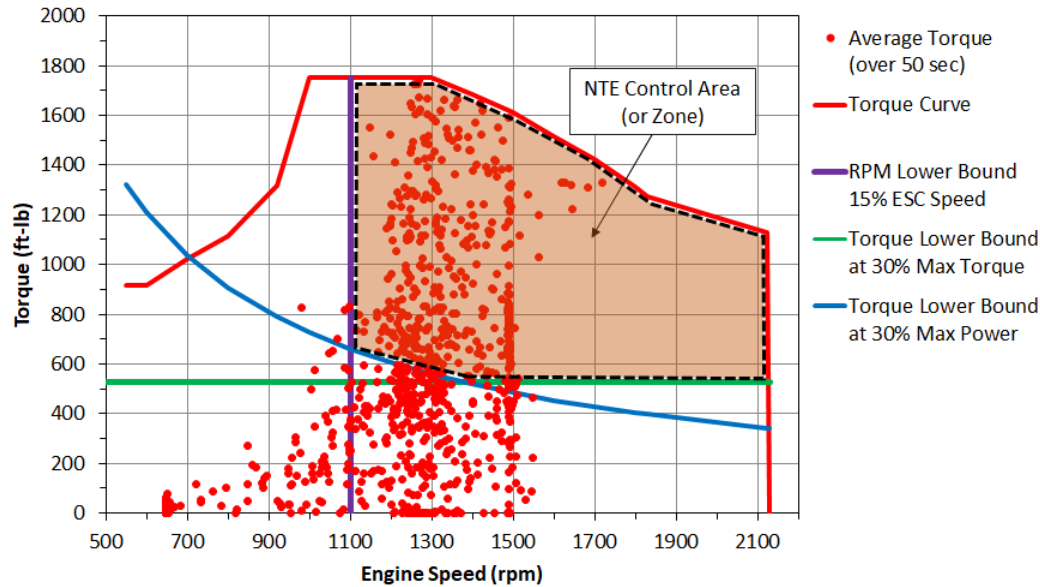
<https://www.epa.gov/compliance-and-fuel-economy-data/manufacturer-run-use-testing-program-data-heavy-duty-diesel-3>

- ❑ **Manufacturers in-use testing is important to ensure on-highway heavy duty diesel engines are in compliance with NTE standards and test procedures.**
- ❑ **Engine selection for in-use testing program forced several manufacturers to initiate voluntary recalls due to defects in the after-treatment system and emission control devices.**
- ❑ **In-use emissions testing can positively influencing air quality by ensuring that manufacturers implement emissions control technologies to achieve emissions reduction under real driving conditions including low speeds and loads.**
- ❑ **Recognizing the difference between type-approval engine emissions and in-use emissions results, adding low load data would more realistically reflect real world operation.**
- ❑ **In addition, data may more realistically reflect real world emissions if NTE Zone(s) boundaries are modified to include:**
 - ❑ **Lower percentage of max. power (e.g., 20%, 10%, etc...), and**
 - ❑ **Cold intake manifold (i.e., removal of exclusion 8).**
 - ❑ **Introduce new NTE multipliers.**
- ❑ **Cold-start and idle NO_x emissions, almost without exception exceed the NTE emission limits.**

APPENDIX

EMA Proposal for In-Use Testing Nationwide not Just California (JB, 10/26/2018)				
Standards are in g/bhp-hr	2024		2027 ⁺	
Composite-FTP	0.15		Approximate 50% reduction in real-world in-use NOx	
Steady State RMC	0.15		New Paradigm potentially utilizing NOx sensors (depending on sensor development and durability) and telematics to assess aggregate in-use engine family performance	
In-Use Program	NTE Standard: 0.22 (0.15 g/bhp-hr x 1.5)? Increased coverage of in-use operations via expanded NTE parameters:			
		Current		Expanded
	Min event duration	30 sec		15 sec
	Max event duration	10 min or 10x shortest event (600 seconds max)		Unlimited
	Min Torque	30%		20% of Max Torque
	Min Power	30%		20% of Max Power
	Min aftertreatment temp	250 °C		230 °C
	IMT exclusion (8)	Reduce by 20 °C		
	Continue data gathering to support New Paradigm in 2027			
OBD Limit	0.40		New Paradigm	
Useful Life	Same as current program		(LHD, MHD, HHD) TBD	
Certification Fuel	Non-bio fuel only		Non-bio fuel only	

NTE Control Area - Engine Family Name: EMFR1-HDEFN3, Vocational Truck



Current NTE Control Area

Valid NTE event duration is between 30 – 600 seconds of vehicle continuous operation in the NTE zone with all exclusions set in the current regulation are applied

