Statisticians reporting back to Caterpillar Surveillance Panel

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5/25/2017: Statisticians reporting back to Caterpillar Surveillance Panel

- May 24th 2017, statisticians met to discuss next steps with respect to COAT correction factors and standard deviation calculations for ltms

- A summary is presented next

Summary

- Industry Correction Factors?
  - Consensus : DO NOT apply a correction factor at this time

- New Standard deviations for Itms?
  - Consensus: need to collect more data faster and the majority supported moving forward at this point with options 1 and 2 below
    - Option 1: No change to the current standard deviation
      - Lab A has Zi alarm
    - Option 2: Update std using all the data
      - Lab A has Zi alarm
    - Option 3: Update std using 9 recent tests
      - Lab A has Zi alarm

- Is it appropriate widening Zi level 2 limits? the current limit is 1.8
- Comments on collecting more data:
  - The goal is to confirm the variability as well as confirm discrimination

- Additional topics as a reminder for future meeting
  - Zi level 1 limit (only positive direction)
  - Level 2 ei alarms

New Standard deviations for ltms?

Consensus: need to collect more data faster

The fact that there are three options demonstrates our difficulty in selecting a proper subset to evaluate the variability of the CAT aeration based on the existing 50 tests: not knowing which additional changes have happened over time; the presence of confounding

Majority selected options 1 or 2 to move forward.

- Option 1: No change to the current standard deviation
- Option 2: Update standard deviation using all the data
- Option 3: Update standard deviation using 9 recent tests
  - This option represents our concern about older data not representing current test state

Standard deviations based on 50 tests by Technology (option 2)

Model 2: df=39

tech	N Rows	Sum(residual squared)	allocating DF proportional to n by tech	stand dev by tech	divided by N-2
tech1	18	1.6608767328	14.04	0.343941948	0.3221875165
tech2	26	3.206432732	20.28	0.3976281213	0.3655152033
tech3	6	0.0924518889	4.68	0.1405513326	0.152029511

For reevaluating ltms, I used 0.344 for tech 1, 0.398 for tech 2 and 0.141 for tech 3.
Standard deviation for SA = 0.398 (corresponding to oil 833 – close to the pass/fail limit).

Model 1: df =35   Model 1 has been selected to do the std. calculations

tech	N Rows	Sum(Mod 1 Resid AAVE squared)	sum mod 1 resid squared / n-2	sqrt (sum mod 1 resid squared / df prop to # of tests per tech)	df prop
tech1	18	0.9975302192	0.2496910865	0.2813699789	12.6
tech2	26	3.2148208694	0.3659929911	0.4202838437	18.2
tech3	6	0.0393292199	0.0991579799	0.0967682798	4.2

For reevaluating ltms, I used 0.281 for tech 1, 0.42 for tech 2 and 0.097 for tech 3.
Standard deviation for SA = 0.42 (corresponding to oil 833 – close to the pass/fail limit).

Standard deviations for options 1 and 3

- Option 1: Current std.

40-50 Hr Average Aeration
Unit of Measure: Percent

Reference Oil	Mean	Standard Deviation
832	10.67	0.203
833	11.94	0.285

- Option 3: Update std. using 9 recent tests
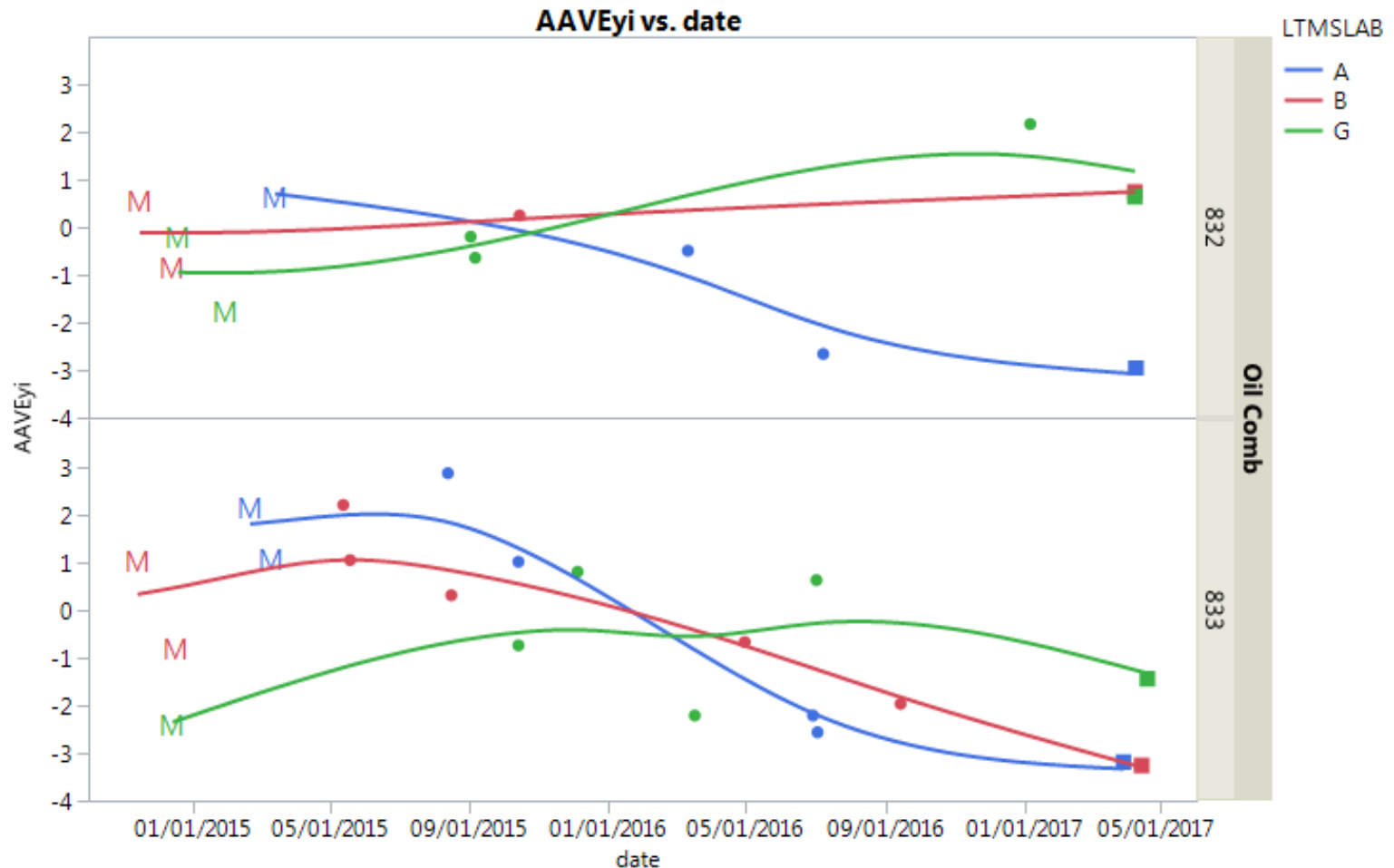 - 832: 0.230
  - 833: 0.263

