

Preliminary Results of Sensor Based Onboard Sensing Analysis And Reporting from Fleets During a Two Month Timeframe

OSAR 2025 Conference

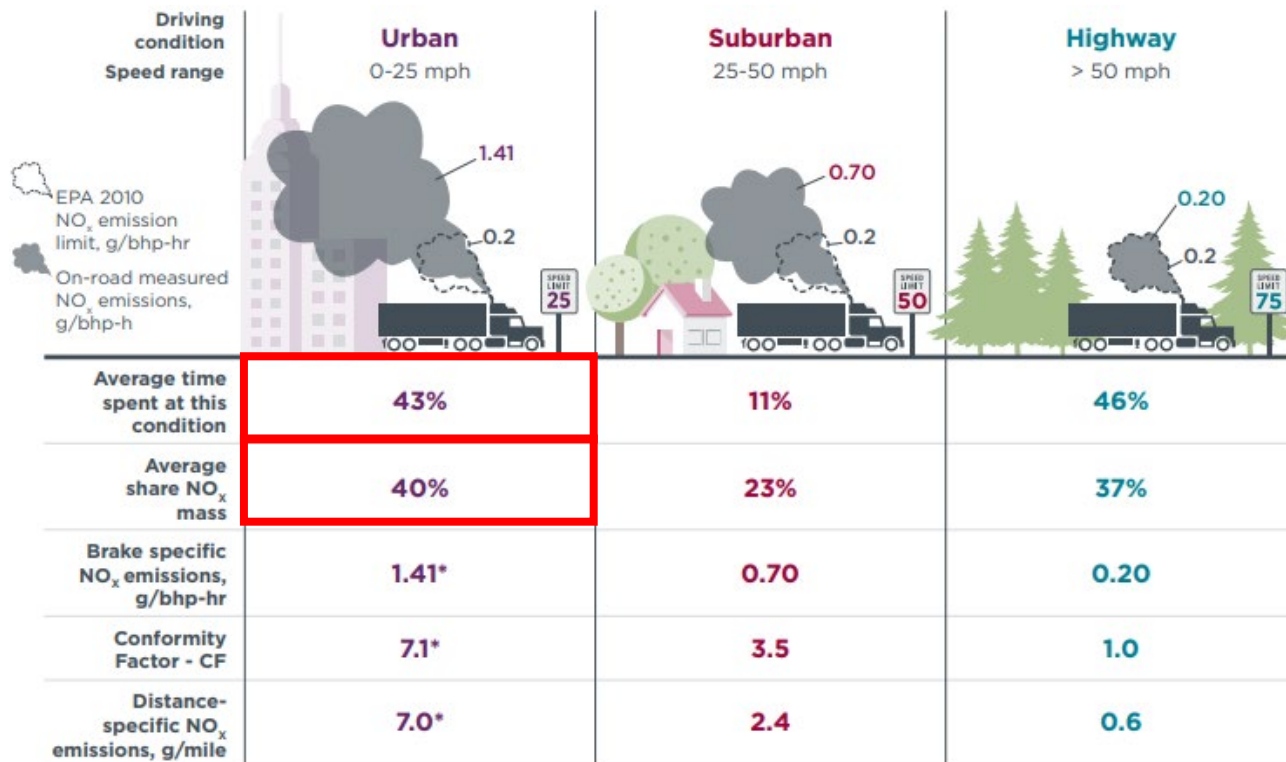
April 17, 2025

Grace Johnson

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CE-CERT



In Use Emissions Vary with Vehicle Operation

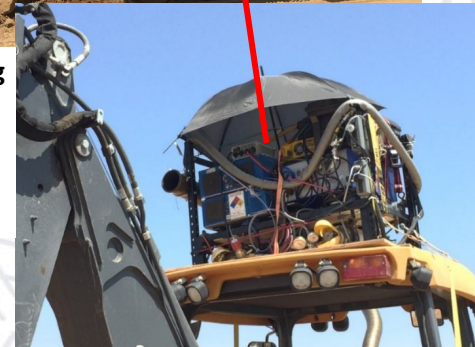
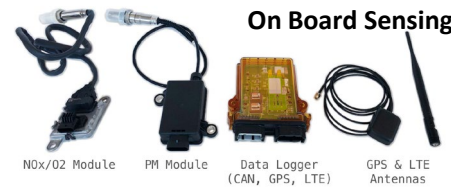
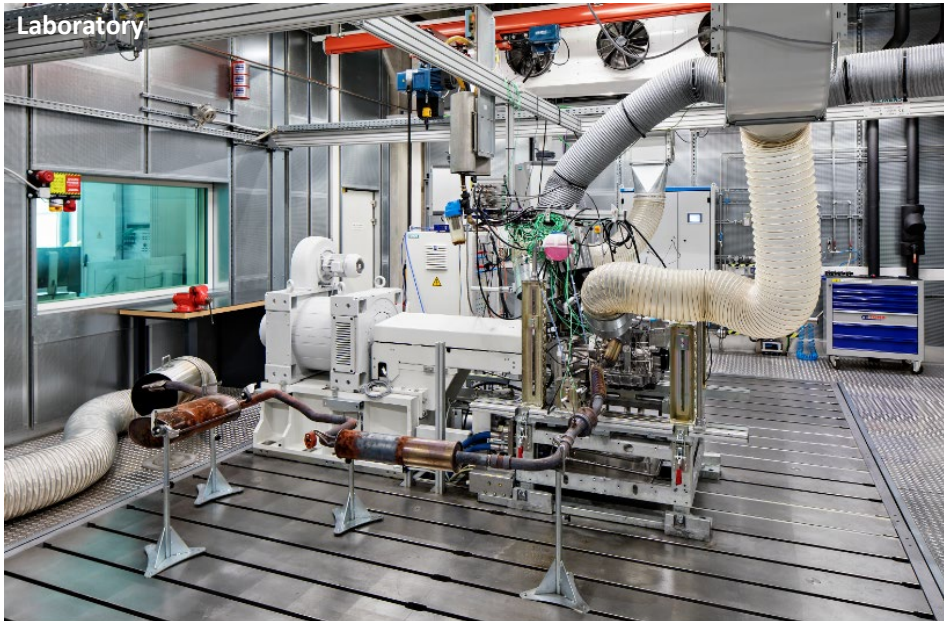


* Brake and distance specific NO_x emissions for Urban bin do not include Idle operation, only 1-25 mph operation is included

- 189 tests between 2010 and 2019
