ESCIT

Afton Catalyst Test and Other Related Issues for GF-5

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ACT Goals and Conditions Quick Overview

- Goals
  - Discern relevance of PEI250 to catalyst protection
  - Develop knowledge base for volatility-related engine oil properties on catalyst protection

- Test Conditions
  - 240-hour test in “flush and run” 4.6L Ford V8
  - 10 oil changes
  - Steady-state aging at moderate catalyst inlet temperatures
    - 550C catalyst inlet temperature
  - 150C oil temperature
  - 122C coolant temperature
  - Catalysts tested before and after aging
    - “T50” calculated

Since last update

- Completed testing on zero-phos field test oil and compiled results.
- Evaluated oils with volatility level of GF-4 chemistry
- Developing possible recommendations for ESCIT

New and Aged Oil Properties

NEW

	FT Oil 32	FT Oil 33	FT Oil 34	High PEI	Low PEI
	RB10357	RB10358	RB10360	RB10331	RB10332
NOACK, %	21	21	21	15	15
PEI250, mg/L	15	46	0	90	11
ZDDP Type	A	A	A	B	A
Ca, ppm	984	0	973	2107	2139
Mg, ppm	673	0	678	0	0
Na, ppm	200	201	195	0	0
P, ppm	949	932	0	1005	1019
Zn, ppm	1065	1055	1082	1174	1159

AGED

Element	RB10357	RB10358	RB10360	RB10331	RB10332
Ca, ppm	1443	0	1244	2508	2503
Mg, ppm	1006	0	856	0	0
Na, ppm	301	277	261	0	0
P, ppm	1006	944	6	990	973
Zn, ppm	1337	1365	1345	1316	1203

Loss of Conversion Efficiency (T50)

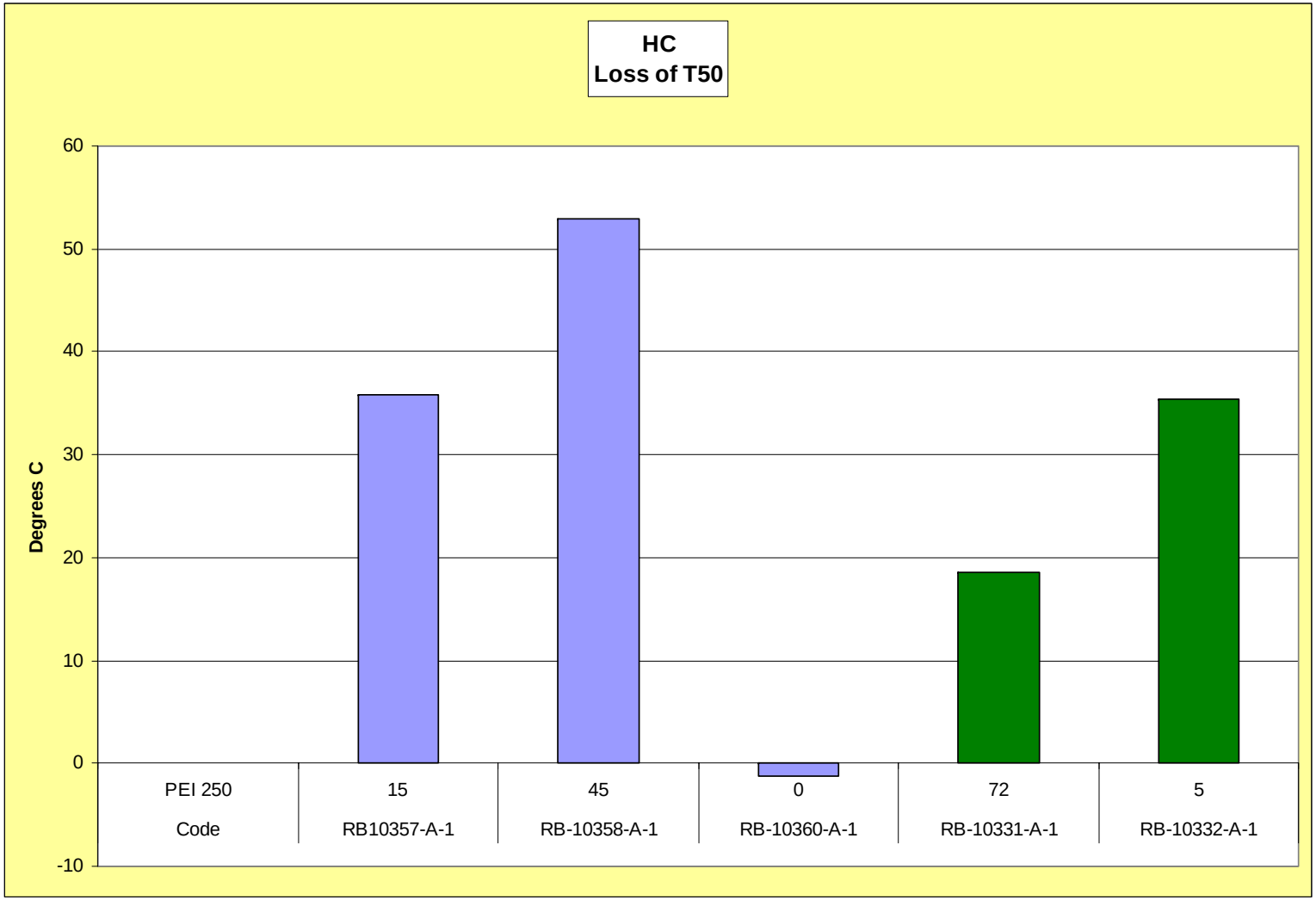
As measured by the increase in temperature where 50% conversion efficiency occurs

