

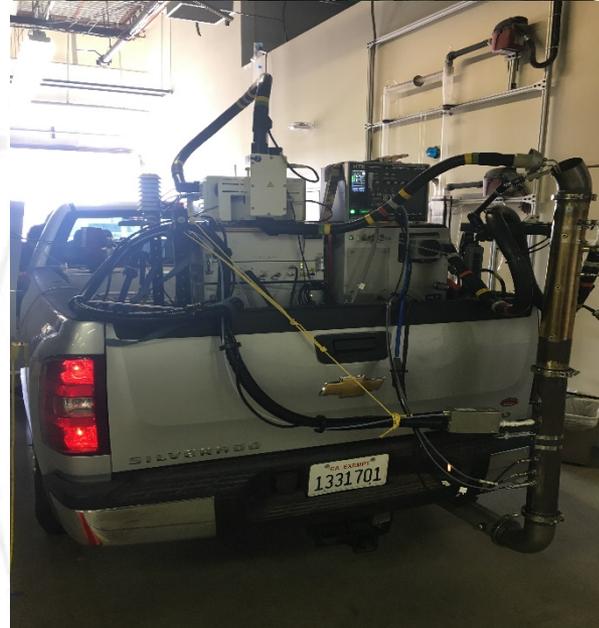
Evaluation of NGK Spark Plug Compact Emission Measurement System (NCEM)



**Jiacheng (Joey) Yang, Kent C. Johnson, Thomas D. Durbin
Georgios Karavalakis, Yu Jiang, J. Wayne Miller, David R. Cocker III**

Outline

- **Background**
- **Approach**
- **Results**
- **Discussions**



Real World PEMS testing is complex



□ Try to fit this in a VW Jetta

Instrumentation

**AVL MOVE
System (NO,
NO₂, CO, CO₂,
THC, PM/SPM,
SPN)
Concerto**



**NCEM
(NO_x, PM, SPN)**



PEMS testing is limited

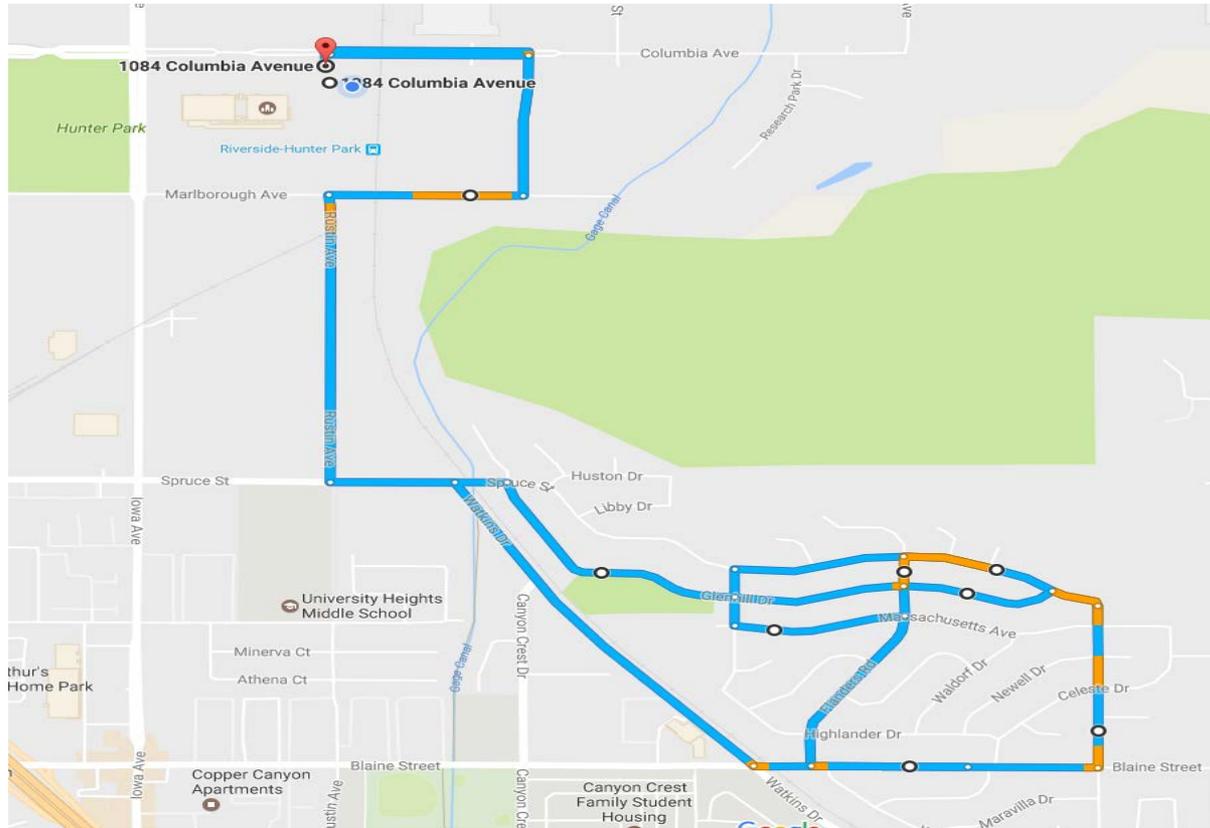
- ▶ Weight of Instrument could impact the emissions
- ▶ Setup complexity (size and system)
- ▶ Operation Complexity (1-2 hour before test)
- ▶ Service purpose
- ▶ The accuracy of these compact unit is also a challenge

