5450naDrivaZ_00001438

EPAct Program Update for Chet France

January 23, 2008

Preliminary information – not for release outside EPA

545OneDrive2_00001438

545OneDrive2_00001438

Light Duty Exhaust Program Overview

- EPA/DOE collaboration
- Objective: Establish effects of RVP,T50,T90, aromatic content and EtOH on exhaust emissions from Tier 2 vehicles
- Fuel matrix includes 29 fuels + 2 added by CRC = total of 31
- Test Program Design
  - Phase 1: RFS 2 Pilot at 75°F
    - 3 fuels (E0, E10 and E15) tested in 19 vehicles
    - Test results to be available for RFS 2 NPRM
  - Phase 2: RFS 2 Pilot at 50°F
    - Same as Phase 1, except temperature
  - Phase 3: Main Program
    - 27 fuels tested in 19 Tier 2 vehicles, E85 tested in 4 FFVs
- LA92 test cycle used throughout the program
- Species measured: Regulated emissions, CO_2, NO_2, VOCs, ethanol, carbonyl compounds
  - N_2O, NH_3 and HCN by FTIR
  - Some PM and SVOC speciation

545OneDrive2_00001438

Status of Testing

- Phase 1 testing complete
  - 75F testing of 19 vehicles on 3 fuels (E0, E10, E15)
  - Data was received by EPA, briefing materials were presented on primary findings
- Interim FTP-cycle testing complete
  - 75F testing of 6 vehicles on 3 fuels (E0, E10, E15)
  - Data was received by EPA, this briefing contains primary findings
- Phase 2 testing underway
  - 50F testing of 19 vehicles on 3 fuels (E0, E10, E15)
  - Fuel 17 and 18 testing were recently completed
  - Fuel 19 testing has begun, to be completed by 2/6
  - Data is being processed at SWRI and here
- Phase 3 testing expected to begin mid-February

545OneDrive2_00001438

Revised EPAct Fuel Matrix

Phase 3
Base Program (EPA)
(Fuels 1-16)

Phases 1 and 2
RFS 2 Subset (EPA/DOE)
(Fuels 17-19)

Phase 3
Additional Fuels (DOE)
(Fuels 20-29)

E85 (DOE)

CRC Additional Fuels

Fuel #	T50 °F	T90 °F	ETOH %	RVP psi	ARO %
1	150	300	10	10	15
2	240	340	0	10	15
3	220	300	10	7	15
4	220	340	10	10	15
5	240	300	0	7	40
6	190	340	10	7	15
7	190	300	0	7	15
8	220	300	0	10	15
9	190	340	0	10	40
10	220	340	10	7	40
11	190	300	10	10	40
12	150	340	10	10	40
13	220	340	0	7	40
14	190	340	0	7	15
15	190	300	0	10	40
16	220	300	10	7	40
17	215	325	0	9	30
18	202	325	10	9	25
19	195	325	15	9	23
20	160	300	20	7	15
21	160	300	20	7	40
22	160	300	20	10	15
23	160	340	20	7	15
24	160	340	20	10	15
25	160	340	20	10	40
26	150	340	15	10	40
27	190	340	15	7	15
28	190	300	15	7	40
29	TBD	TBD	85	TBD	TBD
30	150	325	10	10	40
31	160	325	20	10	15

