

Supporting Information For:

On-road NO_x Emissions Evaluation of the Repair Effectiveness for Recalled Volkswagen Group Light-duty Diesel Vehicles in the United States

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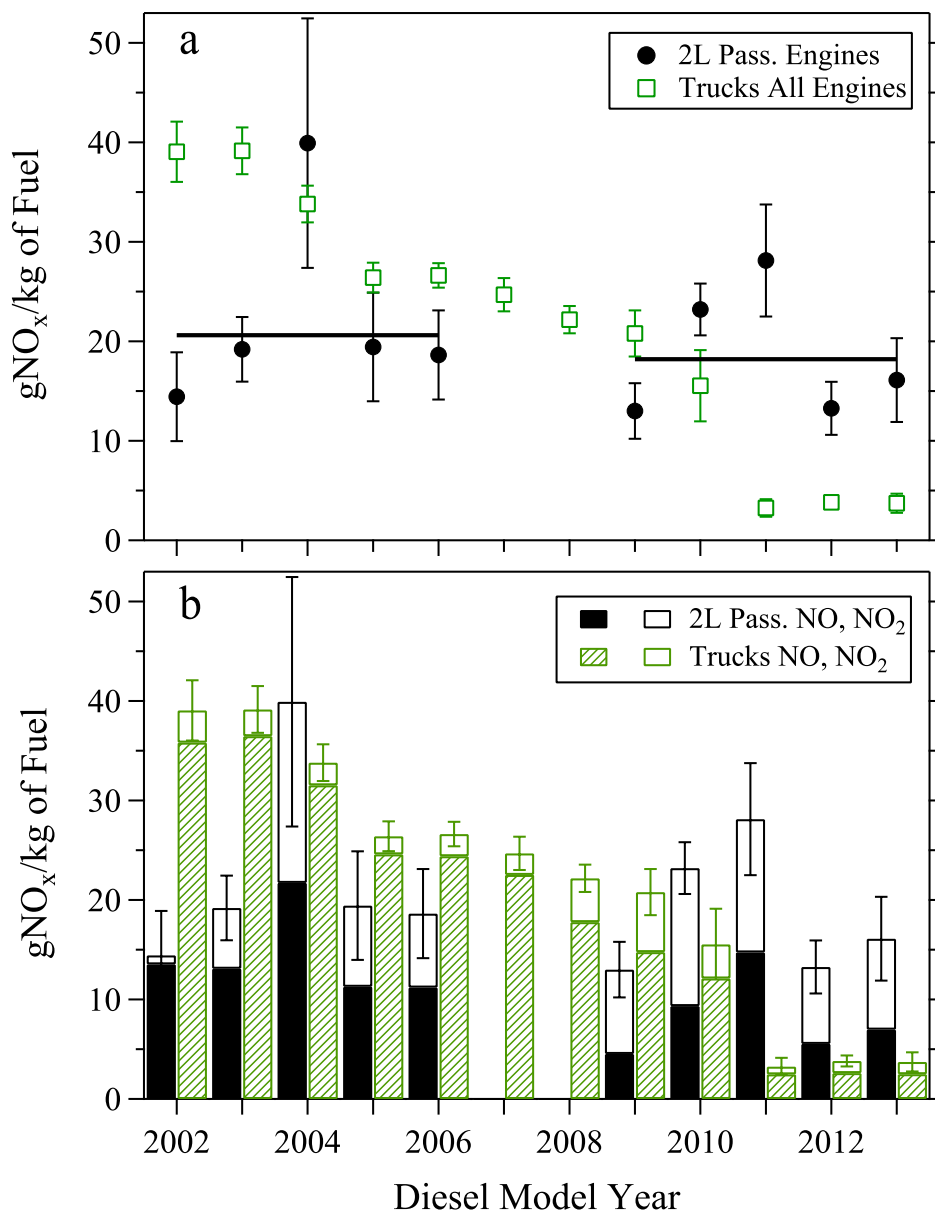


Figure S1. Diesel vehicle grams of NO_x per kilogram of fuel emissions from a combined data set for the 2013 measurements in Denver, Los Angeles, and Tulsa by model year. The top panel graphs average grams of NO_x per kilogram of fuel data for 2 L diesel passenger vehicles (circles) and diesel trucks (squares) as defined by the Polk VIN decoder. The black horizontal lines show the mean emission levels for the 2002–2006 (left) and 2009–2013 (right) 2 L diesel passenger vehicles, which are before and after Tier II/LEV II implementation. The bottom panel graphs the contribution that NO (converted to NO₂ equivalents) and NO₂ make to the NO_x emissions for the same vehicle groupings. The uncertainties plotted are SEMs determined from the daily means for the 2 L passenger vehicles and diesel trucks. (Bishop and Stedman, *Environ. Sci. Technol.* **2015**, 49, (18), 11234-11240.)