EMA Expanded NTE Control Area

Valid NTE event duration is between 15 to unlimited seconds of vehicle continuous operation in the NTE zone

- *EMA is proposing a 0.15 g/bhp-hr national standard*
- *NTE standard $0.15 \times 1.5 = 0.23$ g/bhp-hr*
- *IMT exclusion is reduced by 20 °C (68 °F)*

Valid NTE Events and Vehicle-Pass Ratio - Engine Family Name: EMFR1-HDEFN3, Vocational Truck

Pass Ratios for NTEE Min. Time = 15 sec, at 20% Max. Power	Macro Calculated	MFR/XML Reported
NMHC Pass Ratio:	1.00	1.00
CO Pass Ratio:	1.00	1.00
NOx Pass Ratio:	0.93	1.00
NOx & NMHC Pass Ratio:	N/A	N/A
PM pass ratio:	1.00	1.00
# of NTE Events:	379	38

MFR Reported Standard/FEL, Multiplier, Accuracy Margin, and NTE Threshold	NOx	NMHC	CO	NOx+NMHC	PM
Standard	0.15	0.14	15.5	N/A	0.01
Multiplier	1.5	1.5	1.25	N/A	1.5
In use Margin	N/A	N/A	N/A	N/A	N/A
Accuracy Margin	0.15	0.01	0.15	N/A	0.01
Threshold(g/bhp-hr)	0.38	0.22	19.5	N/A	0.03

Emissions Summary	Total Emissions (g)							Total Work (hp-hr)
	Time (sec)	Time (%)	NOx	NMHC	CO	CO2	PM	Work
Total Throughout Test	47,471	100.0%	340.33	5.90	626.85	873,916.64	2.45	1,727.03
	Percent of Total Emissions and Work							
Percent of	Time (sec)	Time (%)	NOx	NMHC	CO	CO2	PM	Work
Total outside of NTE Control Area	26,120	55.0%	21.5%	58.4%	27.0%	13.0%	52.5%	7.8%
Total in NTE Control Area (w/o exclusions)	21,351	45.0%	78.5%	41.6%	73.0%	87.0%	47.5%	92.2%
Exclusion 6 (Deficiency)	0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Exclusion 7 (EMD/OBD)	0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Exclusion 8 (EGR/Cold Temp Operation)	0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Exclusion 9 (Aftertreatment/Low Temp Operation)	1,626	3.4%	19.6%	18.8%	5.3%	5.4%	8.9%	5.6%
Exclusion 10 (Altitude/Amb Temp)	0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Exclusion 11 (Zero Check)	0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total in NTE Control Area (w/ all exclusions applied)	19,725	41.6%	58.9%	22.8%	67.7%	81.6%	38.6%	86.5%
Total in NTE Control Area with LTR flag	0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total in "Basic" NTE w/o excl with Regen flag	0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total of Valid NTE Events in NTE Control Area	16,825	35.4%	54.7%	18.8%	57.8%	73.8%	35.3%	78.2%