Revised Fuels

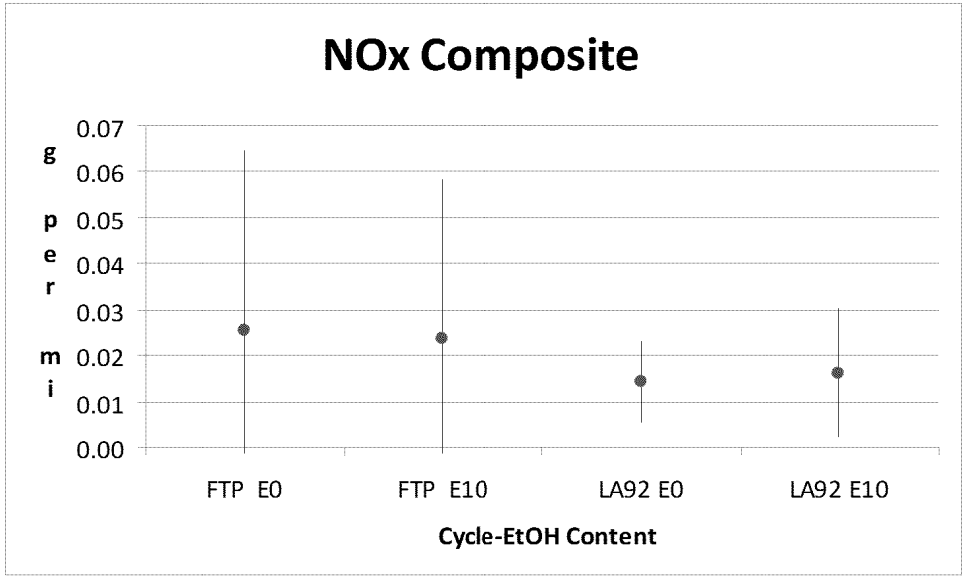
545OneDrive2_00001438

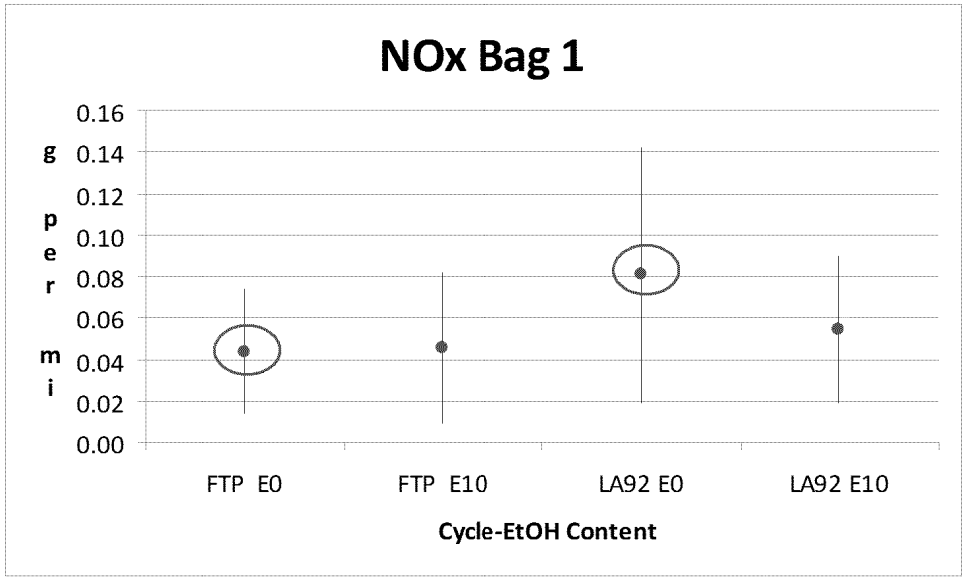
Fuel Blending Is On-Schedule

- Test fuel development being done cooperatively by Haltermann and ASD
  - EPA defines fuel recipes
  - Haltermann prepares hand blends, bulk blends and performs fuel analyses
- 16 of the 28 fuels needed in Phase 3 have been or are being blended in bulk
  - 8 have been delivered to SWRI
  - E85 fuel will be obtained from CRC
- The remaining 12 fuels are in hand blend stage
- We expect to have all fuels blended in bulk by mid-February
- This will allow randomization of fuels for Phase 3, as planned

Preliminary Findings on Effect of Test Cycle - NOx

- Results suggest no significant NOx effect or interaction in the composite
- Only significant finding was in Bag 1:
  - LA92 > FTP on E0
  - *This finding could be a primary driver of our results*
- Note: Statistical significance in these slides is p<0.05 level
  - Things within a colored circle are significantly different from things within a different circle of the same color



