

PROPOSAL FOR COAT TO BE ALTERNATE TEST TO EOAT IN LEGACY API “C” CATEGORIES

Presented to: Caterpillar Test Surveillance Panel

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Performance you can rely on.



Information shared between Infineum USA L.P. and Caterpillar Surveillance Panel

GOAL



Present data that may help the Caterpillar Surveillance Panel:

- Recommend COAT limits for legacy API “C” categories to the API Lubricants Group (LG) and Category Life Oversight Group (CLOG), which would allow COAT to be listed as an alternate test to the EOAT in legacy API “C” categories

- Use TMC-1005 to establish a COAT limit, equivalent to the EOAT limit for API CH-4, CI-4 and CJ-4, and confirm directionality between the two tests with an additional oil (PC-11G).
- Why TMC-1005?
 - Introduced to TMC in 1993
 - Represents “API CH-4” oil technology (older)
 - Reference oil of EOAT
 - Well established and consistent EOAT history of performance (n = 17)
 - Average EOAT Aeration (7.8%) is very close to the EOAT limit (8.0%) for API CH-4, CI-4 and CJ-4
 - Has been run twice in all 3 labs in COAT (n = 6) (Average COAT Aeration = 12.63%)
- Why PC-11G/ oil 832?
 - Oil from the PC-11 COAT Precision/BOI matrix (n=11)
 - Represents PC-11 oil technology (newest)
 - Has also been run in the EOAT to allow for a confirmation of directionality between COAT and EOAT
 - Supports a “good” performing oil in the COAT is a “good” performing oil in the EOAT

Upper bound prediction interval based on 95% confidence interval for the mean of 1005-4



- Assumption: 1005-4 is a passing oil for CH-4, CI-4, and CJ-4
- Goal: Calculate the limit that satisfies the following:
 - Probability of an oil with average aeration and standard deviation S (equivalent to 1005-4) fail = 2.5%
- Steps
 1. Model aeration % with oil (including all six 1005-4 tests) **n= 49, chart = yes**
 - Use the RMSE of the model as the standard deviation S in the formula below
 2. Applied the following formula to obtain the upper bound prediction interval
Average aeration for 1005-4 + (T.INV.2T(0.05, 39) * (RMSE * Sqrt(1+1/6)))=
 $=12.63 + 2.02269092 * 0.393977 * \text{SQRT}(1+1/6) = 13.49074 = \sim \underline{\underline{13.5\%}}$

DIRECTIONALITY SUPPORTED



Engine Test	COAT	EOAT
Test Oil	PC-11G	PC-11G
SAE Grade	SAE 15W-40	SAE 15W-40
% Aeration Result	10.6% (Target from Matrix n = 11)	6.8% (n = 1)

- Results support that directionality is maintained between COAT and EOAT
- A good oil in the COAT is a good oil in the EOAT

ACTION



- Suggest Caterpillar Surveillance Panel considers a motion to recommend to API Lubricants Group (LG) and Category Life Oversight Group (CLOG) to accept COAT test with a **13.5%** Aeration limit, as an alternate to the EOAT test, with an 8.0% Aeration limit, for API CH-4, API CI-4 and API CJ-4.