- Model Year (MY) 2010-2016 with SCR Technology
- **43%** of the activity is between 0-25 mph
- This represents **40%** of the NO_x mass

Laboratory, In-Use Measurement, and On-Board Sensing

- Laboratory 2% margin of error (1 day of data takes weeks/months to set up)
- In-use measurement 5% (1 day of data takes 4-6 hrs to set up)
- On-board sensing 10% (1 **year** of data takes <1 hr to set up)

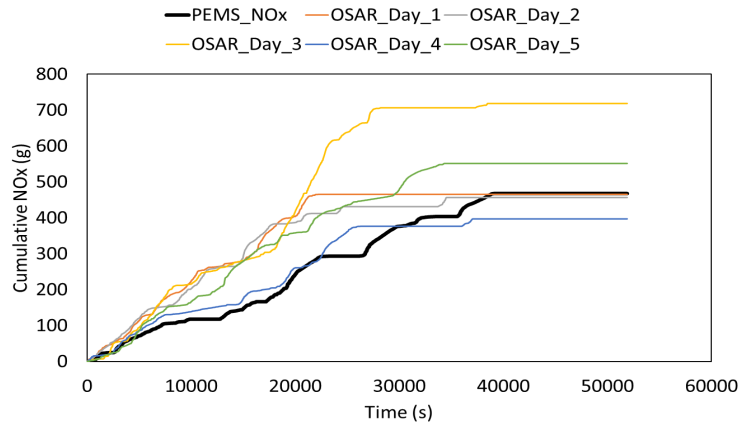
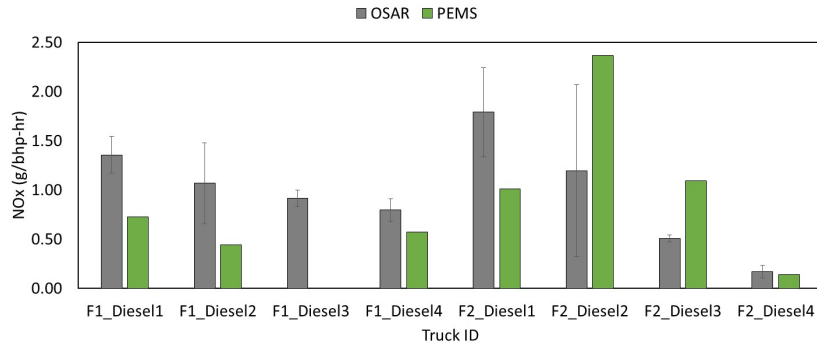


Montes, T., 2018 SAE OBDS Symposium Indianapolis, Diesel OBDS Programs ECARD Division presentation.