Exclusions as Set in the Current Regulations

Set EMD/OBD Code	Regeneration Signal	Engine Incapable LTR Encountered Indicator	Zero Check Indicator	Deficiency Encountered Indicator	Time-Weighted Carve-Out Limited Testing Region (TWCOLTR)	EGR Cold Temperature Operation Indicator (8)	NOx and NMHC Aftertreatment Insufficient Warmup Indicator (9)	High Altitude Indicator	NTE Zone Indicator
EMD_Code_Set An indication, if available, of whether an engine manufacturer diagnostics/on-board diagnostics (EMD/OBD) code was set over the previous second of operation as per J1939, 1587, 1708, or 2284 as appropriate. Permitted values: yes, no. Exclude the test point if an EMD code was set (EMD_Code_Set {DE236} = Y). 86.1910(b)(3).	Regen_Signal An indication, if available, of whether any signal from the ECM to initiate or maintain a regeneration event was set over the previous second. Permitted values: yes, no. If yes, the data recorded at this second are not to be used for NTE calculations. (The number of Ys will be counted to determine the length of the regeneration event.)	EI_LTR_Flag An indication of whether the engine was operating in an engine incapable limited testing region (EILTR) or not during the previous second.. Exclude the test point if the engine was operating in the area of one or more approved deficiencies (Def_Flag {DE384} = 1 - 9 and MY {DE40} = 2007 – 2009 indicates that the point should be excluded). 86.007-11(a)(4)(iv)	Zero_Check_Flag An indication of whether the analyzer was performing a periodic zero check. If yes, the data recorded at this second are unusable for NTE calculations.	Def_Flag An indication of whether the engine was operating under an approved deficiency and if so which one (as numbered in the certification application) (1, 2, 3, 4, 5, 6, 7, 8, 9), was not operating under an approved deficiency (N), or readings were not collected or data were not evaluated to determine whether the engine operated in a deficiency (U), during the previous second. If exclusions of records are claimed based on operation in a deficiency (U) cannot be used.	TWCOLTR_Flag An indication of whether the engine was operating in a Time-Weighted Carve-Out Limited Testing Region (TWCOLTR) or not during the previous second.	EGR_Cold_Ops_Flag An indication of whether an engine with EGR (DE120 = Y) was operating in a region of cold temperature conditions [as per 86.1370-2007(f)] or not during the previous second. If yes, the data recorded at this second are not to be used for NTE calculations. <i>IMT ≤ IMT found in IMP (absolute pressure in bars) = 0.0875 x IMT(°F) – 7.75, or engine coolant temp ≤ ECT found in IMP(abs bar) = 0.0778 x ECT(°F) – 9.8889</i>	Aftertreatment_Cold_Ops_Flag An indication of whether an engine with an aftertreatment device that reduces NOx (DE123 = Y) or NMHC (DE22 = Y) was operating in a region of cold exhaust gas temperature conditions [as per 86.1370-2007(g)] or not during the previous second. If yes, the data recorded at this second are not to be used for NTE calculations. <i>Exclude EGT < 250 °C within 12 inches of the outlet of aftertreatment system.</i>	High_Altitude_Flag An indication of whether an engine was operating in a region it considers high altitude [as per 86.007-11(a)(4)(ii)] or not during the previous second. If yes, the data recorded at this second are not to be used for NTE calculations. <i>All altitudes ≤ 5,500 feet for T(oF) ≤ - 0.00254*A(ft)+ 100</i>	NTEZ_Flag An indication of whether an engine was operating in the NTE Zone (with all exclusions, LTRs, etc. applied) or not during the previous second. If No, the data recorded at this second are not to be used for NTE calculations.

Effects of Exclusions on NTE In-Use Testing

Effects of Exclusions 8, 9, Valid NTE Event Duration and % of Max. Power on In-use Testing

Total Shift Day Testing Time = 47,471 sec (13.20 hr.), and Mass NOx = 340.33 (g)			1	2	3	4	5	6	7	8
			Total Outside of NTE Control Area	Total in NTE Control Area without Exclusions	Exclusion 8: EGR/Cold Temp	Exclusion 9: After treatment Low Temp	Total in NTE Control Area with all Exclusions)	Total of Valid NTE Events in NTE Control Area	Vehicle Pass-Ratio (NOx)	Number of Valid NTE Events
1	NTEE Min. Time = 30 sec with Exclusions 8 and 9 at 30% Max. Power	Time (sec)	30,080	17,391	11,563	2,522	5,270	2,431	1.00	37
		Time (%)	63.4%	36.6%	24.4%	5.3%	11.1%	5.1%		
		NOx (%)	27.3%	72.7%	50.9%	24.6%	13.4%	7.3%		
2	NTEE Min. Time = 30 sec without Exclusions 8 and 9 at 30% Max. Power	Time (sec)	30,080	17,391	0	0	17,391	9,854	0.97	171
		Time (%)	63.4%	36.6%	0.0%	0.0%	36.6%	20.8%		
		NOx (%)	27.3%	72.7%	0.0%	0.0%	72.7%	40.8%		
3	NTEE Min. Time = 30 sec with Exclusions 8 and 9 at 20% Max. Power	Time (sec)	26,120	21,351	14,375	3,689	6,142	2,957	1.00	47
		Time (%)	55.0%	45.0%	30.3%	7.8%	12.9%	6.2%		
		NOx (%)	21.5%	78.5%	54.7%	28.2%	13.7%	8.4%		
4	NTEE Min. Time = 30 sec without Exclusions 8 and 9 at 20% Max. Power	Time (sec)	26,120	21,351	0	0	21,351	13,698	0.96	215
		Time (%)	55.0%	45.0%	0.0%	0.0%	45.0%	28.9%		
		NOx (%)	21.5%	21.5%	0.0%	0.0%	78.5%	50.9%		
5	NTEE Min. Time = 30 sec with Exclusions 8 and 9 at 10% Max. Power	Time (sec)	23,050	24,421	16,443	4,634	6,913	3,859	1.00	64
		Time (%)	48.6%	51.4%	34.6%	9.8%	14.6%	8.1%		
		NOx (%)	18.2%	81.8%	56.2%	30.5%	14.0%	9.1%		
6	NTEE Min. Time = 30 sec without Exclusions 8 and 9 at 10% Max. Power	Time (sec)	23,050	24,421	0	0	24,421	18,838	0.96	266
		Time (%)	48.6%	51.4%	0.0%	0.0%	51.4%	39.7%		
		NOx (%)	18.2%	81.8%	0.0%	0.0%	81.8%	60.4%		
7	NTEE Min. Time = 1 sec with Exclusions 8 and 9 at 30% Max. Power	Time (sec)	30,080	17,391	11,563	2,522	5,270	5,270	0.99	809
		Time (%)	63.4%	36.6%	24.4%	5.3%	11.1%	11.1%		
		NOx (%)	27.3%	72.7%	50.9%	24.6%	13.4%	13.4%		
8	NTEE Min. Time = 1 sec without Exclusions 8 and 9 at 30% Max. Power	Time (sec)	30,080	17,391	0	0	17,391	17,391	0.95	2332
		Time (%)	63.4%	36.6%	0.0%	0.0%	36.6%	36.6%		
		NOx (%)	27.3%	72.7%	0.0%	0.0%	72.7%	72.7%		
9	NTEE Min. Time = 1 sec with Exclusions 8 and 9 at 10% Max. Power	Time (sec)	23,050	24,421	16,443	4,634	6,913	6,913	0.99	939
		Time (%)	48.6%	51.4%	34.6%	9.8%	14.6%	14.6%		
		NOx (%)	18.2%	81.8%	56.2%	30.5%	14.0%	14.0%		
10	NTEE Min. Time = 1 sec without Exclusions 8 and 9 at 10% Max. Power	Time (sec)	23,050	24,421	0	0	24,421	24,421	0.94	2869
		Time (%)	48.6%	51.4%	0.0%	0.0%	51.4%	51.4%		
		NOx (%)	18.2%	81.8%	0.0%	0.0%	81.8%	81.8%		