  Note that these are very similar to the current standard deviations

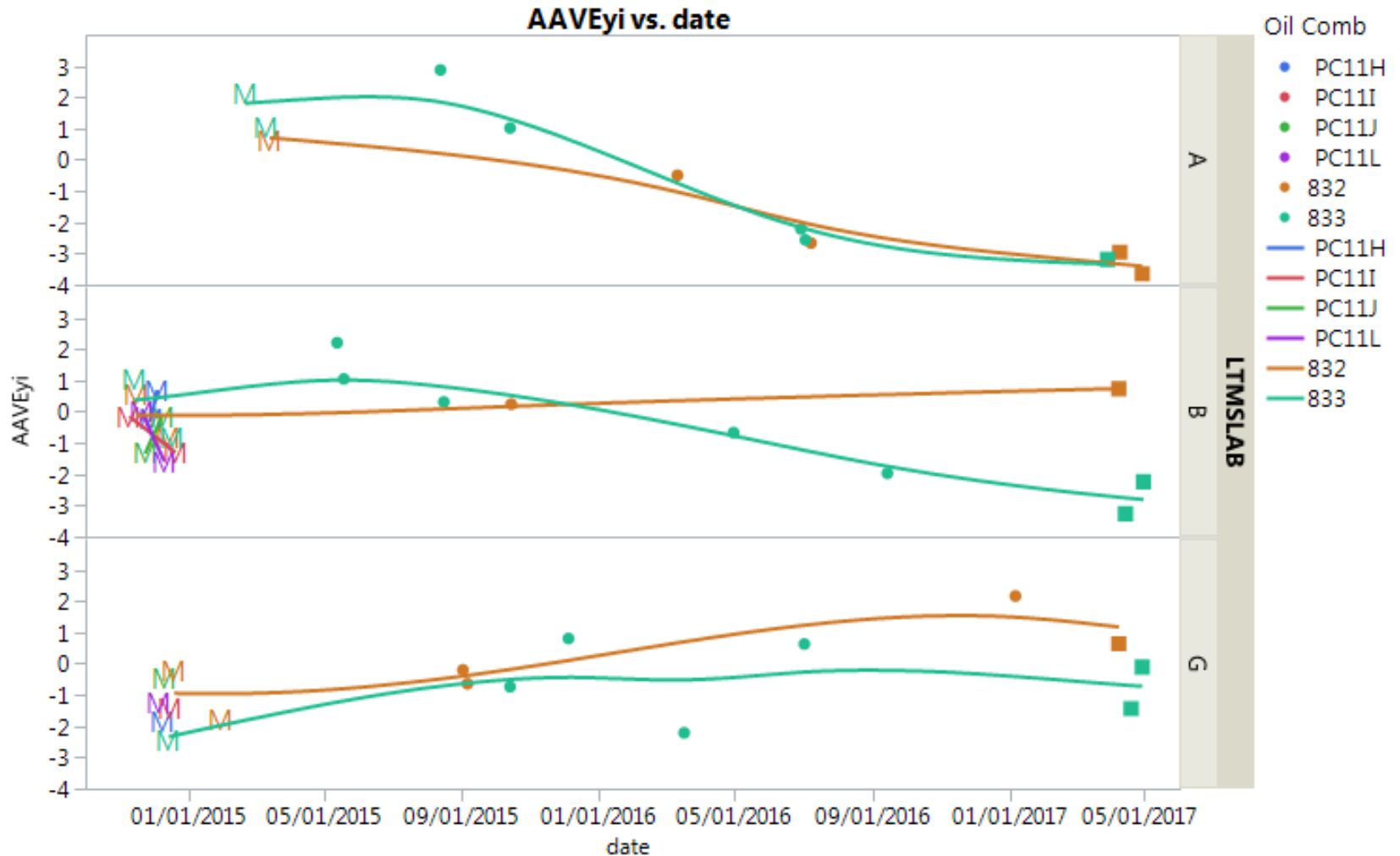# Plots of the data

Average Aeration yi vs. date by Lab and Oil (subset of oils 832 and 833)