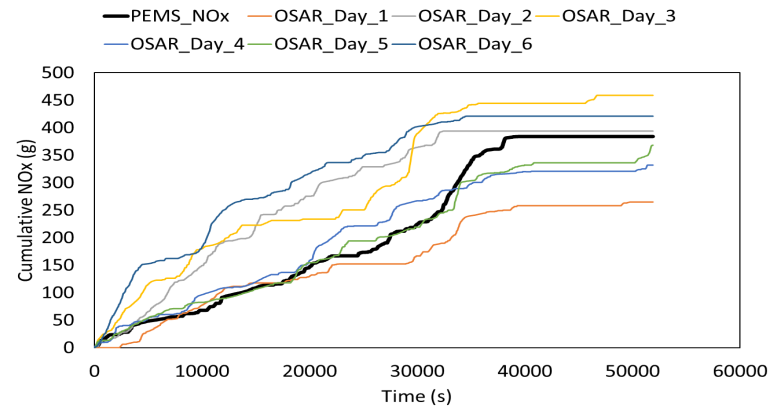
Tan, Y., Collins, J., Yoon, S., Herner, J., Henderick, P., Montes, T., Ham, W., Howard, C., Hu, S., Johnson, K., Scora, G., Sandez, D., Durbin, T., 2018. NOx Emission Estimates from the Activity Data of On-Road Heavy-Duty Diesel Vehicles. Presentation at 28th CRC Real World Emissions Workshop, Garden Grove, CA, March.

Yang, J., Durbin, T.D., Jiang, Y., Tange, T., Karavalakis, G., Cocker III, D.R., Johnson, K.C., 2018. A comparison of a mini-PEMS and a 1065 compliant PEMS for on-road gaseous and particulate emissions from a light duty diesel truck, Science of the Total Environment, vol. 640-641, 368-376.

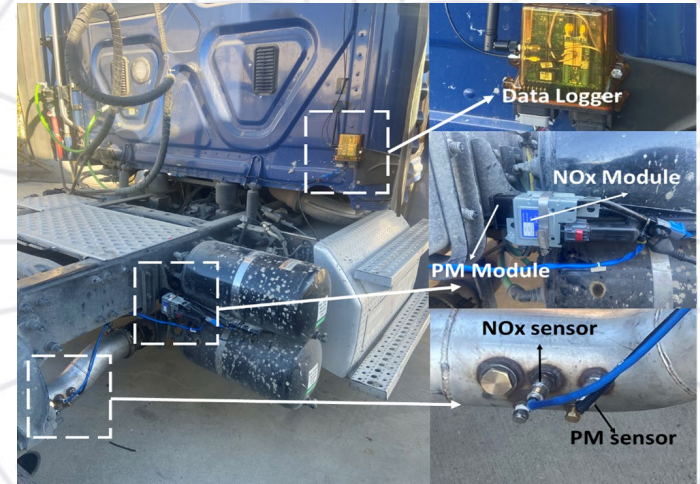
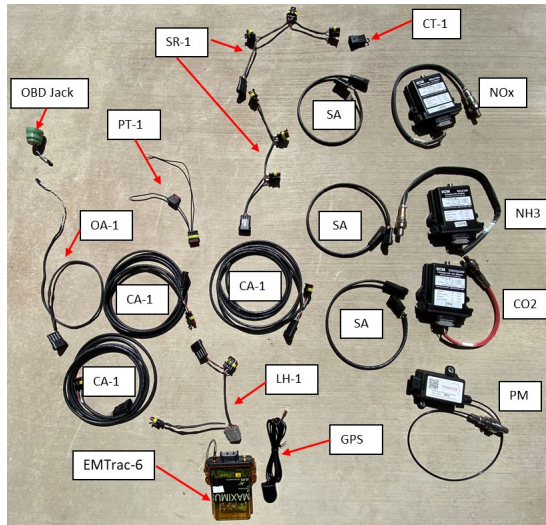
One Day of PEMS Testing Is Not Representative



- Emissions change between days on the same vehicle
- PEMS data presented emissions measured on one day
- OSAR data showed several days of continuous monitoring results