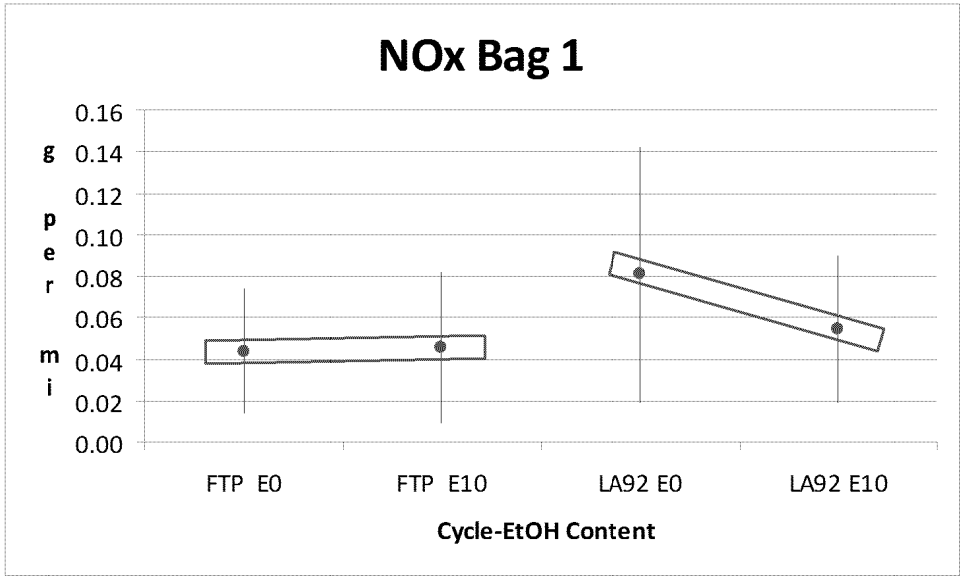


545OneDrive2_00001438

545OneDrive2_00001438

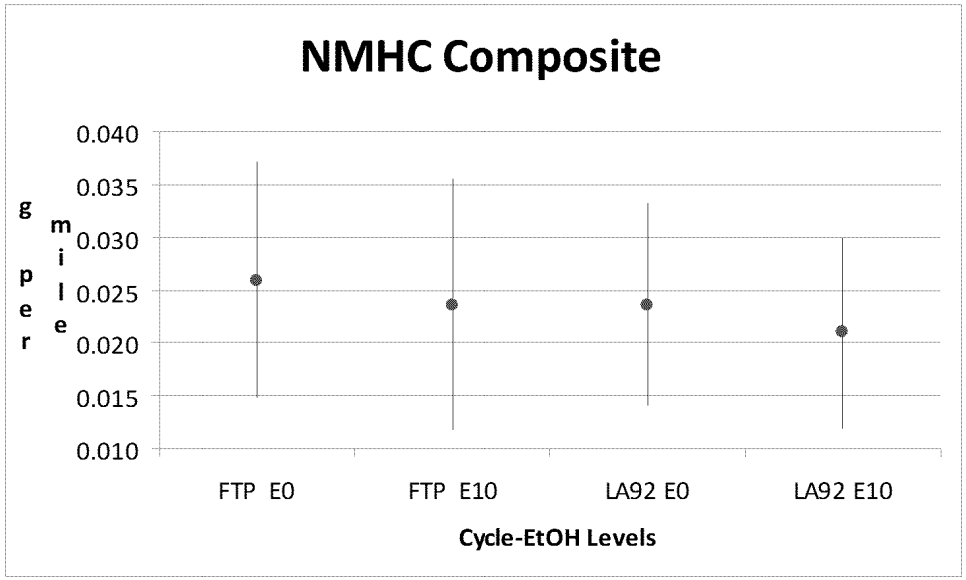
A Few Words About the Cycle Results

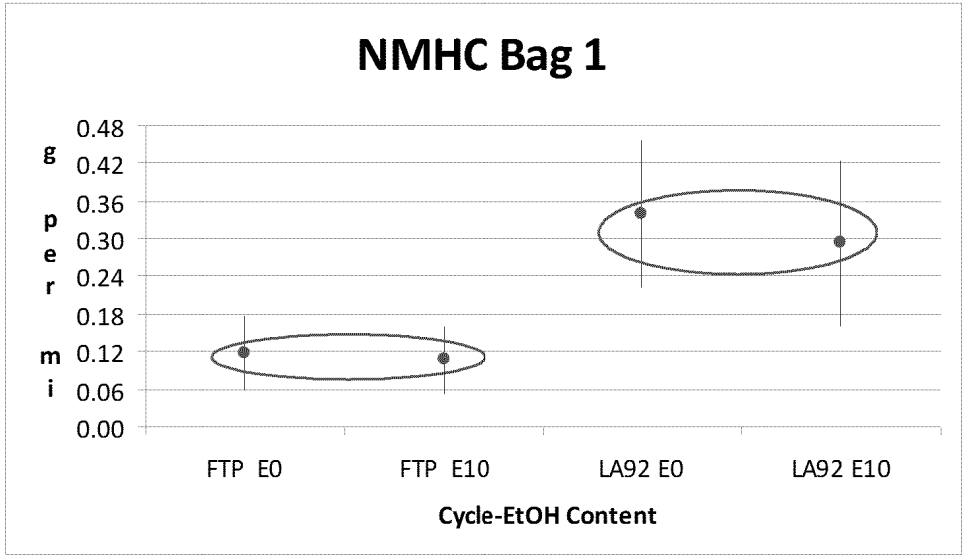
- What question were we trying to answer with this FTP testing?
  - "*Were the effects of ethanol seen in Phase 1 a result of Tier 2 vehicles actually behaving differently from older vehicles, or just an artifact of the LA92 test cycle we chose?*" (Focusing primarily on NOx)
- Did we answer this? What were we looking for in the data?
  - The means appear to suggest E10 may show more favorable effects on cold start NOx emissions with LA92, but deltas are not statistically significant
  - Thus, for now we conclude test cycle was not (highly) influential on NOx results
- Conclusions about test cycle effects were more tenuous than conclusions drawn in Phase 1 about ethanol effects in general, because only six vehicles were tested on FTP cycle



Preliminary Findings on Effect of Test Cycle - NMHC

- Results suggest no significant NMHC effect or interaction in the composite
- Some significant effects were seen in Bags 1 & 3:
  - Bag 1: LA92 > FTP for both levels of ethanol
  - Bag 3: LA92 > FTP for E0

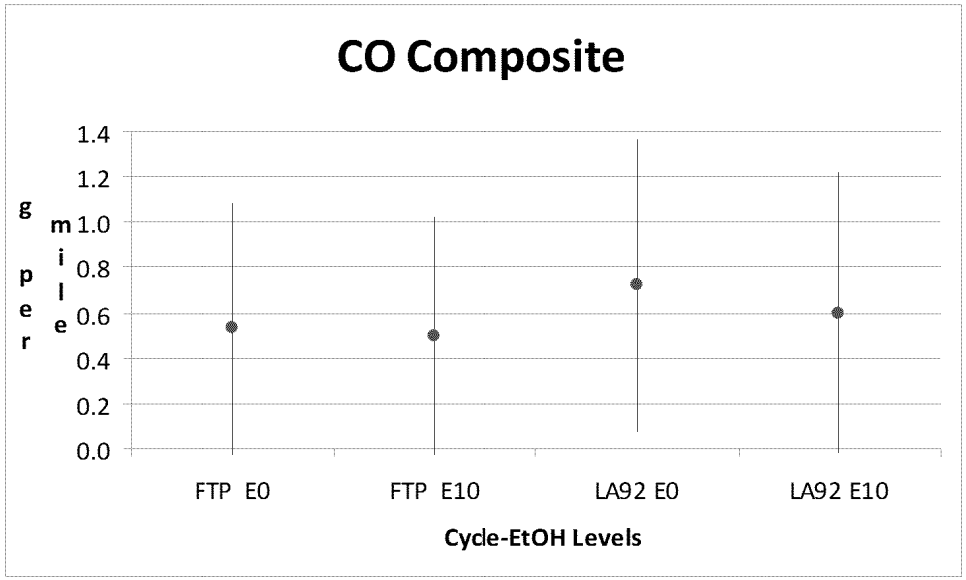


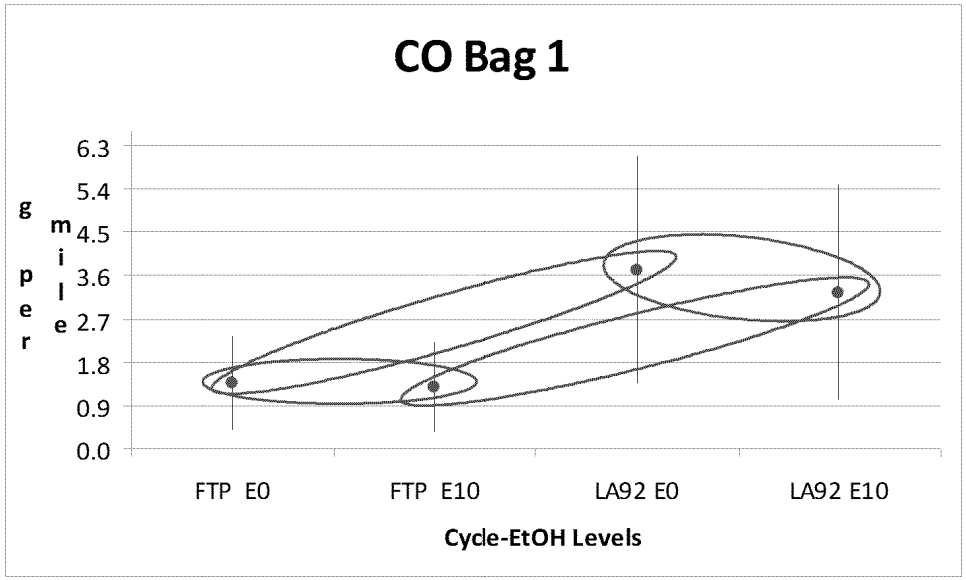


545OneDrive2_00001438

Preliminary Findings on Effect of Test Cycle - CO

- Results suggest no significant CO effect or interaction in the composite
- Some significant effects seen elsewhere:
  - Bag 1: LA92 > FTP for both levels of ethanol
  - Bag 1: E0 > E10 for both cycles
  - Bag 2: LA92 > FTP for both levels of ethanol
  - Bag 3: E0 > E10 for LA92
  - Bag 3: LA92 > FTP for E10