"M" represents matrix data
Square symbol represents New MM cal & Filter

Average Aeration yi vs. date by Lab and Oil

Average Aeration yi vs. date by Lab

AAVEyi vs. date

"M" represents matrix data
Square symbol represents New MM cal & Filter

LTMSLAB
- A
- B
- G

AAVE vs. MM cal & Filter
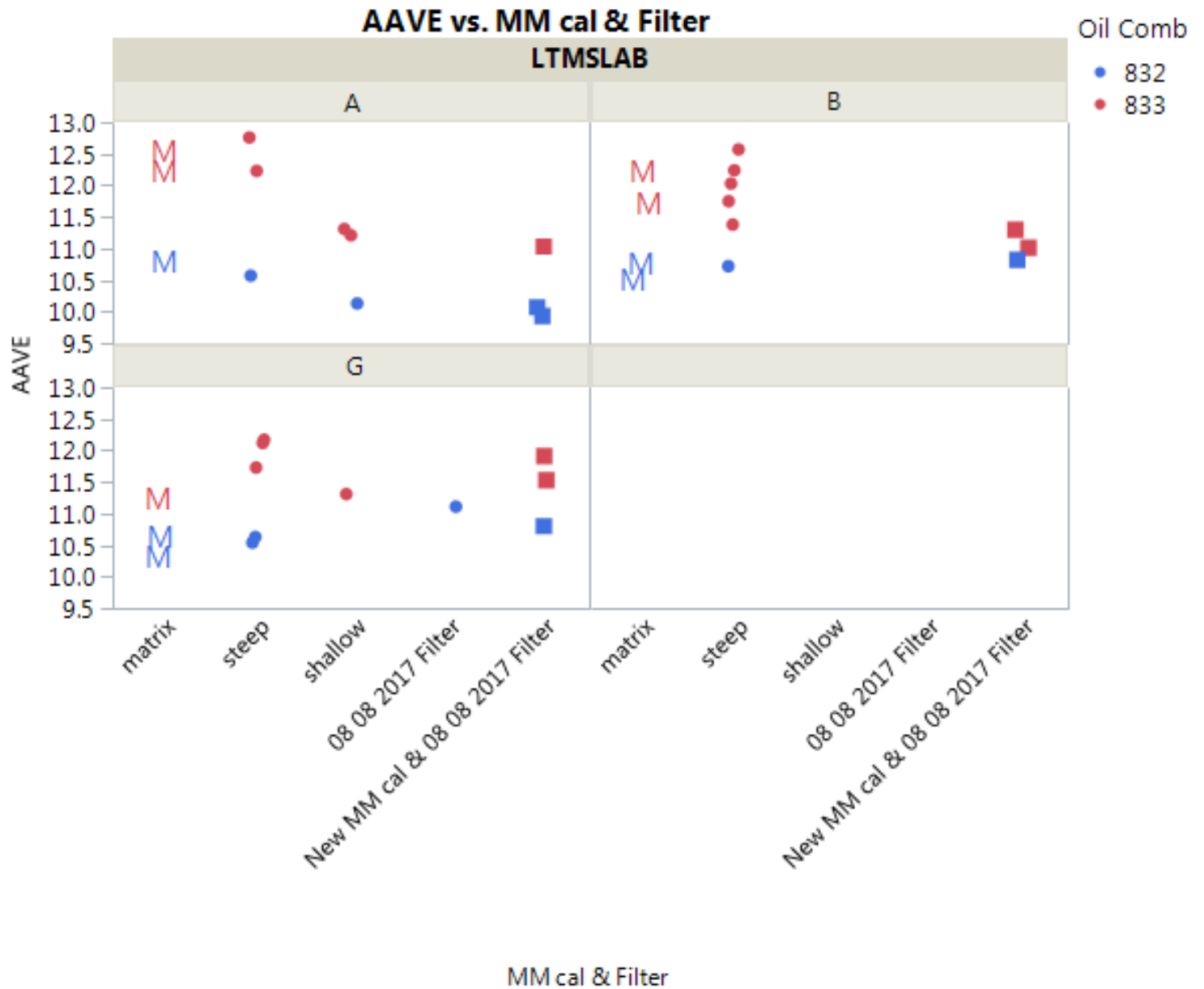
Average Aeration yi vs. "time"
Matrix versus "New MM cal and Filter"
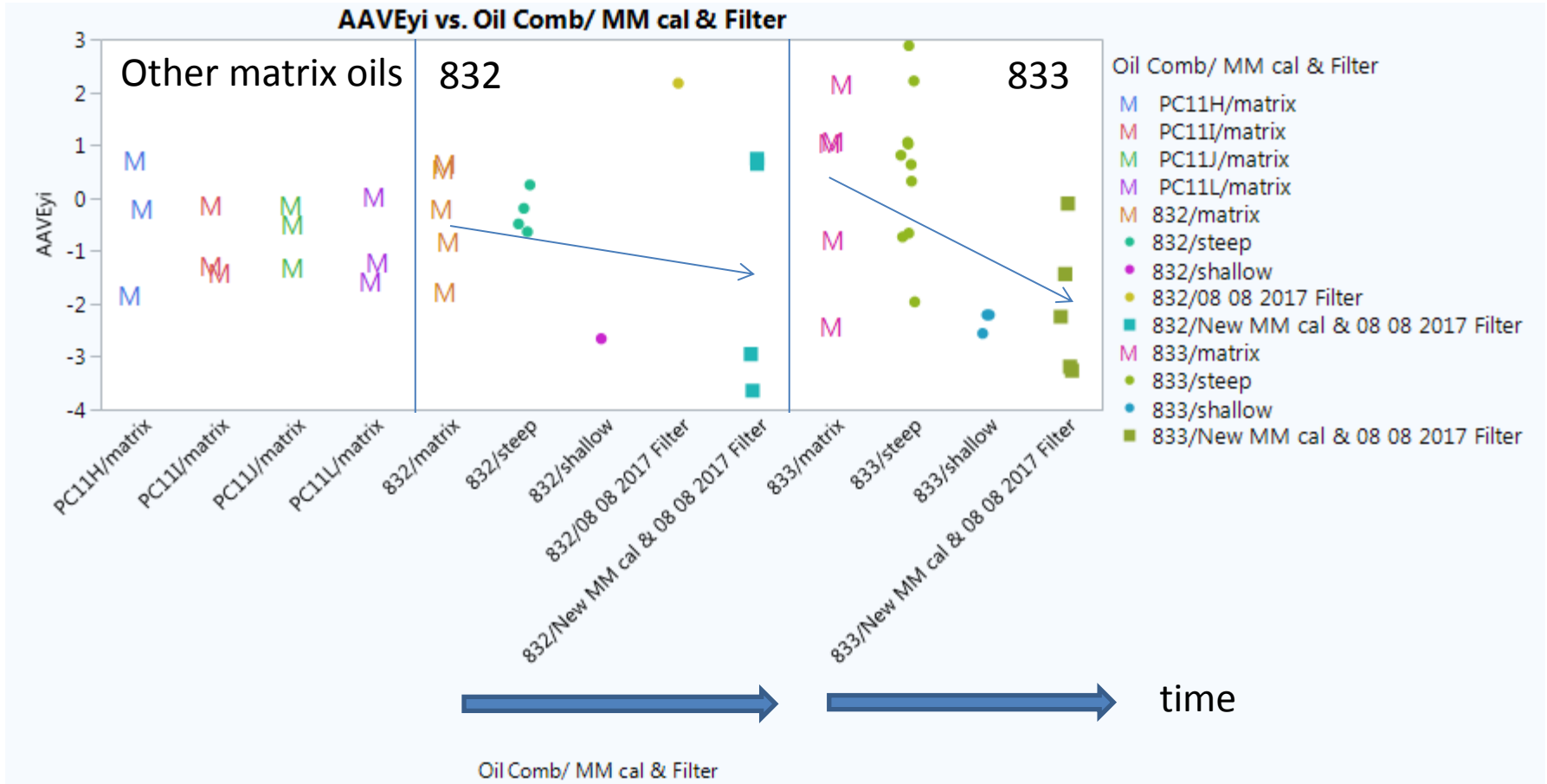
"M" represents matrix data
Square symbol represents New MM cal & Filter