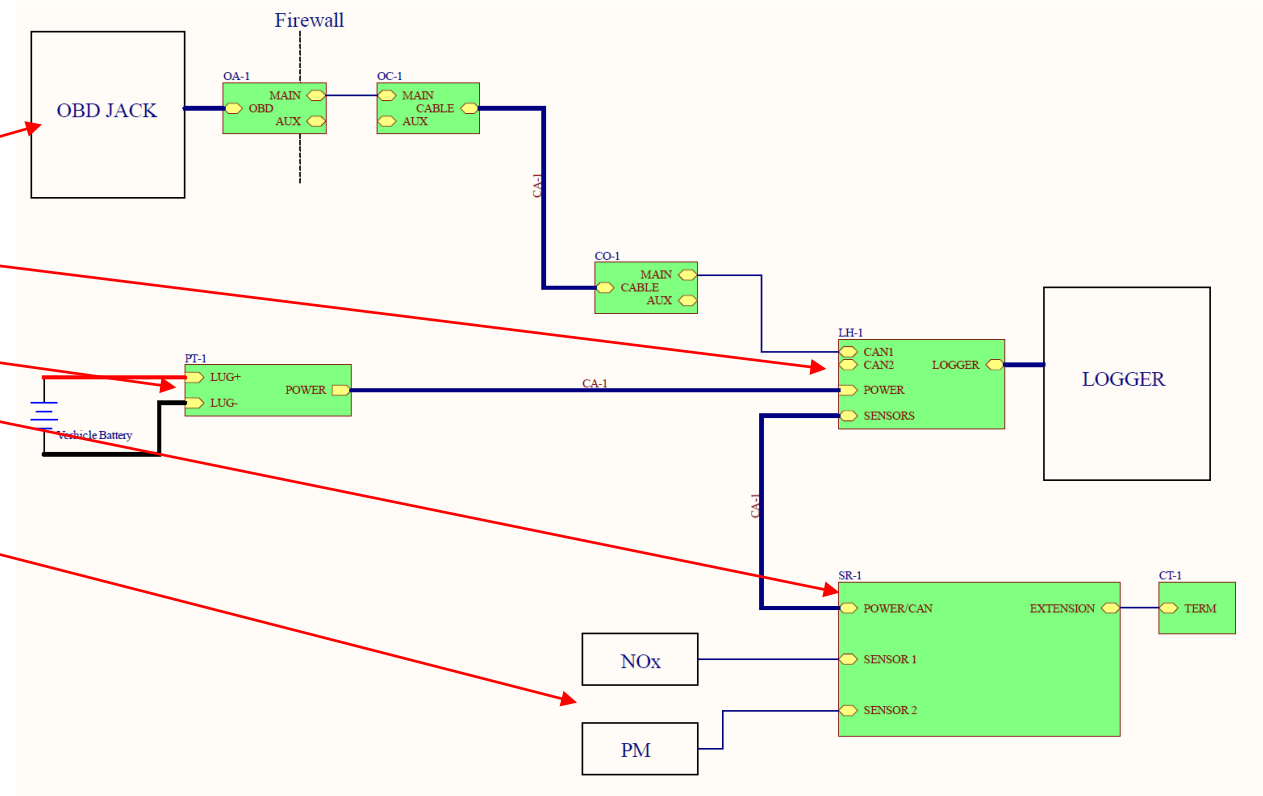


- The Onboard Sensing Analysis and Reporting (OSAR) system was developed for continuous monitoring of diesel and natural gas technologies on an annual basis
- OSAR started out as a consortium lead research initiative, but has now grown to over nine funded programs
- OSAR includes
 - NOx, PM, GPS, CAN, and other sensors
 - Auto starting and shutdown to capture cold starts and all truck operation



Main components:

- OBD jack: OA-1
- OSAR Logger: Emtrac-6, LH-1
- Power supply: PT-1
- Sensor connections: SR-1, CT-1
- NOx Sensor
- PM Sensor
- Extension Cables: CA-1



OSAR systems are ready to go

Just add the bungs to the exhaust, install sensors, and wire harness. No on-site calibration needed. Installation and data is good for a year or more.