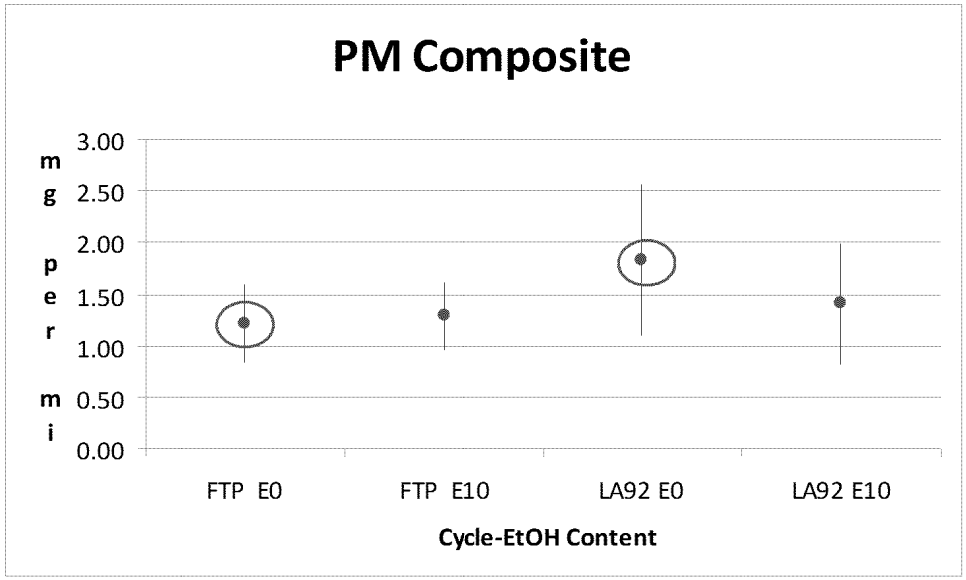


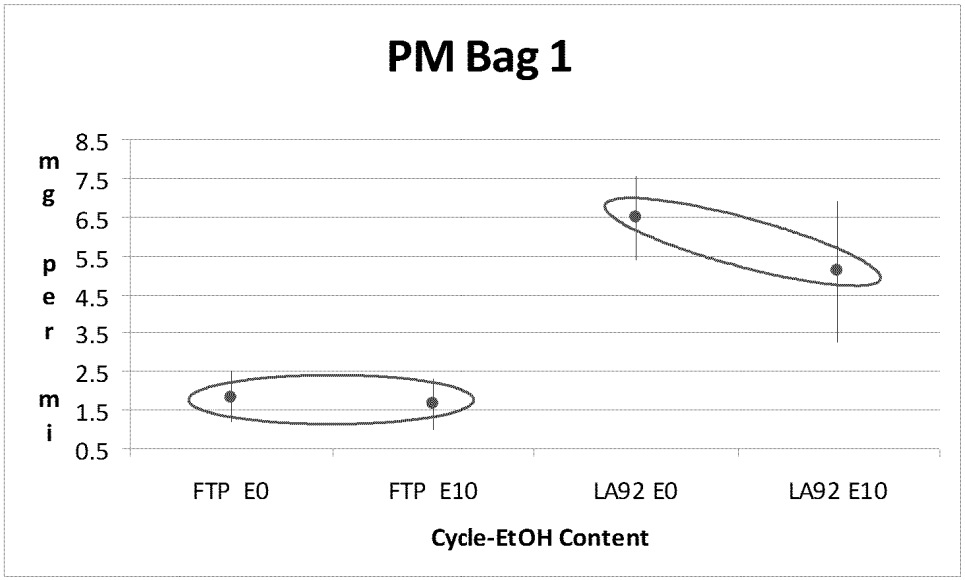


545OneDrive2_00001438

Preliminary Findings on Effect of Test Cycle - PM

- Significant cycle effects in composite, with ethanol interaction:
  - LA92 > FTP for E0
- Significant cycle effects in Bags 1 & 3:
  - Bag 1: LA92 > FTP for both ethanol levels
  - Bag 3: LA92 > FTP for both ethanol levels