Vehicle Information

Vehicle Model	Chevrolet Silverado 2500HD
Year	2012
Type	Pickup Truck
Displacement	6.6 L
Number of Cylinders	8
Engine Air-Intake	Turbocharged
Fuel Injection	Common-rail direct fuel injection
Horsepower	397 hp @ 3000 rpm
Torque	765 lb-ft @ 1600 rpm
Compression Ratio	16.8 : 1
Aftertreatment	DOC/DPF/SCR
Certification Level	USEPA Tier2; CARB LEVII ULEV
Test Fuel	Retail ULSD



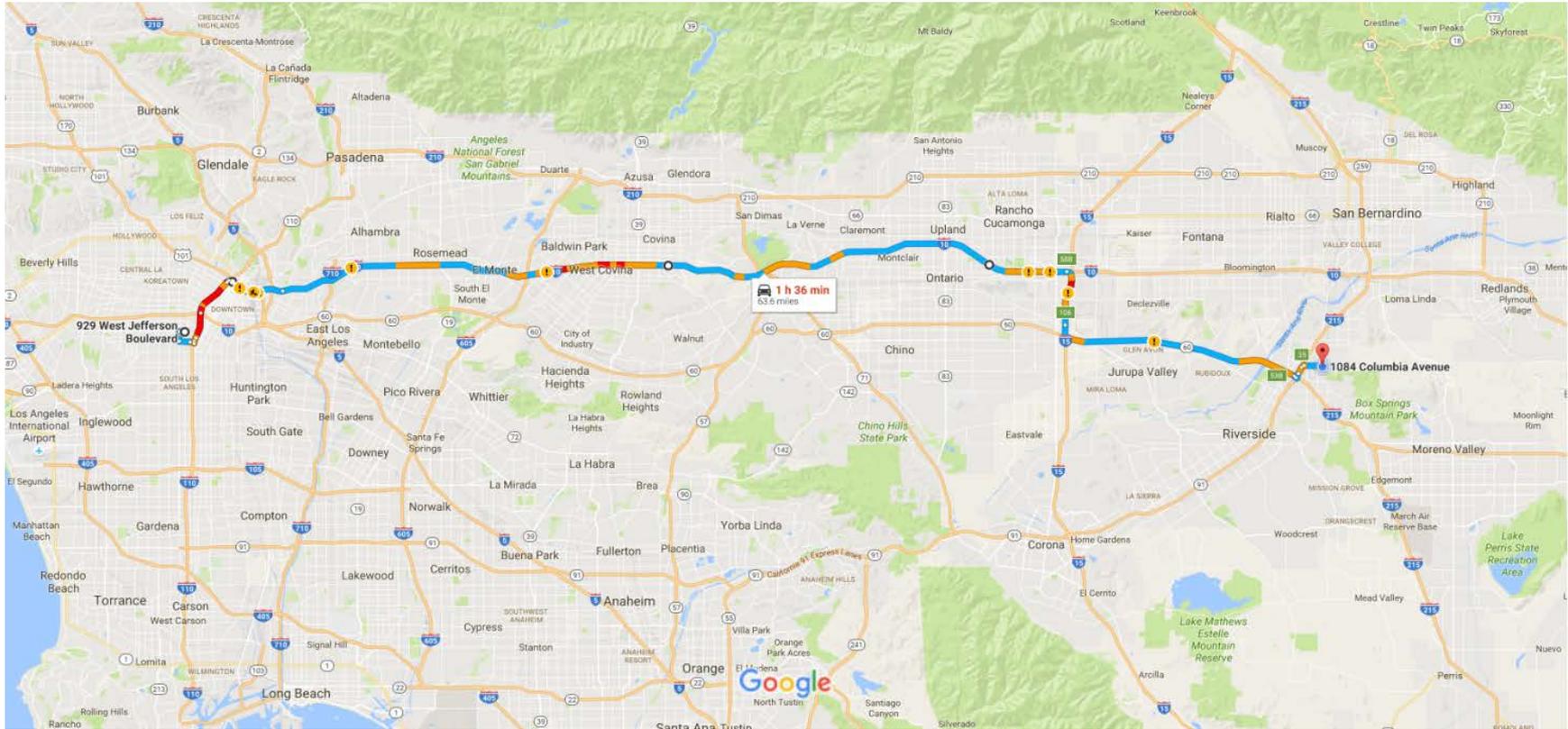
Local Routes



Start Point	End Point	Distance (mi)	Highway
UCR CECERT	UCR CECERT	7.3	None

☐ Local routes simulate urban driving, similar driving pattern to LA4.

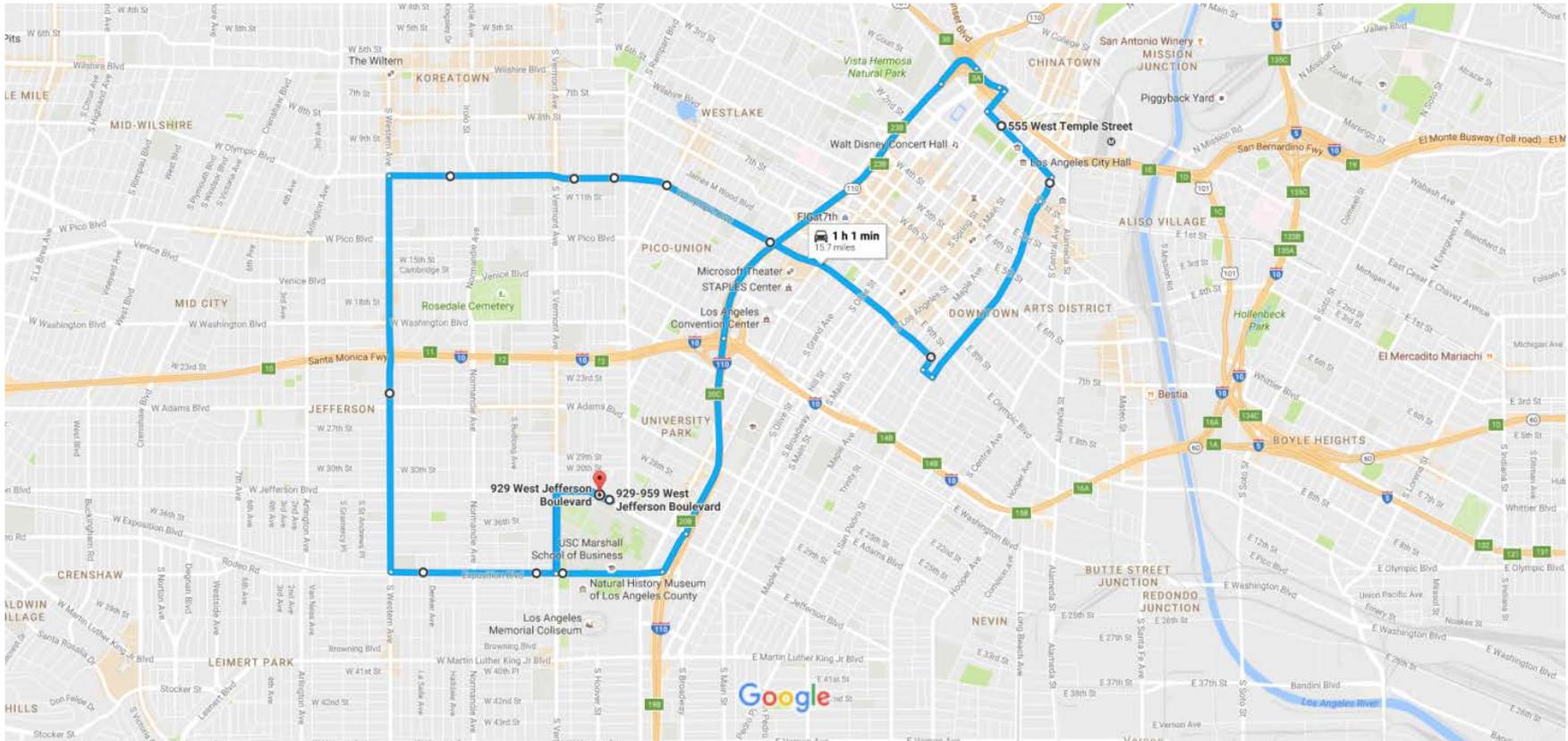
Test Routes (Way to LA)