Full system fits in this box including wire harness and bungs



We have about 40 systems ready for installation

In partnership with

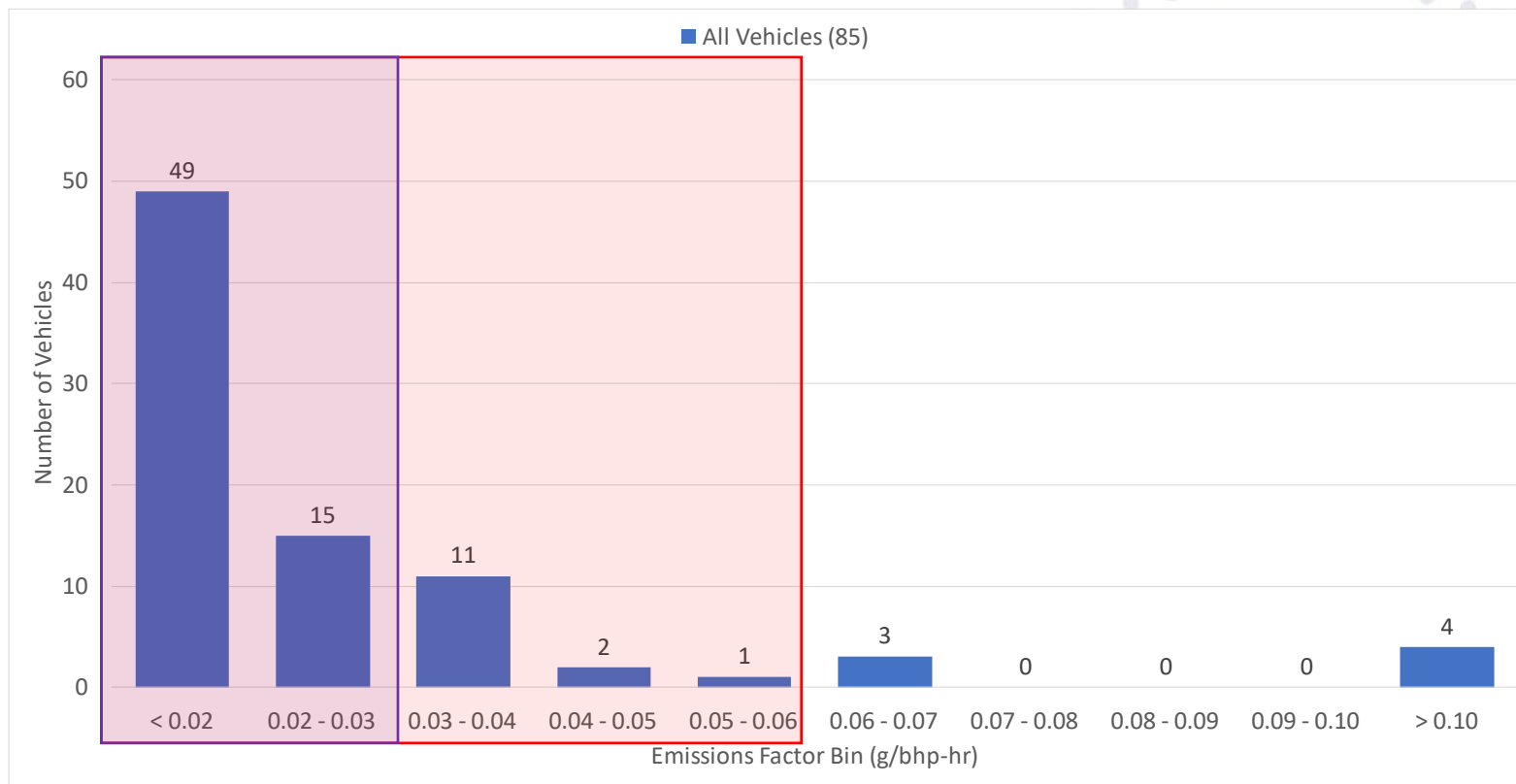


For more information on EmTrac: pt@emisense.com

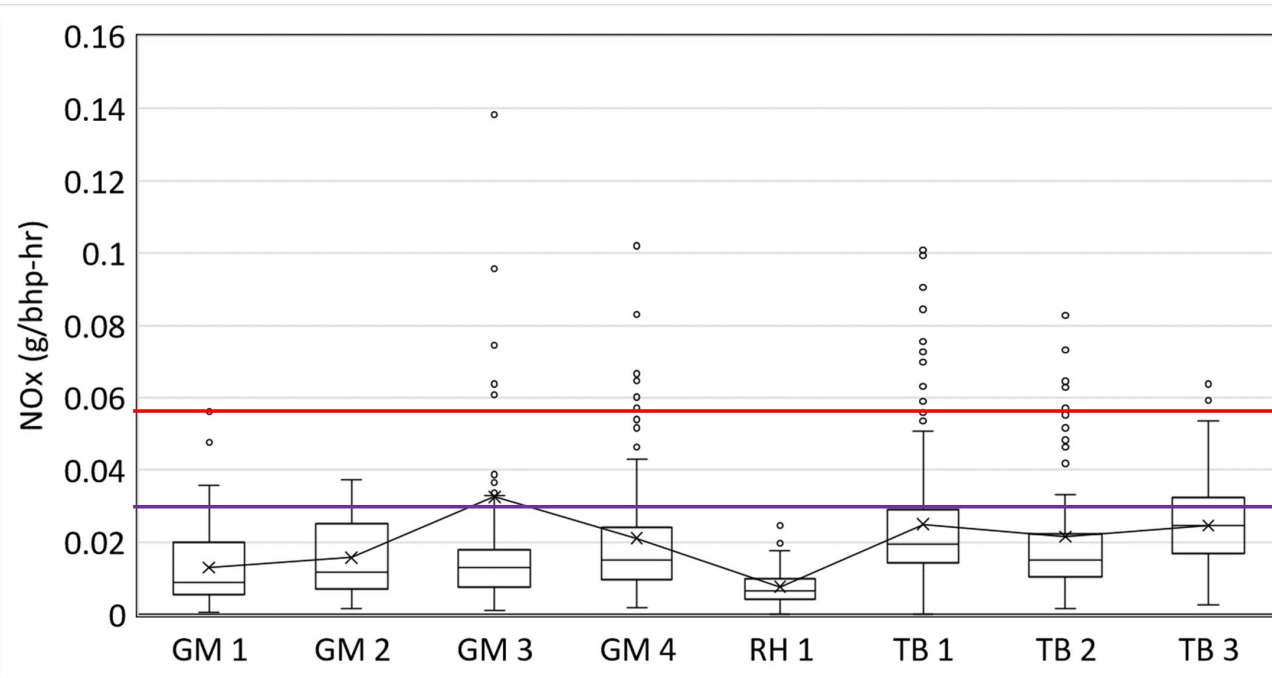
- 9 Heavy Duty Natural Gas Fleets Utilized (model years 2016 – 2023)
 - Average model year 2020
 - Refuse Hauler Fleet (x1)
 - Goods Movement Fleet (x4)
 - Transit Bus Fleet (x3)
- ~10 Vehicles per Natural Gas Fleet
 - OSAR recorded data for approximately 2 months per vehicle
- Filtered out SAE Max and Min ECU and Sensor Values
 - Avoiding Sensor Drop Out
- All figures show data that meets specified criteria
 - 20 min < and 23 bhp-hr <