Average Aeration yi vs. "time" by Lab

another way to look at time (using the Transmitter type, MM Calibration, Aeration profile)

Slopes

"M" represents matrix data
Square symbol represents New MM cal & Filter

ltms by lab with current targets and revised standard deviations (model 1)
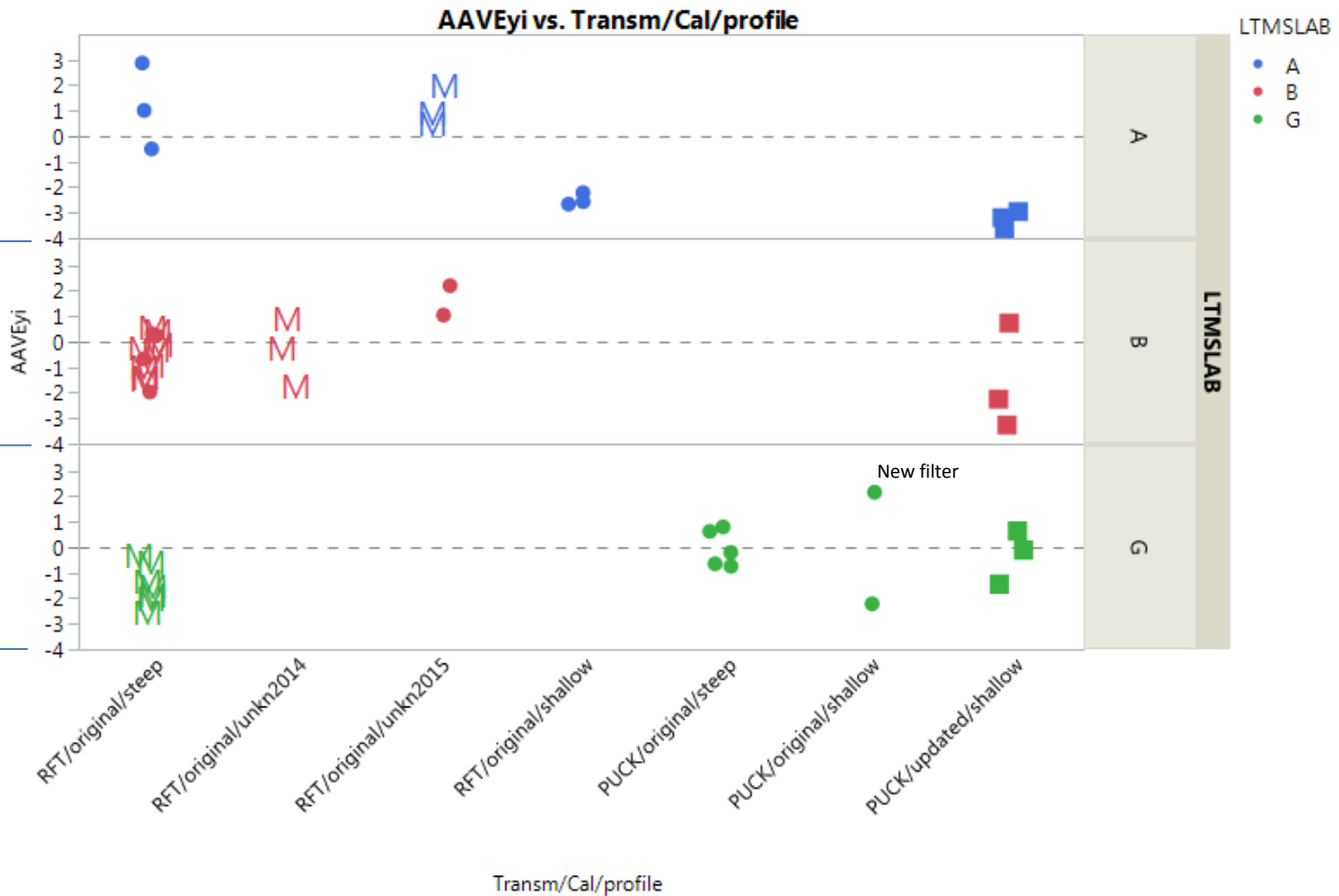
Table — Lab A

TESTKEY	VAL	LTMSAPP	LTMSLAB	IND	Aeration	Target	revised rmse	Yi	Zi	ei	effective Yi	effective Ziv2	abs(ei)	ei Fail Level 3	ei Fail level 2	SA
									0.876433			0.876433373				
106980-COAT	OO	1	A	PC11K	12.55	11.94	0.42	1.452381	1.049218	0.575948	1.452381	1.049217647	0.575948	0	0	-0.44067
107256-COAT	AO	1	A	PC11K	12.24	11.94	0.42	0.714286	0.948738	-0.33493	0.714286	0.948738067	0.334932	0	0	-0.39847
107255-COAT	AO	1	A	PC11G	10.8	10.67	0.281	0.462633	0.802907	-0.4861	0.462633	0.802906682	0.486105	0	0	-0.33722
108379-COAT	AC	1	A	833	12.76	11.94	0.42	1.952381	1.147049	1.149474	1.952381	1.147748963	1.149474	0	0	-0.48205
108380-COAT	AC	1	A	833	12.23	11.94	0.42	0.690476	1.010567	-0.45727	0.690476	1.010567132	0.457273	0	0	-0.42444
111341-COAT	AC	1	A	832	10.57	10.67	0.281	-0.35587	0.600635	-1.36644	-0.35587	0.600635426	1.366439	0	0	-0.25227
108860-COAT	OC	1	A	833	11.31	11.94	0.42	-1.5	-0.02956	-2.10064	-1.5	-0.0295552	2.100635	**1**	**1**	0.012413
116584-COAT	OC	1	A	833	11.21	11.94	0.42	-1.7381	-0.54212	-1.70854	-1.7381	-0.54211721	1.70854	0	0	0.227689
111342-COAT	AC	1	A	832	10.13	10.67	0.281	-1.92171	-0.95599	-1.37959	-1.92171	-0.9559945	1.379591	0	0	0.401518
118883-COAT	PC	1	A	833	11.03	11.94	0.42	-2.16667	-1.3192	-1.21067	-2.16667	-1.31919615	1.210672	0	0	0.554062
111348-COAT	PC	1	A	832	10.07	10.67	0.281	-2.13523	-1.56401	-0.81604	-2.13523	-1.5640067	0.816035	0	0	0.656883
126228-COAT	PC	1	A	832	9.93	10.67	0.281	-2.63345	-1.88484	-1.06945	-2.63345	**-1.88484028**	1.069445	0	0	0.791633