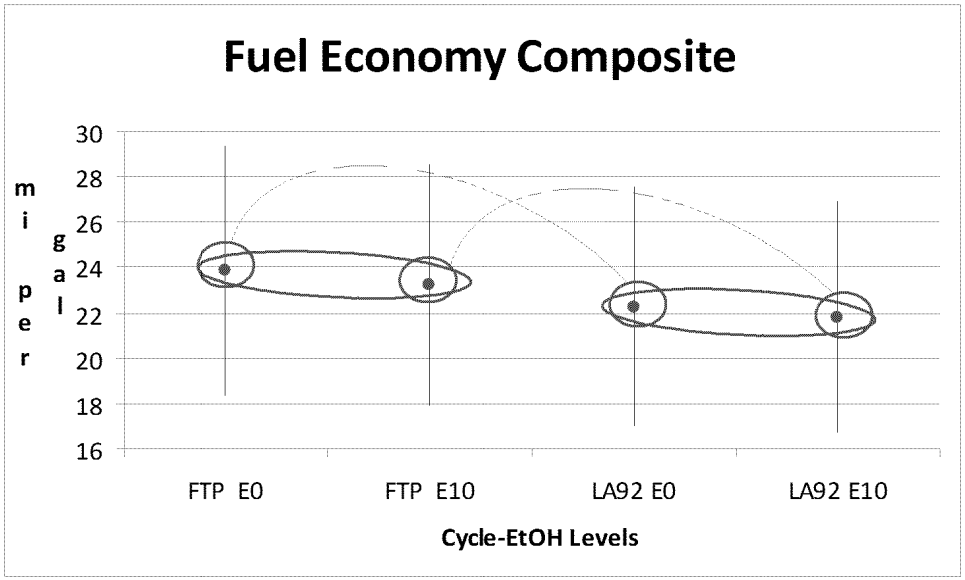


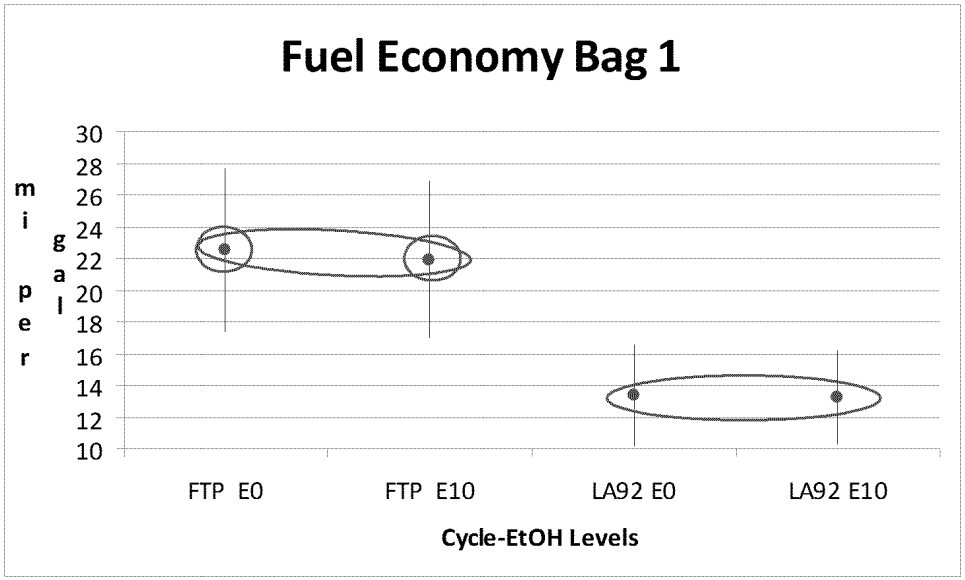


545OneDrive2_00001438

Preliminary Findings on Effect of Test Cycle - FE

- Significant cycle and ethanol effects in composite, with some interaction:
  - FTP > LA92 at both ethanol levels
  - E0 > E10 for both cycles
- Lots of ethanol-cycle interactions in individual bags
- Two interesting findings:
  - In all bags, FTP appears to highlight ethanol FE difference more than LA92
  - In Bag 2, LA92 appears to have equal or slightly better FE than FTP (reverse of other bags & composite)





545OneDrive2_00001438

545OneDrive2_00001438

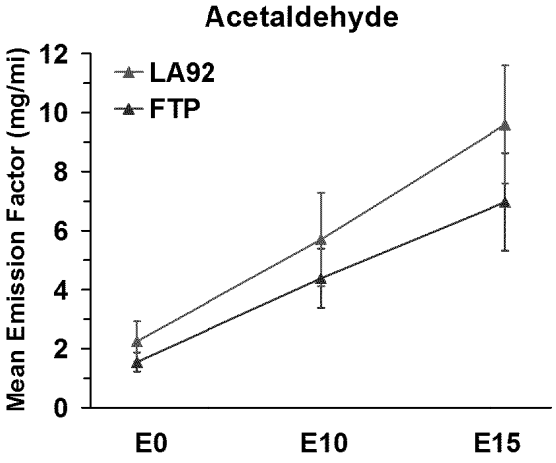
Air Toxics Summary: Phase I and Test Cycle Effects

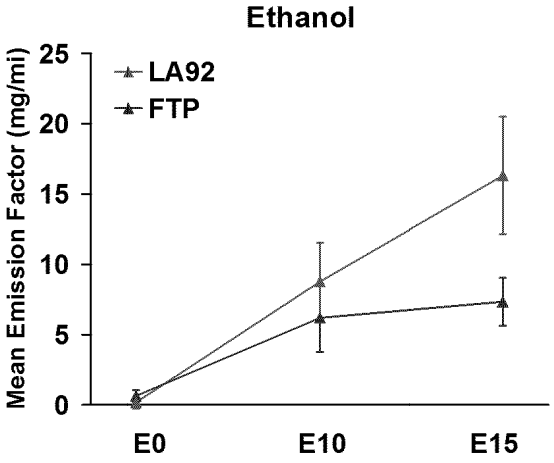
Phase I Results:

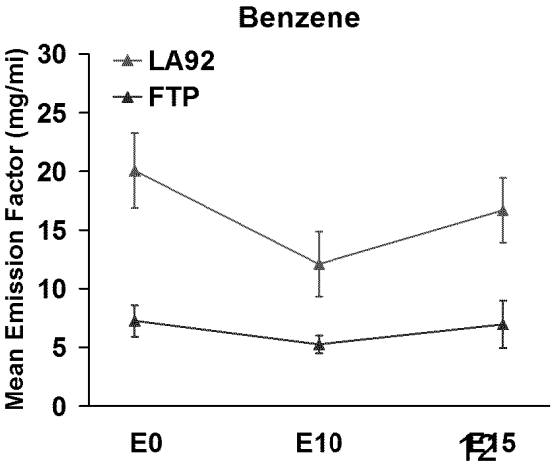
- Overall, emission factors for air toxics are very low.
- Trends for some individual toxics are as expected:
  - Acetaldehyde and ethanol emissions increase with increasing ethanol in fuel.
- Fuel content irregularities obscure trends for some VOCs, including benzene. This will impact Phase II results as well.

Test Cycle Effects:

- Bag 1 data only: Nothing unexpected in trends for individual toxics.
- Cannot conclude that test cycle has an effect.