Vehicle Emissions Factor Histogram

Sum NO_x (g) all trips
Sum Work (bhp-hr) all trips

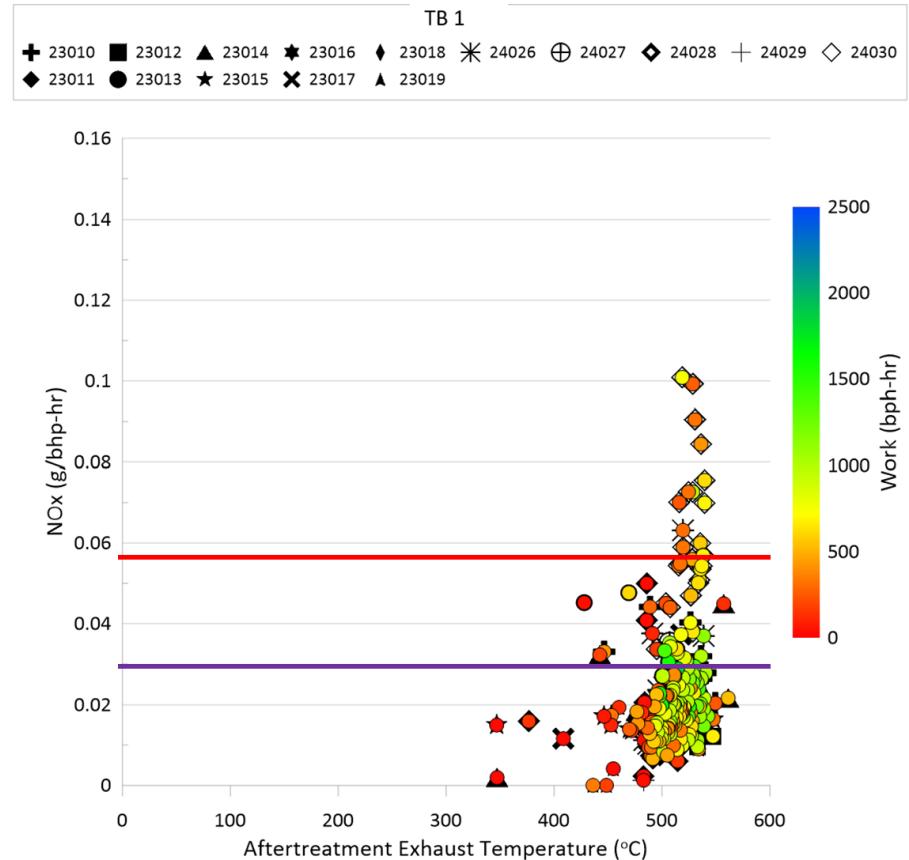


Fleet Comparison – NO_x Emissions



- Red line: 0.058 g/bhp-hr Bin 2 Federal Off-Cycle Standard (2035)
- Purple line: 1.5x 0.02 g/bhp-hr Optional Low NO_x Standard (0.03 g/bhp-hr) (2018)