FEAT Calibration Cylinder Specifications

Bottle 1:

6% carbon monoxide
0.6% propane
0.3% nitric oxide
6% carbon dioxide
nitrogen balance
(Praxair, +/- 2%)

Bottle 2:

0.05% nitrogen dioxide
15% carbon dioxide
air balance
(Praxair, +/- 2%)

Bottle 3:

0.1% ammonia
0.6% propane
nitrogen balance
(Air Liquide, +/- 2%)

Table S1. Summary of Pre-repair Measurements Collected for Volkswagen, Audi and Porsche Diesels.

Location	Collection Dates	Total Records	VW Group (Model Years >=2009)			
			Records ^a (Mean Model Year)	Mean ^b gNO/kg of Fuel	Mean ^c gNO ₂ /kg of Fuel	Mean ^c gNO _x /kg of Fuel
Chicago	9/11/2014 to 9/13/2014	20,395	74/71/71 (2012.7)	3.79±0.27	6.46±0.31	12.25±0.56
Denver ^d	12/12/2013 12/13/2013 1/3/2014	19,242	88/85/85 (2011.9)	3.74±0.26	10.91±1.89	16.77±2.25
Denver ^d	12/9/2015 12/10/2015 1/13/2016 1/27/2016 to 1/29/2016	23,297	66/65/65 (2012.9)	3.30±0.62	3.36±0.89	8.29±1.65
Los Angeles	4/27/2013 to 5/4/2013	27,196	44/43/43 (2011.0)	8.14±1.84	7.81±1.39	19.87±3.31
Los Angeles	3/28/2015 to 4/3/2015	22,124	62/62/62 (2012.7)	6.56±0.88	8.71±1.11	18.77±2.14
Tulsa	9/30/2013 to 10/4/2013	21,115	29/23/23 (2012.2)	2.99±1.26	6.61±1.21	12.28±3.32
Tulsa	9/14/2015 to 9/18/2015	19,601	52/52/52 (2012)	2.08±0.74	3.13±0.67	6.32±1.33
Totals		152,970	415/401/401 (2012.2)	4.31±0.58	6.97±0.59	13.62±1.29

^aValid measurements for NO/NO₂/NO_x.

^bgrams of NO.

^cgrams of NO₂.

^dWinter measurements in Denver are only collected on dry and fair weather days and as such are usually not sequential.

Uncertainties are standard error of the mean determined using the daily means.

All of the databases can be accessed at <https://digitalcommons.du.edu/feat/>

Table S2. Summary of Post-repair Measurements Collected for all the Volkswagen, Audi and Porsche Diesels.

Location	Collection Dates	Total Records	VW Group (Model Years >=2009)			
			Records ^a (Mean Model Year)	Mean ^b gNO/kg of Fuel	Mean ^c gNO ₂ /kg of Fuel	Mean ^c gNO _x /kg of Fuel
Chicago	9/14/2020 to 9/18/2020	19,025	61/61/61 (2014.1)	2.26±0.68	0.34±0.06	3.81±1.04
Denver ^d	1/16/2020 1/22/2020 1/24/2020 2/21/2020	19,909	33/32/32 (2013.1)	0.33±0.10	0.46±0.20	0.83±0.47
Tulsa	9/9/2019 to 9/13/2019	23,376	38/38/38 (2014.4)	0.51±0.34	0.22±0.07	1.00±0.54
Totals		62,310	132/131/131 (2013.9)	1.28±0.37	0.33±0.09	2.27±0.62

^aValid measurements for NO/NO₂/NO_x.

^bgrams of NO.

^cgrams of NO₂.

^dWinter measurements in Denver are only collected on dry and fair weather days and as such are usually not sequential.