	GF-2-Style FT Oils				**GF-4-Volatility PEI Comparison Oils**	
Oil Code	FT 32	FT33	FT34		RB10331	RB10332
PEI250, mg/L	15	46	0		90	11
Pollutant						
HC	36	53	-1		19	35
CO	37	57	9		28	66
NOx	34	53	6		28	60

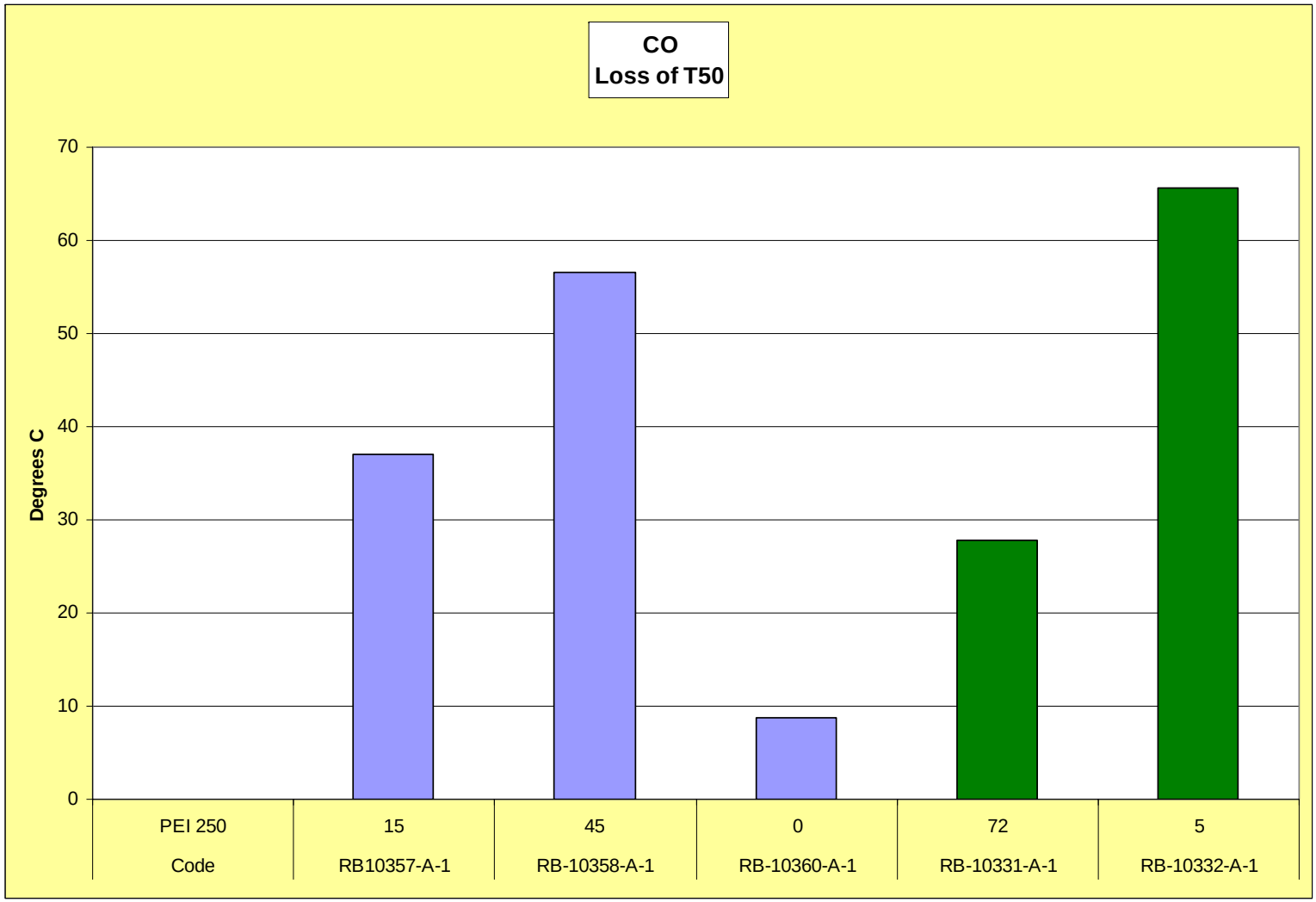
✓ GF-2 Field Test oils were ranked according to Ford/Afton/Delphi SAE Paper.