In-use emissions data were collected from 44 heavy-duty (HD) on-highway vehicles that were operated on their representative routes in different states consistent with Not-To-Exceed (NTE) test procedures. These vehicles were selected by EPA and CARB for 2016 Test Order manufacturer run in-use testing program for HD diesel engines from model years 2013- 2015. The selected vehicle classes are light, medium and heavy-duty, with trailers, no trailers, plain closed box, dump trailers, tank and others. All vehicles had engines that were certified to either 0.20, 0.25, 0.31, or 0.50 g/hp-hr NO_x standard/family emission limits, and to 0.01 g/hp-hr PM. The NTE limits for these vehicles ranged from 0.45 to 0.90 g/hp-hr.

Our computational and statistical analyses of the in-use data showed that the percent time and work outside the NTE zone are 67% and 24%; in the NTE zone with all exclusions set in the current regulation are 17% and 39%; and without exclusions are 33% and 76% respectively. Consequently, the percent time and work of the valid NTE sampling events are only 7% and 16%. Analyses also revealed that the urban and rural driving represent over 40% of NO_x emissions time and the average brake-specific NO_x emissions are about 3-4 times the NTE standards. In addition, the brake-specific NO_x emissions were significantly higher below 30% of max. power set in the current regulations.

Calculated results showed that the overall average brake-specific NO_x from the 44 vehicles ranged from 0.25 to 0.67 g/hp-hr, for NO_x outside the NTE zone from 0.29 to 1.55 g/hp-hr, for cold NO_x from 1.47 to 4.05 g/hp-hr, and for distance-specific NO_x ranged from 0.5 to 2.28 g/mile. For all vehicles, the average NO_x emissions from the valid NTE sampling events were lower than the certification values, and the corresponding average vehicle-pass ratio was 98%. Results also indicated that low speed and idling are major part of the duty cycles even for line haul and delivery vehicles.

Finally, without the EGR cold temperature and (NO_x and NMHC) aftertreatment warmup exclusions, the percent time in the NTE zone had remarkably improved, and the vehicle-pass ratio was slightly reduced. Also, changing the valid NTE event duration from 30 to 1 sec, had improved significantly the number of NTE events. In contrast, lowering the percent of maximum power from 30% to 10% had slightly reduced the vehicles-pass ratio. In this study, with all exclusion applied only two vehicles failed the in-use testing and several reported no valid NTE events. However, without applying the EGR cold temperature and (NO_x and NMHC) aftertreatment warmup exclusions more than 10% of the vehicles failed the in-use testing.