Start Point	End Point	Distance (mi)	Highway
Columbia Ave, Riverside	West Jefferson Boulevard	63.6	I-60, I-10, I-710, and I-110

☐ 95% highway driving between UCR CECERT and main campus of the USC.

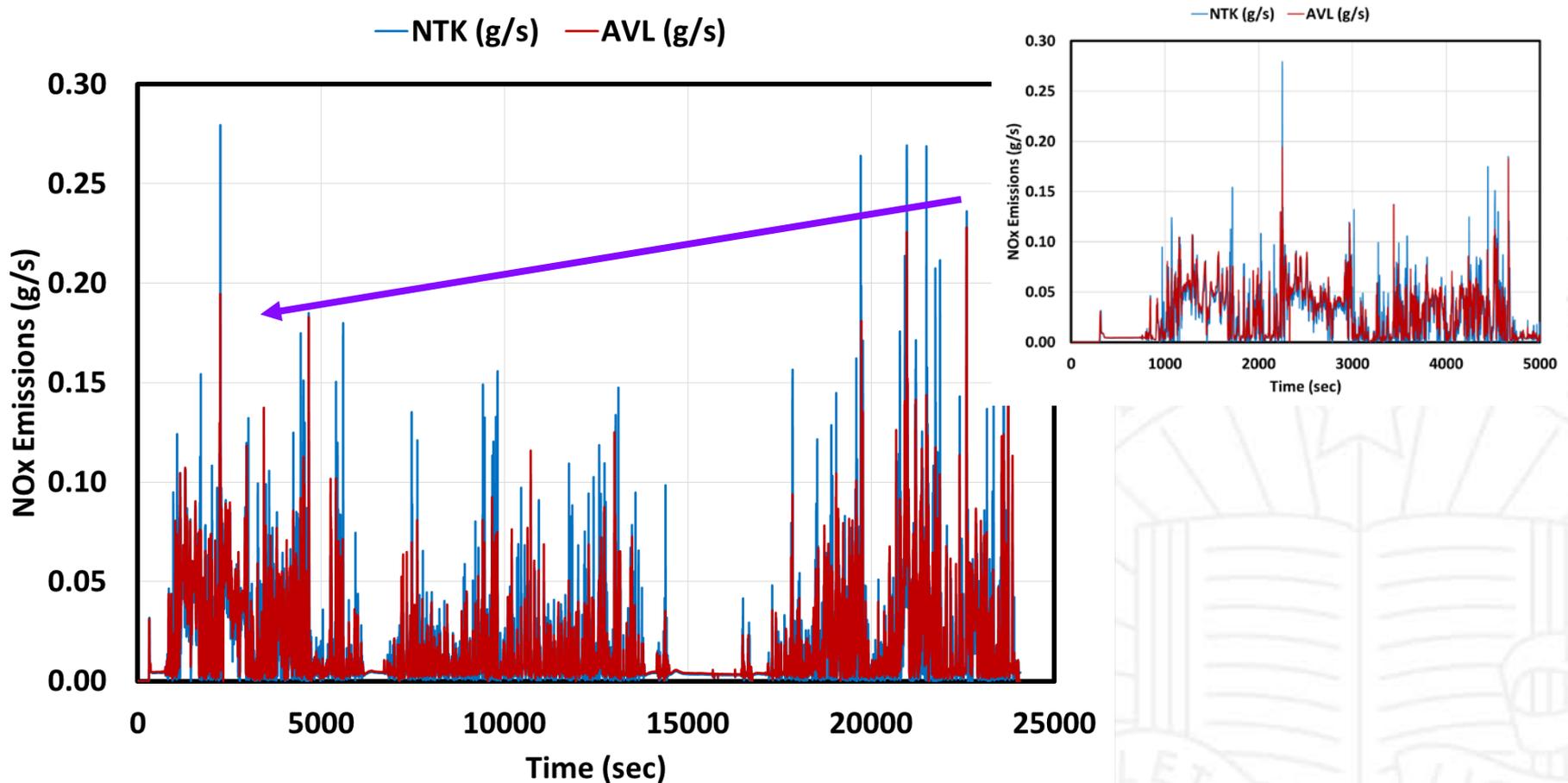
Test Routes (LA Downtown)