Lab A: Zi alarm
SA: 0.79

Table — Lab B

TESTKEY	VAL	LTMSAPP	LTMSLAB	IND	Aeration	Target	revised rmse	Yi	Zi	ei	effective Yi	effective Ziv2	abs(ei)	ei Fail Level 3	ei Fail level 2	SA
									0.291917			0.291916566				
104081-COAT	AO	1	B	PC11I	10.9	10.92	0.097	-0.20619	0.142486	-0.4981	-0.20619	0.142485926	0.498102	0	0	-0.05984
103459-COAT	AO	1	B	PC11K	12.23	11.94	0.42	0.690476	0.306883	0.54799	0.690476	0.306883005	0.54799	0	0	-0.12889
103625-COAT	AO	1	B	PC11G	10.78	10.67	0.281	0.391459	0.332256	0.084576	0.391459	0.332255826	0.084576	0	0	-0.13955
103957-COAT	AO	1	B	PC11L	10.73	10.73	0.097	0	0.232579	-0.33226	0	0.232579078	0.332256	0	0	-0.09768
103465-COAT	AO	1	B	PC11J	10.33	10.6	0.281	-0.96085	-0.12545	-1.19343	-0.96085	-0.12545087	1.193433	0	0	0.052689
103452-COAT	AO	1	B	PC11H	12.08	12.14	0.42	-0.14286	-0.13067	-0.01741	-0.14286	-0.13067275	0.017406	0	0	0.054883
103453-COAT	AO	1	B	PC11H	12.34	12.14	0.42	0.47619	0.051386	0.606863	0.47619	0.051386215	0.606863	0	0	-0.02158
103466-COAT	AO	1	B	PC11J	10.57	10.6	0.281	-0.10676	0.003942	-0.15815	-0.10676	0.003941881	0.158148	0	0	-0.00166
103958-COAT	AO	1	B	PC11L	10.51	10.73	0.097	-2.26804	-0.67765	**-2.27198**	-2.26804	-0.67765305	**2.271983**	**1**	**1**	0.284614
103626-COAT	AO	1	B	PC11G	10.5	10.67	0.281	-0.60498	-0.65585	0.072671	-0.60498	-0.6558518	0.072671	0	0	0.275458
103460-COAT	AO	1	B	PC11K	11.71	11.94	0.42	-0.54762	-0.62338	0.108233	-0.54762	-0.62338197	0.108233	0	0	0.26182
105877-COAT	AO	1	B	PC11I	10.74	10.92	0.097	-1.85567	-0.99307	-1.23229	-1.85567	-0.99306841	1.232288	0	0	0.417089
108857-COAT	OC	1	B	833	12.57	11.94	0.42	1.5	-0.24515	**2.493068**	1.5	-0.24514789	**2.493068**	**1**	**1**	0.102962
108858-COAT	AC	1	B	833	12.24	11.94	0.42	0.714286	0.042682	0.959434	0.714286	0.042682192	0.959434	0	0	-0.01793
110230-COAT	AC	1	B	833	12.03	11.94	0.42	0.214286	0.094163	0.171604	0.214286	0.094163249	0.171604	0	0	-0.03955
110736-COAT	AC	1	B	832	10.72	10.67	0.281	0.177936	0.119295	0.083773	0.177936	0.119295057	0.083773	0	0	-0.0501
111033-COAT	AC	1	B	833	11.75	11.94	0.42	-0.45238	-0.05221	-0.57168	-0.45238	-0.05220775	0.571676	0	0	0.021927
115075-COAT	AC	1	B	833	11.38	11.94	0.42	-1.33333	-0.43655	-1.28113	-1.33333	-0.43654542	1.281126	0	0	0.183349
119478-COAT	PC	1	B	832	10.82	10.67	0.281	0.533808	-0.14544	0.970353	0.533808	-0.14543945	0.970353	0	0	0.061085
120248-COAT	PC	1	B	833	11.01	11.94	0.42	-2.21429	-0.76609	**-2.06885**	-2.21429	-0.76609333	**2.068846**	**1**	**1**	0.321759
120249-COAT	PC	1	B	833	11.3	11.94	0.42	-1.52381	-0.99341	-0.75772	-1.52381	-0.99340819	0.757716	0	0	0.417231