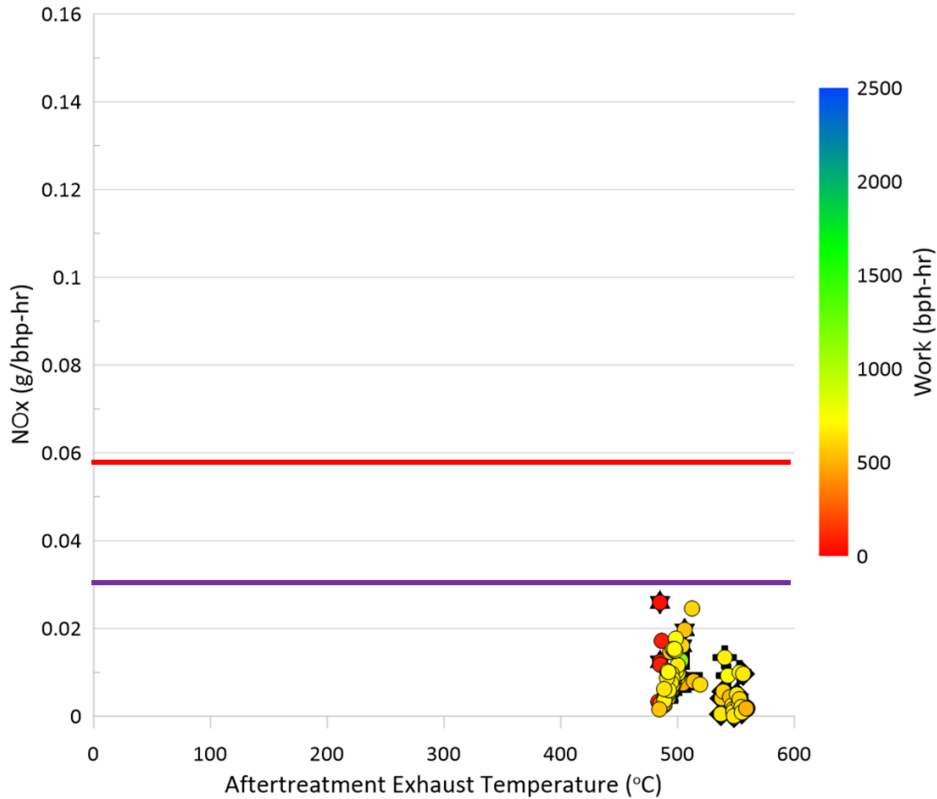
- Each datapoint represents a day of data
- NOx in g/bhp-hr
- Aftertreatment Temperature in °C
- Work (bhp-hr) gradient applied
 - Blue: highest work values across all fleets
 - Green: more frequent work values across all fleets
 - Yellow: lower but not uncommon work values across all fleets
 - Red: significantly low work values across all fleets