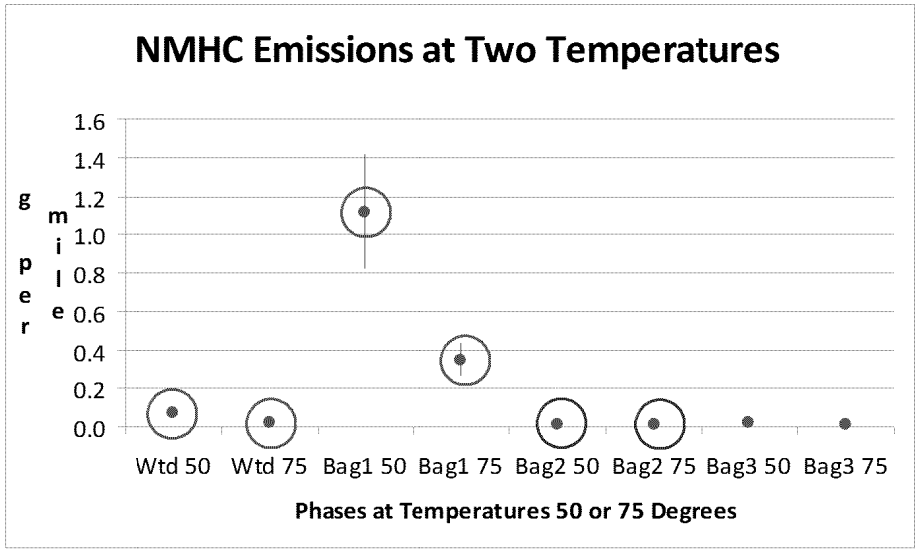


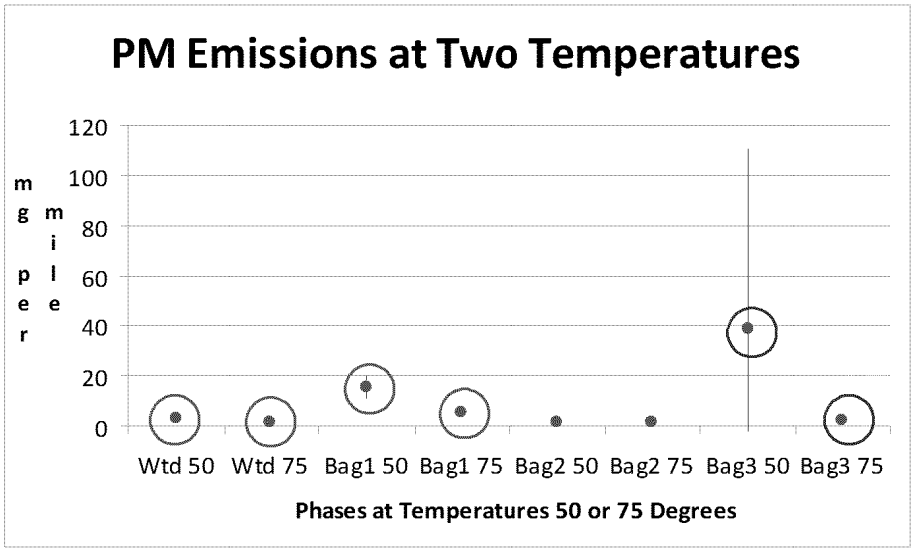


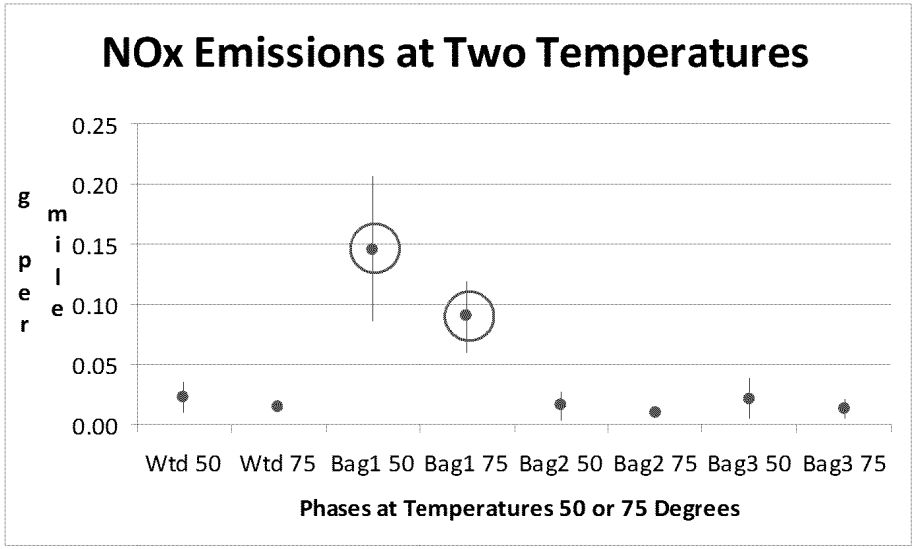
545OneDrive2_00001438

Preliminary Findings on Effect of Test Temperature

- As expected, lower temperature caused emission increases in most cases
  - Colored circle pairs indicate significant differences
- E10 & E15 data still being collected







545OneDrive2_00001438

Budget Considerations Going Forward

- Original program cost estimate: $4,271,000
- Cost overrun wrt the original scope of program: Ex. 4 - CBI
- Cost overrun including additional projects: $ Ex. 4 - CBI
- ASD staff have worked hard with SwRI to reduce costs while still keeping the program intact

	Program or Project	Cost	Cumulative Cost	Difference of Total From the Original Estimate of $4,271,000	
ORIGINAL PROGRAM	EPAct Program, April 2008 Cost Estimate	$ 4,271,000	-	-	-
	EPAct Program, January 2009 Cost Estimate	$ 4,698,100	Ex. 4 - CBI		
	Fuel Cost Adjustment	Ex. 4 - CBI			
ADDITIONAL PROJECTS	FTP Testing (Partially Competed)				
	EFM Resolution (Completed)				
	Fuel Matrix Redesign (Completed)				
	Blending of Two CRC Fuels				
	EmissionTesting of Two CRC Fuels				

545OneDrive2_00001438

Budget Considerations Going Forward (Cont'd)

- Phase 3 cost estimate: $1,860,000
- Current shortfall: Ex. 4 - CBI
- Funds spent or obligated as of Jan. 23, 2009: Ex. 4 - CBI
- Phase 3 (Starts in Feb. 2009): Ex. 4 - CBI
- Blending and testing of CRC fuels: $301,000

	Program or Project	Date Estimated	Cost		Cumulative Cost	Difference of Total From the Original Estimate of $4,271,000		Comments
			Estimated	Actual				
ORIGINAL PROGRAM	Whole EPAct Program	29-Apr-08 6-Jan-09	$ 4,271,000 $ 4,698,100	-	-	-	-	Ex. 4 - CBI
ORIGINAL PROGRAM	Phase 1 (Completed)	Ex. 4 - CBI						
ORIGINAL PROGRAM	Phase 2 (Compl. Feb 2009)							Ex. 4 - CBI
ORIGINAL PROGRAM	Phase 3 (Starts Feb 09)							
ORIGINAL PROGRAM	Fuel Cost							
ORIGINAL PROGRAM	Fuel Cost Adjustment							Fuel cost adjustment related to rebending of one fuel, some stranded fuel development work by Haltermann and EPA involvement in test fuel development
ADDITIONAL PROJECTS	FTP Testing (Partially Competed)							Additional test program to compare LA-92 and FTP tests wrt ethanol impacts
ADDITIONAL PROJECTS	EFM Resolution (Completed)							Additional program to enable the use of the Sensors exhaust flowmeter in the EPAct Program
ADDITIONAL PROJECTS	Fuel Matrix Redesign (Completed)							Statistical redesign of the fuel matrix
ADDITIONAL PROJECTS	Blending of Two CRC Fuels							Exchange with CRC
ADDITIONAL PROJECTS	EmissionTesting of Two CRC Fuels							Exchange with CRC
				Grand Total >>>	$ 5,413,500	$ 1,142,500	26.8%	

Ex. 4 - CBI

545OneDrive2_00001438

Projected Schedule Going Forward

- Launch of Phase 3 testing: Mid-February 2009
- Completion of Phase 3 testing: Early December 2009
- Reporting: December 2009 – mid-March 2010