Lab B: no alarms
SA: 0.42

Table — Lab G

TESTKEY	VAL	LTMSAPP	LTMSLAB	IND	Aeration	Target	revised rmse	Yi	Zi	ei	effective Yi	effective Ziv2	abs(ei)	ei Fail Level 3	ei Fail level 2	SA
									-1.12345			-1.12345132				
103954-COAT	AO	1	G	PC11L	10.56	10.73	0.097	-1.75258	-1.31219	-0.62913	-1.75258	-1.31218912	0.629126	0	0	0.551119
103455-COAT	OO	1	G	PC11H	11.61	12.14	0.42	-1.2619	-1.2971	0.050284	-1.2619	-1.29710381	0.050284	0	0	0.544784
103468-COAT	AO	1	G	PC11J	10.5	10.6	0.281	-0.35587	-1.01473	0.941232	-0.35587	-1.01473424	0.941232	0	0	0.426188
103462-COAT	OO	1	G	PC11K	11.25	11.94	0.42	-1.64286	-1.20317	-0.62812	-1.64286	-1.20317111	0.628123	0	0	0.505332
104083-COAT	AO	1	G	PC11I	10.72	10.92	0.097	-2.06186	-1.46078	-0.85868	-2.06186	-1.46077648	0.858685	0	0	0.613526
103629-COAT	AO	1	G	PC11G	10.63	10.67	0.281	-0.14235	-1.06525	1.318428	-0.14235	-1.06524816	1.318428	0	0	0.447404
106458-COAT	AO	1	G	PC11G	10.31	10.67	0.281	-1.28114	-1.13002	-0.21589	-1.28114	-1.13001535	0.215891	0	0	0.474606
110235-COAT	AC	1	G	832	10.63	10.67	0.281	-0.14235	-0.83372	0.987667	-0.14235	-0.83371537	0.987667	0	0	0.35016
110728-COAT	AC	1	G	832	10.54	10.67	0.281	-0.46263	-0.72239	0.371082	-0.46263	-0.72239079	0.371082	0	0	0.303404
111346-COAT	AC	1	G	833	11.73	11.94	0.42	-0.5	-0.65567	0.222391	-0.5	-0.65567356	0.222391	0	0	0.275383
111347-COAT	AC	1	G	833	12.17	11.94	0.42	0.547619	-0.29469	1.203293	0.547619	-0.29468578	1.203293	0	0	0.123768
112704-COAT	AC	1	G	833	11.31	11.94	0.42	-1.5	-0.65628	-1.20531	-1.5	-0.65628004	1.205314	0	0	0.275638
112705-COAT	AC	1	G	833	12.12	11.94	0.42	0.428571	-0.33082	1.084851	0.428571	-0.3308246	1.084851	0	0	0.138946
111343-COAT	OC	1	G	832	11.11	10.67	0.281	1.565836	0.238174	**1.896661**	1.565836	0.238173669	**1.896661**	0	**1**	-0.10003
111344-COAT	PC	1	G	832	10.8	10.67	0.281	0.462633	0.305512	0.22446	0.462633	0.305511604	0.22446	0	0	-0.12831
116607-COAT	PC	1	G	833	11.53	11.94	0.42	-0.97619	-0.079	-1.2817	-0.97619	-0.07899902	1.281702	0	0	0.03318
116608-COAT	PC	1	G	833	11.91	11.94	0.42	-0.07143	-0.07673	0.00757	-0.07143	-0.07672789	0.00757	0	0	0.032226

Lab G: no alarms
SA: 0.03

ltms by lab with current targets and standard deviations

Table A

TESTKEY	VAL	LTMSAPP	LTMSLAB	IND	Aeration	Target	rmse	Yi	Zi	ei	effective Yiv2	effective Ziv2	abs(ei)	ei Fail (level 3)	ei Fail (level 2)	SA
									1.277792			1.277792				
106980-COAT	OO	1	A	PC11K	12.55	11.94	0.285	2.140351	1.53656	0.862559	2.140351	1.53656	0.862559	0	0	-0.43792
107256-COAT	AO	1	A	PC11K	12.24	11.94	0.285	1.052632	1.391381	-0.48393	1.052632	1.391381	0.483928	0	0	-0.39654
107255-COAT	AO	1	A	PC11G	10.8	10.67	0.203	0.640394	1.166085	-0.75099	0.640394	1.166085	0.750987	0	0	-0.33233
108379-COAT	AC	1	A	833	12.76	11.94	0.285	2.877193	1.679418	1.711108	2.877193	1.679418	1.711108	0	0	-0.47863
108380-COAT	AC	1	A	833	12.23	11.94	0.285	1.017544	1.480855	-0.66187	1.017544	1.480855	0.661874	0	0	-0.42204
111341-COAT	AC	1	A	832	10.57	10.67	0.203	-0.49261	0.888816	**-1.97347**	-0.49261	0.888816	**1.973466**	0	1	-0.25331
108860-COAT	OC	1	A	833	11.31	11.94	0.285	-2.21053	-0.04099	**-3.09934**	-2.21053	-0.04099	**3.099342**	1	1	0.011681
116584-COAT	OC	1	A	833	11.21	11.94	0.285	-2.5614	-0.79711	**-2.52042**	-2.5614	-0.79711	**2.520416**	1	1	0.227177
111342-COAT	AC	1	A	832	10.13	10.67	0.203	-2.6601	-1.35601	**-1.86299**	-2.6601	-1.35601	**1.862987**	0	1	0.386462
118883-COAT	PC	1	A	833	11.03	11.94	0.285	-3.19298	**-1.9071**	**-1.83697**	-3.19298	-1.9071	**1.836975**	0	1	0.543524
111348-COAT	PC	1	A	832	10.07	10.67	0.203	-2.95567	**-2.22167**	-1.04856	-2.95567	-2.22167	1.048565	0	0	0.633176
126228-COAT	PC	1	A	832	9.93	10.67	0.203	-3.64532	**-2.64876**	-1.42365	-3.64532	-2.64876	1.42365	0	0	0.754898