X High PEI RB10331 had better performance than low PEI RB10332

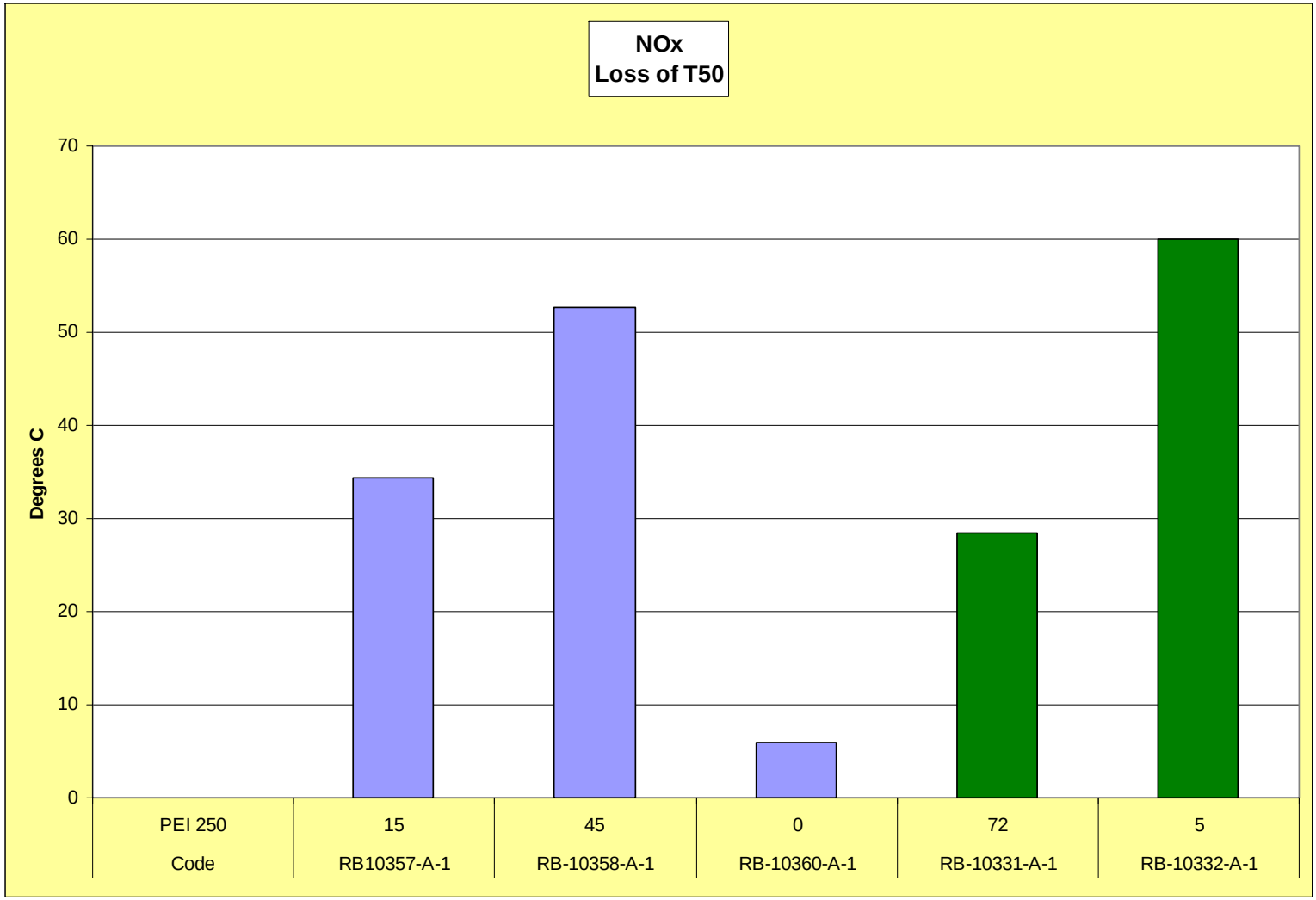
T50 Hydrocarbon Comparison



T50 Carbon Monoxide Comparison



T50 NOx Comparison



Calculated Phosphorus Retention

From SAE 2002-01-2680

Calculation for % phos retention: $(Ca_{new} / Ca_{hrx})^* (Phos_{hrx}/Phos_{new)} *100$

Calculated phosphorus retention*

Based on Element	RB10357	RB10358	RB10360	RB10331	RB10332
Phos Retention (Zn)	84.4	78.3	N/A	87.9	92.0
Phos Retention (Ca)	72.3	N/A	N/A	82.8	81.6

✓ Zero-detergent GF-2 oil (RB10358) retained less Phos

X High PEI250 GF-4 oil (RB10331) performed similarly to Low PEI

Phosphorus Depletion Mechanisms

- Consistent with SAE 2004-01-2909, analysis of blowby condensate from ACT suggests at least three mechanisms for phosphorus depletion occurring in the engine
  - Volatilization of phosphorus from bulk oil
  - Volatilization of phosphorus from cylinder wall oil film
  - Consumption of oil mist
- Phosphorus throughput and resulting catalyst poisoning is a complicated mechanism dependent on oil formulation variables in addition to phosphorus volatility

Conclusions

- No strong evidence that PEI_{250} relates to increased phosphorus throughput and resulting catalyst poisoning
- PEI_{250} does not appear to be related to phosphorus retention when fully-formulated oils are considered.
- No indication that “Phos Retention” is related to catalyst protection
- Alkaline-earth metal detergents are carried out with blowby to varying degrees. In Afton testing the high PEI_{250} oil carried out the most detergent chemistry.
- Observation in SAE 2002-01-2680 about elevated PEI_{250} leading to increased catalyst poisoning is most likely related to lack of detergent.

Forward Plan

- Afton to work cooperatively with Savant, Inc to develop bench testing methodology that correlates with ACT and field.

- Goal is to have proposal for ESCIT by end of 2006.

- Note: Afton is willing to test limited number of outside oils with field data in ACT, in conjunction with SAVANT, with input from ESCIT.