		JAN 2009				FEB 2009				MAR 2009					APR 2009				MAY 2009				JUN 2009					JUL 2009				AUG 2009					SEP 2009				OCT 2009				NOV 2009					DEC 2009			
		5	12	19	26	2	9	16	23	2	9	16	23	30	6	13	20	27	4	11	18	25	1	8	15	22	29	6	13	20	27	3	10	17	24	31	7	14	21	28	5	12	19	26	2	9	16	23	30	7	14	21	28
Phase 1[a]	14 weeks																																																						
50F setup	3 weeks																																																						
Phase 2[b]	9 weeks	4	5	6	7	8	9																																																
50F teardown	2 weeks																																																						
Phase 3[a]	26 weeks							1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26																							
NREL fuels[a]	17 weeks																																	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17				
CRC fuels	4 weeks																																																			1	2	3	
NREL high emitter	2 weeks																																																						
draft final report	6 weeks																																																			1	2	3	
EPA/NREL review	4 weeks																																																						
final report	4 weeks																																																						

		JAN 2010				FEB 2010				MAR 2010					APR 2010				MAY 2010				JUN 2010					JUL 2010				AUG 2010					SEP 2010				OCT 2010				NOV 2010					DEC 2010			
		5	12	19	26	2	9	16	23	2	9	16	23	30	6	13	20	27	4	11	18	25	1	8	15	22	29	6	13	20	27	3	10	17	24	31	7	14	21	28	5	12	19	26	2	9	16	23	30	7	14	21	28
Phase 1[a]	14 weeks																																																						
50F setup	3 weeks																																																						
Phase 2[b]	9 weeks																																																						
50F teardown	2 weeks																																																						
Phase 3[a]	26 weeks																																																						
NREL fuels[a]	17 weeks																																																						
CRC fuels	4 weeks	4																																																					
NREL high emitter	2 weeks		1	2	3																																																		
draft final report	6 weeks	4	5	6																																																			
EPA/NREL review	4 weeks				1	2	3	4																																															
final report	4 weeks								1	2	3	4																																											

545OneDrive2_00001438

Summary of Next Steps

- Complete analysis of FTP cycle effect
  - E15 data is still pending
- Complete Phase 2 testing
  - Analyze and present results for E10 and E15 fuels
- Complete fuel blending
- Perform Phase 3 testing

Additional Slides

545OneDrive2_00001438

Measured Species

- Bag (phase) level and composite emissions of THC, NMHC, NMOG, CO, CO_2, NOx, NO_2, ethanol and PM
- Bag (phase) level speciated volatile organic compounds (VOCs)
  - Over 200 compounds, incl. alcohols and carbonyls
- Continuous and integrated by bag (phase) emissions of the following species in raw exhaust:
  - THC, NMHC, CO, CO_2, NOx
  - N_2O, NH_3 and HCN by FTIR for a subset of tests
- Semi-volatile and high molecular weight VOC and PM measured in Phases 1 and 2 only

545OneDrive2_00001438

EPAct Vehicles vs. Tier 2 Emission Standards

EPAct Vehicle	Tier 2 Bin #	NMOG g/mile	CO g/mile	NOx g/mile	PM g/mile
Ford Focus, Ford Explorer	4	0.070	2.1	0.04	0.01
All other EPAct vehicles	5	0.075	3.4	0.05	0.01
Ford F150, Dodge Caravan	8	0.100	3.4	0.14	0.02

545OneDrive2_00001438

545OneDrive2_00001438

E10 Impacts on Emissions from Tier 2 Vehicles

From EPAct Phase 1, 19 Vehicles, Paired t-test, $p<0.05$

Pollutant	Percent Change vs. E0			
	Weighted	Bag 1	Bag 2	Bag 3
NOx	-	-24.8	-	-
THC	-	-6.9	-	-31.2
CO	-17.6	-	-19.9	-41.9
PM	-20.8 ($0.1<p<0.05$)	-	-24.8	44.7

E10 Impacts on Emissions from Tier 2 Vehicles

From CRC E-74b Program (7 Vehicles, Mixed Model, $p<0.05$)

Pollutant	Percent Change vs. E0			
	Weighted	Bag 1	Bag 2	Bag 3
NOx	-	-	-	-
NMHC	-12.9 ($0.1<p<0.05$)	-	-	-
CO	-22.4	-22.4	-	-
CO_2	-	-	-	-