Lab A: Zi alarm
SA: 0.75

Table B

TESTKEY	VAL	LTMSAPP	LTMSLAB	IND	Aeration	Target	rmse	Yi	Zi	ei	effective Yiv2	effective Ziv2	abs(ei)	ei Fail (level 3)	ei Fail (level 2)	SA
									0.471844			0.471844				
104081-COAT	AO	1	B	PC11I	10.9	10.92	0.139	-0.14388	0.287125	-0.61573	-0.14388	0.287125	0.615729	0	0	-0.08183
103459-COAT	AO	1	B	PC11K	12.23	11.94	0.285	1.017544	0.506251	0.730419	1.017544	0.506251	0.730419	0	0	-0.14428
103625-COAT	AO	1	B	PC11G	10.78	10.67	0.203	0.541872	0.516937	0.035621	0.541872	0.516937	0.035621	0	0	-0.14733
103957-COAT	AO	1	B	PC11L	10.73	10.73	0.139	0	0.361856	-0.51694	0	0.361856	0.516937	0	0	-0.10313
103465-COAT	AO	1	B	PC11J	10.33	10.6	0.203	-1.33005	-0.14572	-1.69191	-1.33005	-0.14572	1.691905	0	0	0.041529
103452-COAT	AO	1	B	PC11H	12.08	12.14	0.285	-0.21053	-0.16516	-0.06481	-0.21053	-0.16516	0.064811	0	0	0.04707
103453-COAT	AO	1	B	PC11H	12.34	12.14	0.285	0.701754	0.094915	0.866913	0.701754	0.094915	0.866913	0	0	-0.02705
103466-COAT	AO	1	B	PC11J	10.57	10.6	0.203	-0.14778	0.022106	-0.2427	-0.14778	0.022106	0.242698	0	0	-0.0063
103958-COAT	AO	1	B	PC11L	10.51	10.73	0.139	-1.58273	-0.45935	-1.60484	-1.58273	-0.45935	1.604839	0	0	0.130914
103626-COAT	AO	1	B	PC11G	10.5	10.67	0.203	-0.83744	-0.57277	-0.37809	-0.83744	-0.57277	0.378092	0	0	0.163241
103460-COAT	AO	1	B	PC11K	11.71	11.94	0.285	-0.80702	-0.64305	-0.23424	-0.80702	-0.64305	0.234244	0	0	0.183268
105877-COAT	AO	1	B	PC11I	10.74	10.92	0.139	-1.29496	-0.83862	-0.65192	-1.29496	-0.83862	0.651917	0	0	0.239007
108857-COAT	OC	1	B	833	12.57	11.94	0.285	2.210526	0.076122	**3.049148**	2.210526	0.076122	**3.049148**	1	1	-0.02169
108858-COAT	AC	1	B	833	12.24	11.94	0.285	1.052632	0.369075	0.976509	1.052632	0.369075	0.976509	0	0	-0.10519
110230-COAT	AC	1	B	833	12.03	11.94	0.285	0.315789	0.353089	-0.05329	0.315789	0.353089	0.053286	0	0	-0.10063
110736-COAT	AC	1	B	832	10.72	10.67	0.203	0.246305	0.321054	-0.10678	0.246305	0.321054	0.106784	0	0	-0.0915
111033-COAT	AC	1	B	833	11.75	11.94	0.285	-0.66667	0.024738	-0.98772	-0.66667	0.024738	0.987721	0	0	-0.00705
115075-COAT	AC	1	B	833	11.38	11.94	0.285	-1.96491	-0.57216	**-1.98965**	-1.96491	-0.57216	**1.98965**	0	1	0.163065
119478-COAT	PC	1	B	832	10.82	10.67	0.203	0.738916	-0.17884	1.311073	0.738916	-0.17884	1.311073	0	0	0.050968
120248-COAT	PC	1	B	833	11.01	11.94	0.285	-3.26316	-1.10413	**-3.08432**	-3.26316	-1.10413	**3.084323**	1	1	0.314678
120249-COAT	PC	1	B	833	11.3	11.94	0.285	-2.24561	-1.44658	-1.14148	-2.24561	-1.44658	1.141482	0	0	0.412274

Lab B: no alarms
SA: 0.41

Table G

TESTKEY	VAL	LTMSAPP	LTMSLAB	IND	Aeration	Target	rmse	Yi	Zi	ei	effective Yiv2	effective Ziv2	abs(ei)	ei Fail (level 3)	ei Fail (level 2)	SA
									-1.19176			-1.19176				
103954-COAT	AO	1	G	PC11L	10.56	10.73	0.139	-1.22302	-1.20114	-0.03126	-1.22302	-1.20114	0.031261	0	0	0.342325
103455-COAT	OO	1	G	PC11H	11.61	12.14	0.285	-1.85965	-1.39869	-0.65851	-1.85965	-1.39869	0.65851	0	0	0.398627
103468-COAT	AO	1	G	PC11J	10.5	10.6	0.203	-0.49261	-1.12687	0.906081	-0.49261	-1.12687	0.906081	0	0	0.321157
103462-COAT	OO	1	G	PC11K	11.25	11.94	0.285	-2.42105	-1.51512	-1.29419	-2.42105	-1.51512	1.294185	0	0	0.43181
104083-COAT	AO	1	G	PC11I	10.72	10.92	0.139	-1.43885	-1.49224	0.076274	-1.43885	-1.49224	0.076274	0	0	0.425289
103629-COAT	AO	1	G	PC11G	10.63	10.67	0.203	-0.19704	-1.10368	1.295197	-0.19704	-1.10368	1.295197	0	0	0.314549
106458-COAT	AO	1	G	PC11G	10.31	10.67	0.203	-1.7734	-1.3046	-0.66972	-1.7734	-1.3046	0.669717	0	0	0.37181
110235-COAT	AC	1	G	832	10.63	10.67	0.203	-0.19704	-0.97233	1.107553	-0.19704	-0.97233	1.107553	0	0	0.277114
110728-COAT	AC	1	G	832	10.54	10.67	0.203	-0.64039	-0.87275	0.331937	-0.64039	-0.87275	0.331937	0	0	0.248734
111346-COAT	AC	1	G	833	11.73	11.94	0.285	-0.73684	-0.83198	0.135908	-0.73684	-0.83198	0.135908	0	0	0.237114
111347-COAT	AC	1	G	833	12.17	11.94	0.285	0.807018	-0.34028	1.638995	0.807018	-0.34028	1.638995	0	0	0.09698
112704-COAT	AC	1	G	833	11.31	11.94	0.285	-2.21053	-0.90135	**-1.87025**	-2.21053	-0.90135	**1.870247**	0	1	0.256886
112705-COAT	AC	1	G	833	12.12	11.94	0.285	0.631579	-0.44147	1.532932	0.631579	-0.44147	1.532932	0	0	0.12582
111343-COAT	OC	1	G	832	11.11	10.67	0.203	2.167488	0.341215	**2.608961**	2.167488	0.341215	2.608961	1	1	-0.09725
111344-COAT	PC	1	G	832	10.8	10.67	0.203	0.640394	0.430969	0.299179	0.640394	0.430969	0.299179	0	0	-0.12283
116607-COAT	PC	1	G	833	11.53	11.94	0.285	-1.4386	-0.1299	**-1.86957**	-1.4386	-0.1299	**1.869565**	0	1	0.037022
116608-COAT	PC	1	G	833	11.91	11.94	0.285	-0.10526	-0.12251	0.024638	-0.10526	-0.12251	0.024638	0	0	0.034915