Start Point	End Point	Distance (mi)	Highway
West Jefferson Boulevard	West Jefferson Boulevard	15.7	I-110

- ❑ Urban Driving downtown LA
- ❑ This routes essentially represents the ‘LA4’ lab cycle, which was used in developing the original FTP cycle.

Results: Second by Second over LA Routes



□ The NOx emissions measurement between this two PEMS instruments does correspond well and both show quick response while rapid NOx emissions.

Test Results (NOx)

Routes		NOx (g)		Distance Travelled (mi)	NOx (g/mi)	
		NTK	AVL		NTK	AVL
Local Routes	Local 1	23.26	25.14	6.75	3.444	3.723
	Local 2	33.19	31.06	6.89	4.818	4.508
	Local 3	34.22	26.85	6.76	5.060	3.970
LA Routes	Riverside to USC	137.21	142.99	63.22	2.170	2.262
	LA Down Town_1	36.39	35.75	15.80	2.304	2.263
	LA Down Town_2	39.03	37.71	15.80	2.470	2.386
	Idle, Creep	10.38	11.45	1.80	5.762	6.358
	USC to Riverside	144.14	146.72	62.97	2.289	2.330
	SUM	457.84	457.68	Average	3.540	3.475
	% Difference	0.03%		% Difference	1.86%	
	p-value	0.9994		p-value	0.9309	

- ❑ Over 10 hours of operation with all different kind of driving conditions, the different between NCEM and AVL PEMS system is 0.03% in respect to the total gram of NOx measured, 1.86% in respect to g/mi measured.
- ❑ There is no significant different (p-value) between NCEM and AVL PEMS system on measuring NOx emissions.
- ❑ NOx emissions way high than certification level (LEVII ULEV, 0.20g/mi, for vehicles less than 50,000 mi), suggesting SCR malfunction.
- ❑ There is no indication of SCR malfunction during the on road testing.