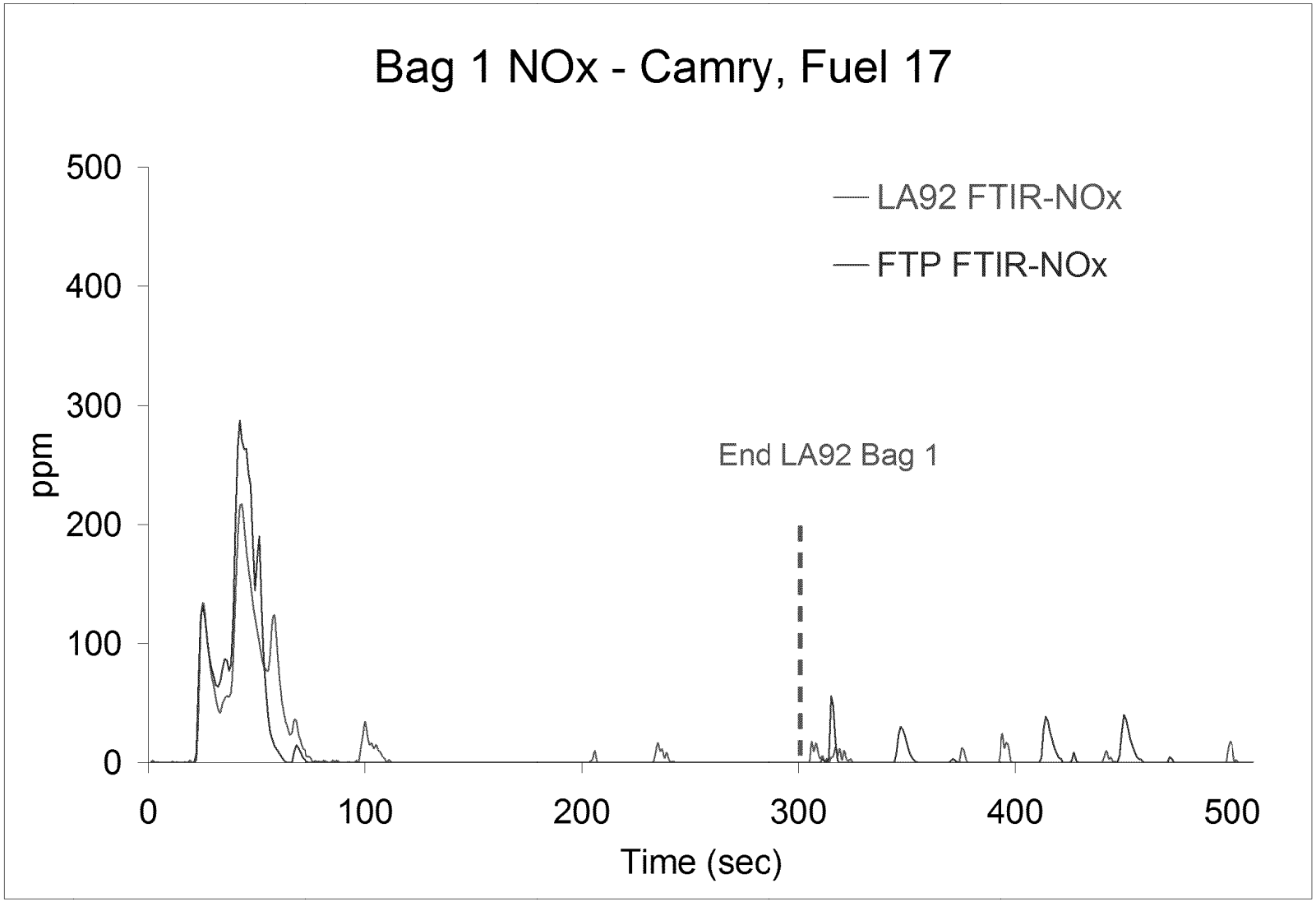
545OneDrive2_00001438

545OneDrive2_00001438

Test Fuel Properties

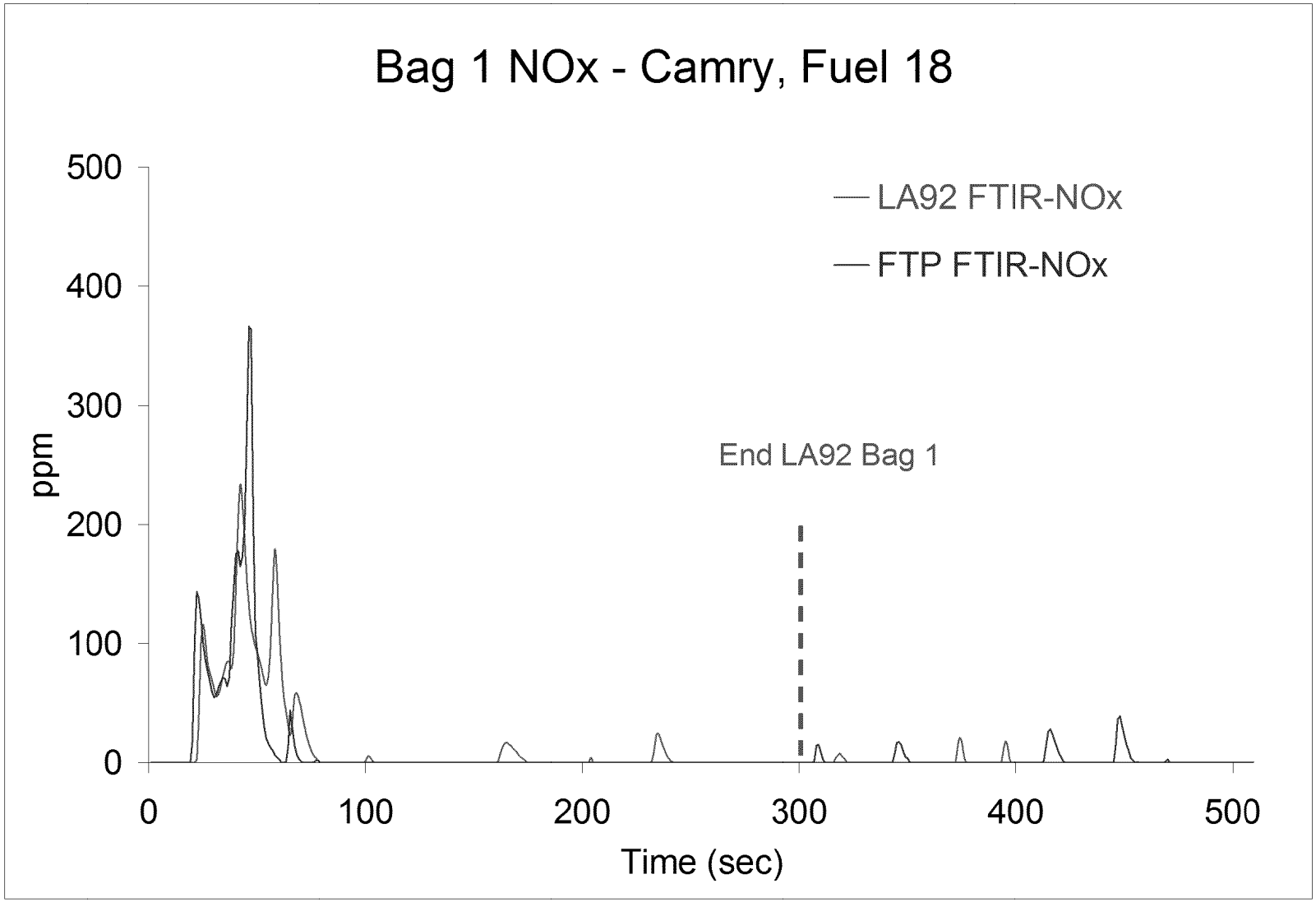
PROPERTY	UNIT	METHOD	FUEL		
			E0	E10	E15
Ethanol Content	vol. %	D5599	<0.1	9.35	14.5
T50	ºF	D86	215	209	182
T90	ºF	D86	324	319	310
RVP	psi	D5191	9.17	9.05	8.91
Aromatics	vol. %	D1319	29.3	22.9	18.7
Olefins	vol. %	D1319	6.4	5.7	5.6
Benzene	vol. %	D3606	0.48	0.49	0.46
S	mg/kg	D5453	23	23	21
RON	-	D2699	93.4	93.7	93.9
MON	-	D2700	83.5	84.9	84.6
(R + M)/2	-	Calc.	88.5	89.3	89.2

Modal NOx Comparison – FTP vs. LA92



545OneDrive2_00001438

Modal NOx Comparison – FTP vs. LA92



545OneDrive2_00001438