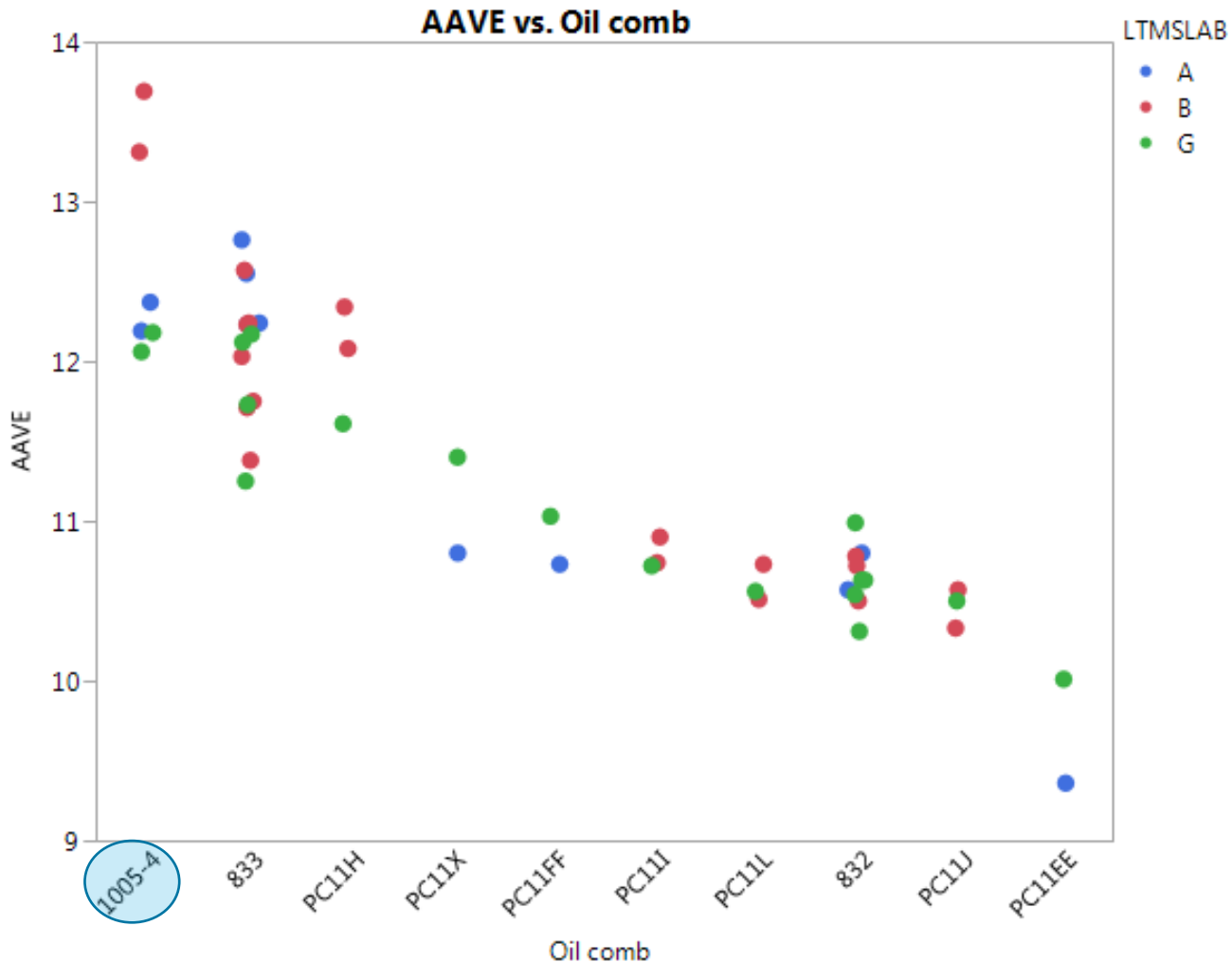
APPENDIX: MORE DETAILS ABOUT THE DATA

Data Used in Analysis:



- EOAT
 - Total 38 LTMS chartable test results
- COAT
 - Total 49 LTMS chartable test results including six TMC 1005-4 test results

COAT: 40 to 50 hr. Aeration % by Oil and Lab: ordered from highest to lowest oil mean



COAT controlled to a target pressure

Aeration Profile & Oil Filter Date for TMC 1005-4



Oil comb	OILFIL date	profile	# of tests
1005-4	missing	steep	2
1005-4	missing	shallow	1
1005-4	11/11/2014	shallow	1
1005-4	1/5/2015	shallow	1
1005-4	4/7/2015	shallow	1
832	11/11/2014	steep	1
832	1/5/2015	steep	2

COAT: Means and Standard deviations by Oil



Oil comb	N Rows	Mean(AAVE)	Std Dev(AAVE)
1005-4	6	12.633	0.6891
833	15	12.064	0.4289
PC11H	3	12.01	0.37
PC11X	2	11.1	0.4243
PC11FF	2	10.88	0.2121
PC11I	3	10.787	0.0987
PC11L	3	10.6	0.1153
832	10	10.647	0.1877
PC11J	3	10.467	0.1234
PC11EE	2	9.685	0.4596