Repair Record from Dealership

=VIP=(APP) UCR RIVERSIDE FLEET SEV. ACCOUNTING OFC 2 RIVERSIDE, CA 92521-0001 PAT.GEPHART@UCR.EDU	LABOR RATE	LICENSE NO.	MILEAGE	1 /	COU																																																										
	YEAR / MAKE / MODEL				DEU																																																										
	12/CHEVROLET TRUCK/SILVERADO 2500H/E				SELL																																																										
	VEHICLE ID. NO.				1 G C 2 K X E 8 9 C Z 1 2 3 1 1 3	R.O.																																																									
RESIDENCE PHONE		BUSINESS PHONE		COMMENTS																																																											
		951-827-2277																																																													
LABOR & PARTS																																																															
# 1-07CVZ01 DIESEL DIAGNOSIS TECH(S):301259 652.00 <u>CUSTOMER STATES ENGINE LIGHT IS ON -- REDUCE POWER MESSAGE</u> <u>AND COOLANT ERROR MESSAGE -- CHECK AND ADVISE</u> P2544,P2610,P0205B,P21B00,P21AB,P2510,P150C,U0073 PRESENT ON ARRIVAL AND ALL SHOWING PASSED. POSSIBLE DEF TANK WENT EMPTY, INHIBITING PARTICULATED FILTER REGENERATION, CAUSING VEHICLE SPEED TO BE REDUCED. PERFORMED DTC DIAG. DEF LEVEL SENSORS SHOWING DEF TANK IS FULL CURRENTLY. RAN VEHICLE TILL DTC'S SHOWED "PASSED". "SERVICE EMISSIONS SYSTEM" WARNING STILL ON BECAUSE PARTICULATE SOOT MASS AT 20 GRAMS.PERFORMED 3 REGENERATION CYCLES TO REDUCE SOOT MASS TO 0 GRAMS. TEST DROVE. P205B RESET.REDUCTANT TEMPERATURE READING IS SKEWED.REPLACED REDUCTANT TEMPERATURE SENSOR/RESERVOIR.CLEARED DTC.PERFORMED "SERVICE EMISSIONS SYSTEM" IN DIC RESET.TEST DROVE 20 MILES <u>REPLACED COOLANT RESERVOIR/LOW COOLANT SENSOR ASSEMBLY</u>																																																															
<table border="1"> <thead> <tr> <th>PARTS</th> <th>QTY</th> <th>FP</th> <th>NUMBER</th> <th>DESCRIPTION</th> <th>LIST PRICE</th> <th>UNIT PRICE</th> <th>PRICE</th> </tr> </thead> <tbody> <tr> <td>JOB # 1</td> <td>1</td> <td></td> <td>23379348</td> <td>RESERVOIR 3.120</td> <td>301.63</td> <td>301.63</td> <td>301.63</td> </tr> <tr> <td>JOB # 1</td> <td>1</td> <td></td> <td>19286292</td> <td>FLUID 8.800</td> <td>22.21</td> <td>22.21</td> <td>22.21</td> </tr> <tr> <td>JOB # 1</td> <td>1</td> <td></td> <td>22866587</td> <td>TANK 1.240</td> <td>51.97</td> <td>51.97</td> <td>51.97</td> </tr> <tr> <td colspan="4"></td> <td>COLTON</td> <td colspan="3"></td> </tr> <tr> <td colspan="7"></td> <td>JOB # 1 TOTAL PARTS</td> <td>375.81</td> </tr> <tr> <td colspan="7"></td> <td>JOB # 1 TOTAL LABOR & PARTS</td> <td>1027.81</td> </tr> </tbody> </table>						PARTS	QTY	FP	NUMBER	DESCRIPTION	LIST PRICE	UNIT PRICE	PRICE	JOB # 1	1		23379348	RESERVOIR 3.120	301.63	301.63	301.63	JOB # 1	1		19286292	FLUID 8.800	22.21	22.21	22.21	JOB # 1	1		22866587	TANK 1.240	51.97	51.97	51.97					COLTON											JOB # 1 TOTAL PARTS	375.81								JOB # 1 TOTAL LABOR & PARTS	1027.81
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- During the test, the only MIL light is low coolant level warning.
- Later was discovered the low coolant level is related to low DEF tank level, and then impact the amount of urea injection for SCR operation.
- Local dealer was able to fix the issue and clear the MIL.

Summary

Previous Study			This Study(SCR Issue)					Post Study (After Repair)		
		g/mi				g/mi				g/mi
Cycle	Test Fuel	NOx	Routes		Test Fuel	NTK_NOx	AVL_NOx	Cycle	Test Fuel	NOx
FTP	Federal ULSD	0.145	Local Routes	Local 1	Retail ULSD	3.444	3.723	FTP	Retail ULSD	0.145
	CARB ULSD	0.150		Local 2	Retail ULSD	4.818	4.508		Retail ULSD	0.150
	B20 Stock 1	0.173		Local 3	Retail ULSD	5.060	3.970			
	B20 Stock 2	0.153	LA Routes	Riverside to USC	Retail ULSD	2.170	2.262			
	B20 Stock 3	0.181		LA Down Town_1	Retail ULSD	2.304	2.263			
	B20 Stock 4	0.139		LA Down Town_2	Retail ULSD	2.470	2.386			
	B20 Stock 5	0.142		Idle, Creep	Retail ULSD	5.762	6.358			
	AVE	0.154		USC to Riverside	Retail ULSD	2.289	2.330		AVE	0.147

- ❑ The SCR malfunction could cause NOx emission rate in the range of 2.1-5.8 g/mi, potentially 11-29 times higher than the certification standard and 14-38 times higher than the previous results.
- ❑ Both AVL PEMS and NCEM are good enough to capture a possible high emitting NOx malfunction vehicles
- ❑ Repair done at the dealership is able to bring the NOx emission level back to its original level.

Acknowledgements

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Technical Staff

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