Lab G: no alarms
SA: 0.03

Model 1: Lab,
Oil Comb/MM cal & Filter

Response AAVE

Whole Model

Actual by Predicted Plot
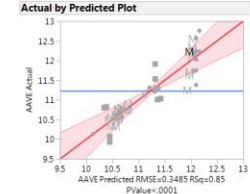
Residual by Predicted Plot
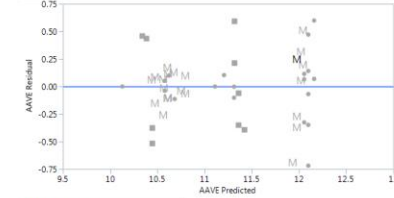
Summary of Fit

RSquare	0.846192
RSquare Adj	0.784669
Root Mean Square Error	0.348535
Mean of Response	11.23
Observations (or Sum Wgts)	50

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	14	23.391120	1.67079	13.7540
Error	35	4.251680	0.12148	Prob > F
C. Total	49	27.642800		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|	VIF
Intercept	11.040581	0.059894	184.33	<.0001*	
LTMSLAB[A]	0.0558573	0.088998	0.63	0.5343	1.8582983
LTMSLAB[B]	-0.006279	0.074454	-0.08	0.9333	1.7194499
Oil Comb/ MM cal & Filter[PC11H/matrix]	0.9901308	0.198411	4.99	<.0001*	2.5666265
Oil Comb/ MM cal & Filter[PC11I/matrix]	-0.233203	0.198411	-1.18	0.2478	2.5666265
Oil Comb/ MM cal & Filter[PC11I/matrix]	-0.553203	0.198411	-2.79	0.0085*	2.5666265
Oil Comb/ MM cal & Filter[PC11L/matrix]	-0.419869	0.198411	-2.12	0.0415*	2.5666265
Oil Comb/ MM cal & Filter[832/matrix]	-0.42541	0.155327	-2.74	0.0096*	1.9860972
Oil Comb/ MM cal & Filter[832/steep]	-0.413187	0.171577	-2.41	0.0214*	2.1762118
Oil Comb/ MM cal & Filter[832/shallow]	-0.966439	0.340547	-2.84	0.0075*	5.4226331
Oil Comb/ MM cal & Filter[832/08 08 2017 Filter]	0.1189972	0.333301	0.36	0.7232	5.1943309
Oil Comb/ MM cal & Filter[832/New MM cal & 08 08 2017 Filter]	-0.649546	0.173777	-3.74	0.0007*	2.2323813
Oil Comb/ MM cal & Filter[833/matrix]	0.945503	0.156567	6.04	<.0001*	2.0179278
Oil Comb/ MM cal & Filter[833/steep]	1.0642602	0.118211	9.00	<.0001*	1.6679786
Oil Comb/ MM cal & Filter[833/shallow]	0.2153734	0.202739	1.06	0.2954	2.6798311

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
LTMSLAB	2	2	0.064440	0.2652	0.7686
Oil Comb/ MM cal & Filter	12	12	23.167193	15.8928	<.0001*

LTMSLAB

Least Squares Means Table

Level	Least Sq Mean	Std Error	Mean
A	11.096439	0.11482365	11.2358
B	11.034302	0.09056834	11.2971
G	10.991003	0.09111440	11.1429

LS Means Plot
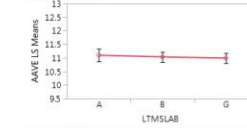
LSMeans Differences Tukey HSD

α= 0.050 Q= 2.44728

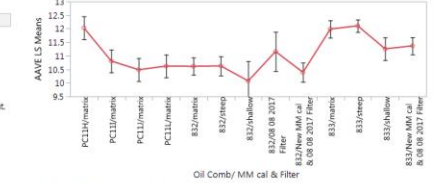| Level		Least Sq Mean
A	A	11.096439
B	A	11.034302
G	A	10.991003

Levels not connected by same letter are significantly different.

Oil Comb/ MM cal & Filter

Leverage Plot
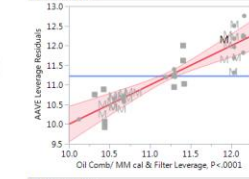
LS Means Plot

LSMeans Differences Tukey HSD

α= 0.050 Q= 3.54944

Level		Least Sq Mean
833/steep	A	12.104841
PC11H/matrix	A B	12.030712
833/matrix	A B	11.986084
833/New MM cal & 08 08 2017 Filter	B C	11.367171
833/shallow	A B C D	11.255955
832/08 08 2017 Filter	A B C D	11.159578
PC11I/matrix	C D	10.807379
832/steep	C D	10.627395
PC11L/matrix	C D	10.620712
832/matrix	C D	10.615171
PC11I/matrix	C D	10.487379
832/New MM cal & 08 08 2017 Filter	C D	10.391036
832/shallow	C D	10.074143

Levels not connected by same letter are significantly different.

Contrast

Test Detail

PC11H/matrix	0	0
PC11I/matrix	0	0
PC11I/matrix	0	0
PC11L/matrix	0	0
832/matrix	1	0
832/steep	0	0
832/shallow	0	0
832/08 08 2017 Filter	0	0
832/New MM cal & 08 08 2017 Filter	-1	0
833/matrix	0	1
833/steep	0	0
833/shallow	0	0
833/New MM cal & 08 08 2017 Filter	0	-1
Estimate	0.2241	0.6189
Std Error	0.2372	0.2224
t Ratio	0.9449	2.7835
Prob>|t|	0.3512	0.0086
SS	0.1085	0.9412

SS	NumDF	DenDF	F Ratio	Prob > F
1.063	2	35	4.3753	0.0201*

Contrast

Test Detail

PC11H/matrix	0
PC11I/matrix	0
PC11I/matrix	0
PC11L/matrix	0
832/matrix	0.5
832/steep	0
832/shallow	0
832/08 08 2017 Filter	0
832/New MM cal & 08 08 2017 Filter	-0.5
833/matrix	0.5
833/steep	0
833/shallow	0
833/New MM cal & 08 08 2017 Filter	-0.5
Estimate	0.4215
Std Error	0.1609
t Ratio	2.6195
Prob>|t|	0.0129
SS	0.8336

SS	NumDF	DenDF	F Ratio	Prob > F
0.834	1	35	6.8619	0.0129*