COAT: Summary for 1005-4

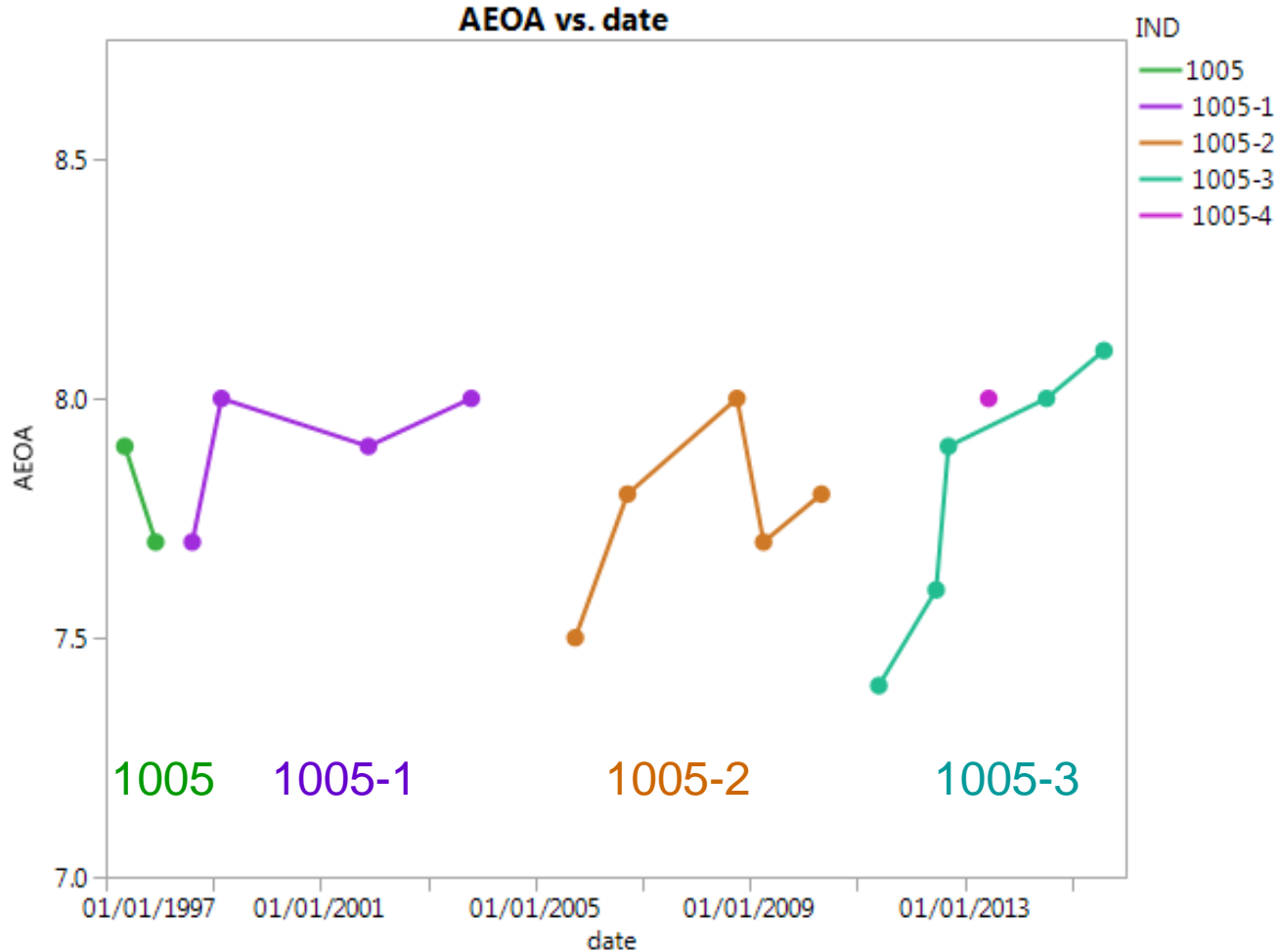


1005-4					
LTMSLAB	TESTKEY	SA	AAVE as measured		AAVE severity adjusted
A	109710-COAT	-0.33	12.19		11.86
A	112489-COAT	-0.48	12.37		11.89
B	107387-COAT	0.24	13.31		13.55
B	110215-COAT	-0.11	13.69		13.58
G	100263-COAT	0.37	12.06		12.43
G	109830-COAT	0.25	12.18		12.43
		Mean	12.63		12.62
		Median	12.28		12.43