Daily Variability

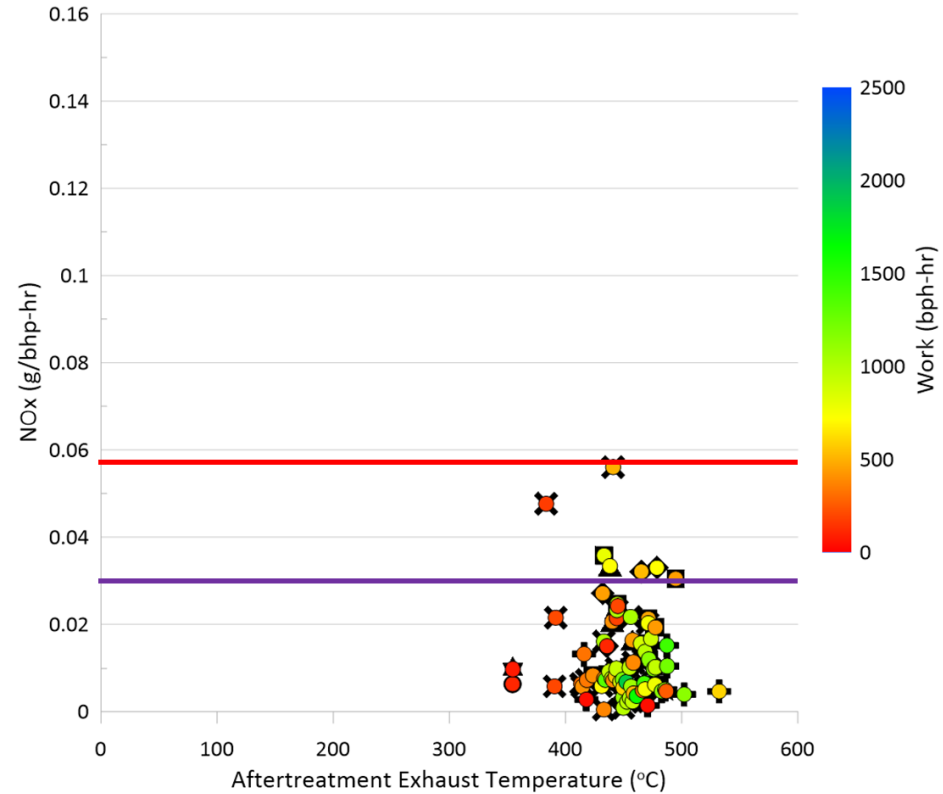
RH 1

+ 23031 ♦ 23035 ■ 23036 ● 23037 ▲ 23043 ★ 23050 ☆ 23051 ✕ 23055 ◆ 23057



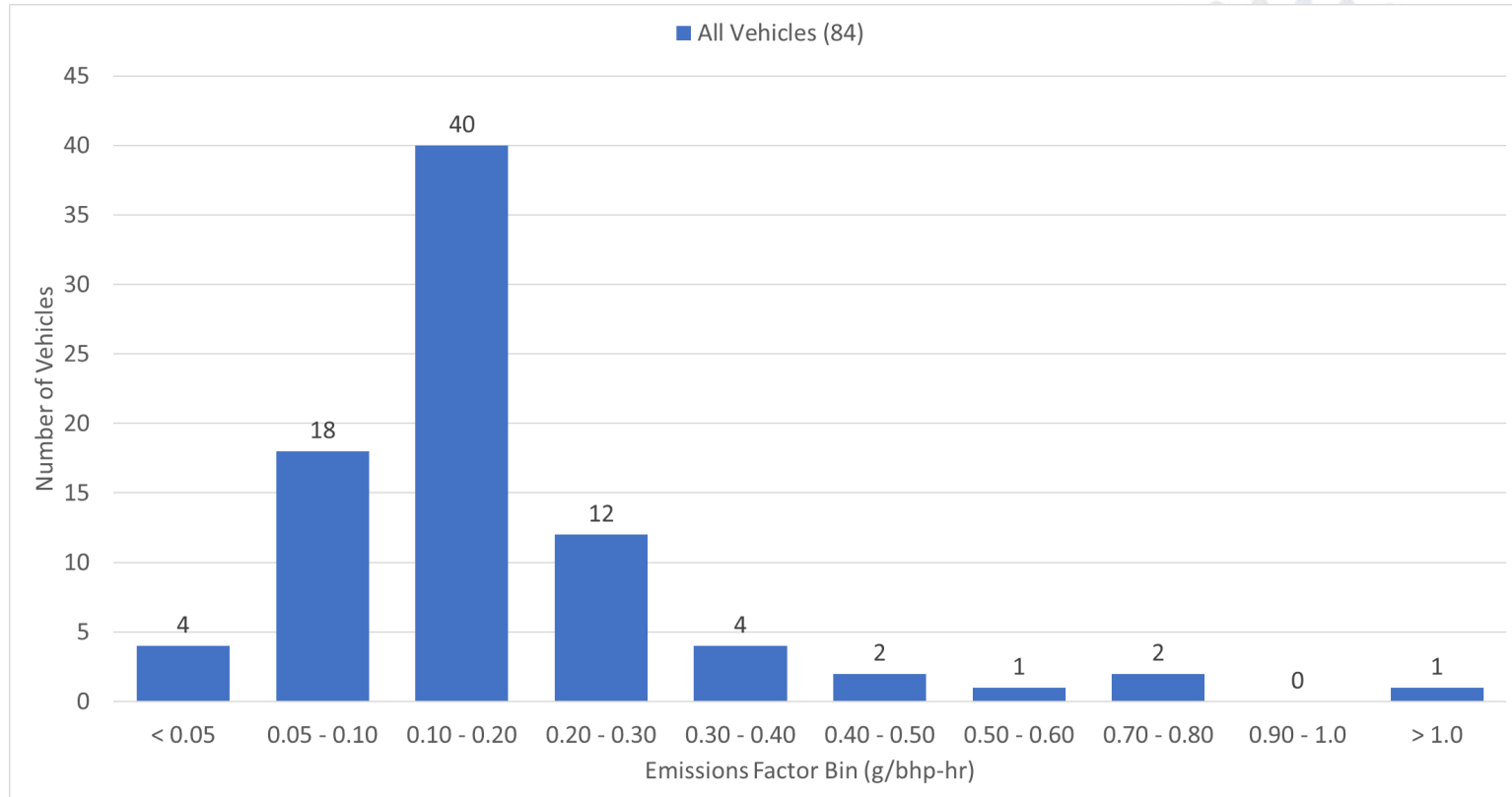
GM 1

+ 23027 ♦ 23028 ■ 23029 ● 23030 ▲ 23033 ★ 23040 ☆ 23041 ✕ 23044 ◆ 23047 ▲ 23048

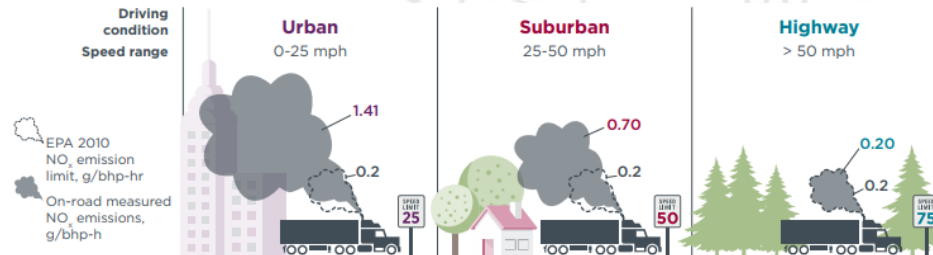


Ammonia Impacts

Average NH₃ g/bhp-hr



- The natural gas vehicles we tested fall on average under the current 1.5x 0.02 g/bhp-hr Optional Low NO_x Standard and the to-be-implemented 0.058 g/bhp-hr Bin 2 Federal Off-Cycle Standard
- In-use conditions have large variability in loads, distances, and other conditions that can significantly affect emissions control systems with multiple types of variable control
- Natural gas engines can reduce NO_x ozone inventory today
- Natural gas engines emit ammonia which can form ammonia nitrate particles which could affect particulate matter output





Questions?