Uncertainties are standard error of the mean determined using the daily means.

All of the databases can be accessed at <https://digitalcommons.du.edu/feat/>

Table S3. Number and Percent Total of NO_x Measurements by Model Year for each Repair Category from Figure 1.

Model Year	Number of NO _x Measurements		
	Pre-Repair (% Total)	Post-Repair All Measurements (% Total)	Post-Repair Fully Repaired (% Total)
2009	32 (8.0%)	0	0
2010	42 (10.5%)	6 (4.6%)	5 (4.4%)
2011	53 (13.2%)	12 (9.2%)	12 (10.5%)
2012	67 (16.7%)	18 (13.7%)	17 (14.9%)
2013	105 (26.2%)	18 (13.7%)	18 (15.8%)
2014	79 (19.7%)	16 (12.2%)	15 (13.2%)
2015	22 (5.5%)	38 (29.0%)	24 (21.0%)
2016	1 (0.2%)	1 (.8%)	1 (0.9%)
2017	0	22 (16.8%)	22 (19.3%)
Total Measurements	401	131	114

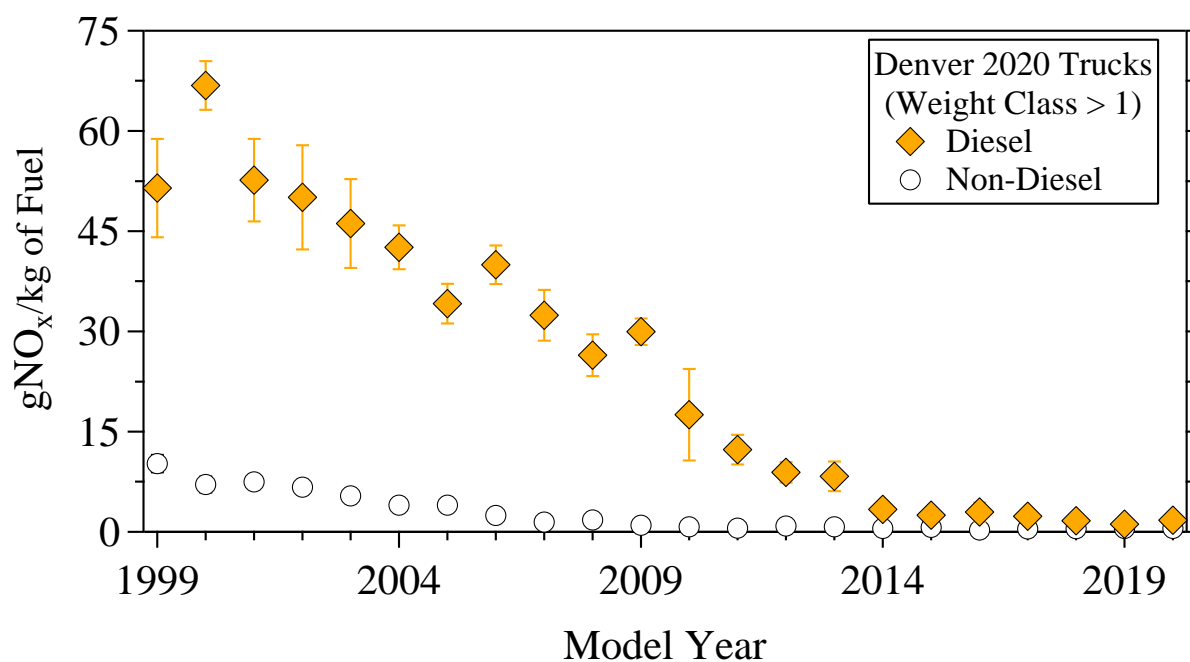


Figure S2. Fuel specific NO_x emissions by model year for the Denver 2020 diesel (diamonds) and non-diesel trucks (circles) in weight classes larger than 1. Uncertainties are standard error of the mean calculated using the daily means for each model year.

Literature Cited:

1. Bishop, G. A.; Stedman, D. H., Reactive Nitrogen Species Emission Trends in Three Light-/Medium-Duty United States Fleets., *Environ. Sci. Technol.* **2015**, 49, (18), 11234-11240, DOI: 10.1021/acs.est.5b02392.