Std AAVE as measured = 0.6891

Std AAVE after SA = 0.7706

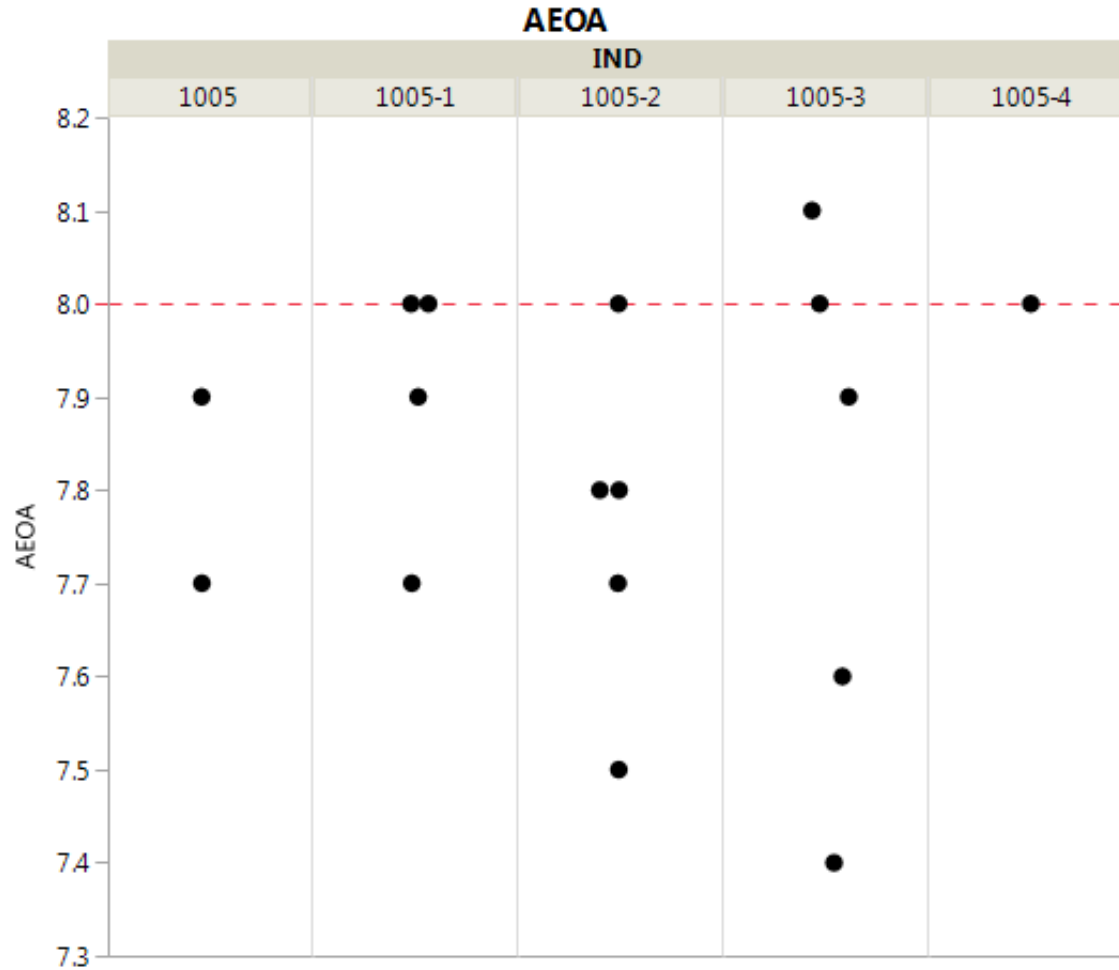
EOAT: Aeration for 1005 and re-blends



Aeration is measured at ambient pressure

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EOAT: Aeration by Oil



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EOAT: Mean, Standard deviation and Median for 1005 and re-blends



IND	# of tests	Mean(AEOA)	Std	
			Dev(AEOA)	Median(AEOA)
1005	2	7.8	0.1414	7.8
1005-1	4	7.9	0.1414	7.95
1005-2	5	7.76	0.1817	7.8
1005-3	5	7.8	0.2915	7.9
1005-4	1	8	.	8

Mean and Std. ignoring batch

N Rows	Mean(AEOA)	Std Dev(AEOA)
17	7.8235294118	0.1985239651