COAT Standard Deviation Update

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Performance you can rely on.

Statistics group and TMC

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- Labs
  - Martin Chadwick, IAR
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Thank you!

- Sean Moyer, TMC
- Afton
  - Abaigeal Ritzenthaler
  - Todd Dvorak
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Recommendation

- Keep the standard deviation as is

Background

- Since 10/2018, data have been collected on the improved Caterpillar Aeration Engine test set up
  - dash zero oils (original reference oils, currently depleted)
  - dash one oils (re-blend of reference oils)

- On May 10th, 2019 the Caterpillar Surveillance Panel voted to reset the COAT LTMS using only tests run on *dash one* oils started on or after 10/01/2018 with a CF=0.9606 applied
  - Correction Factor option selected by SP (0.96) was based on 833-0/833-1 prediction compared to target (11.94%)
  - SP also kept the existing target for 833-1 and adopted new target for 832-1 (i.e.10.23%)
  - Current Targets and Standard deviation are presented in the next slide. The current standard deviation (equal to 0.2774) is also used for obtaining lab severity adjustments. Six reference tests have been run since then.

- Current dash one data: 15 tests after 10/01/2018; chart=Yes; one test failed calibration

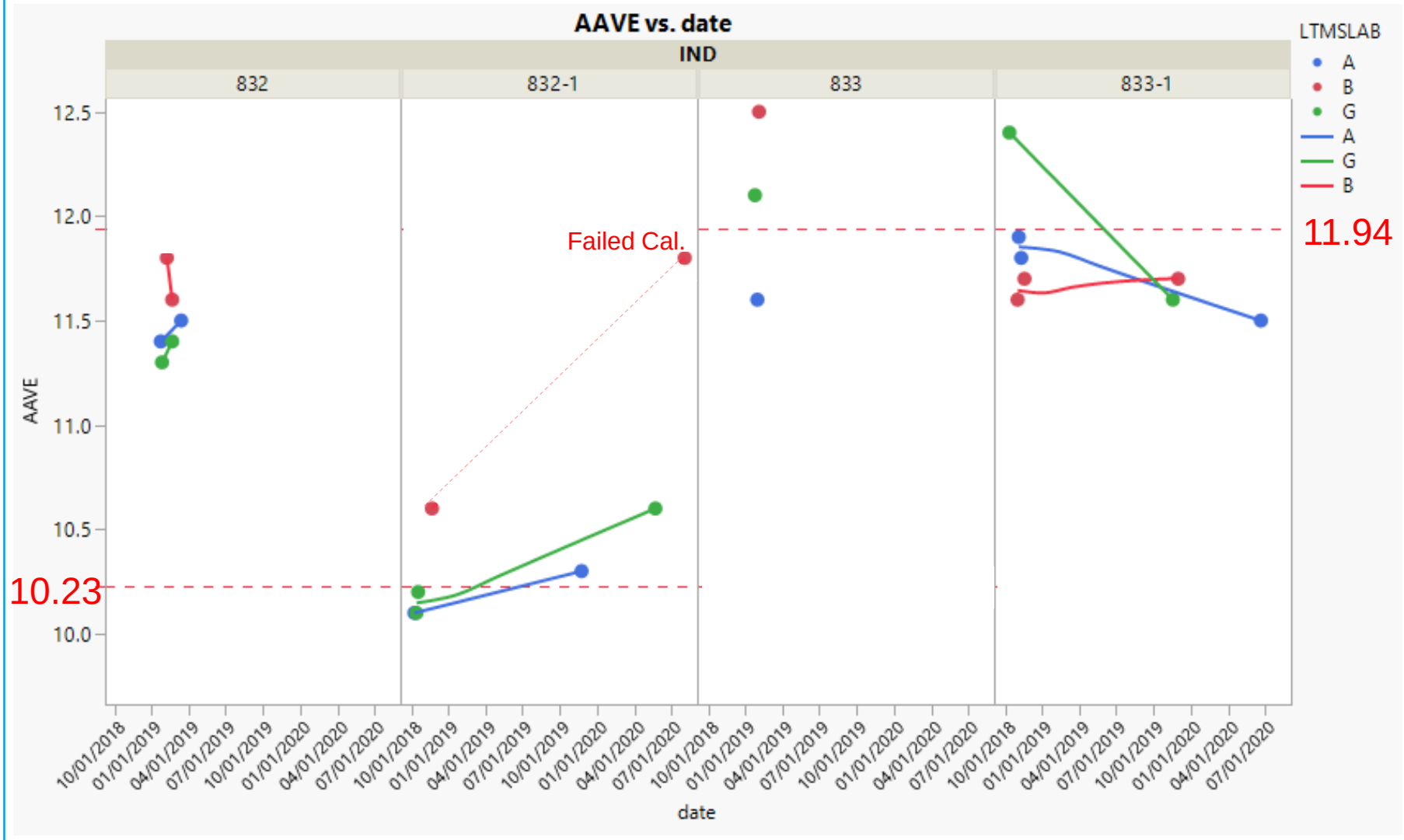
Current Targets and Standard Deviation by reference oil

40-50 Hr Average Aeration
Unit of Measure: Percent

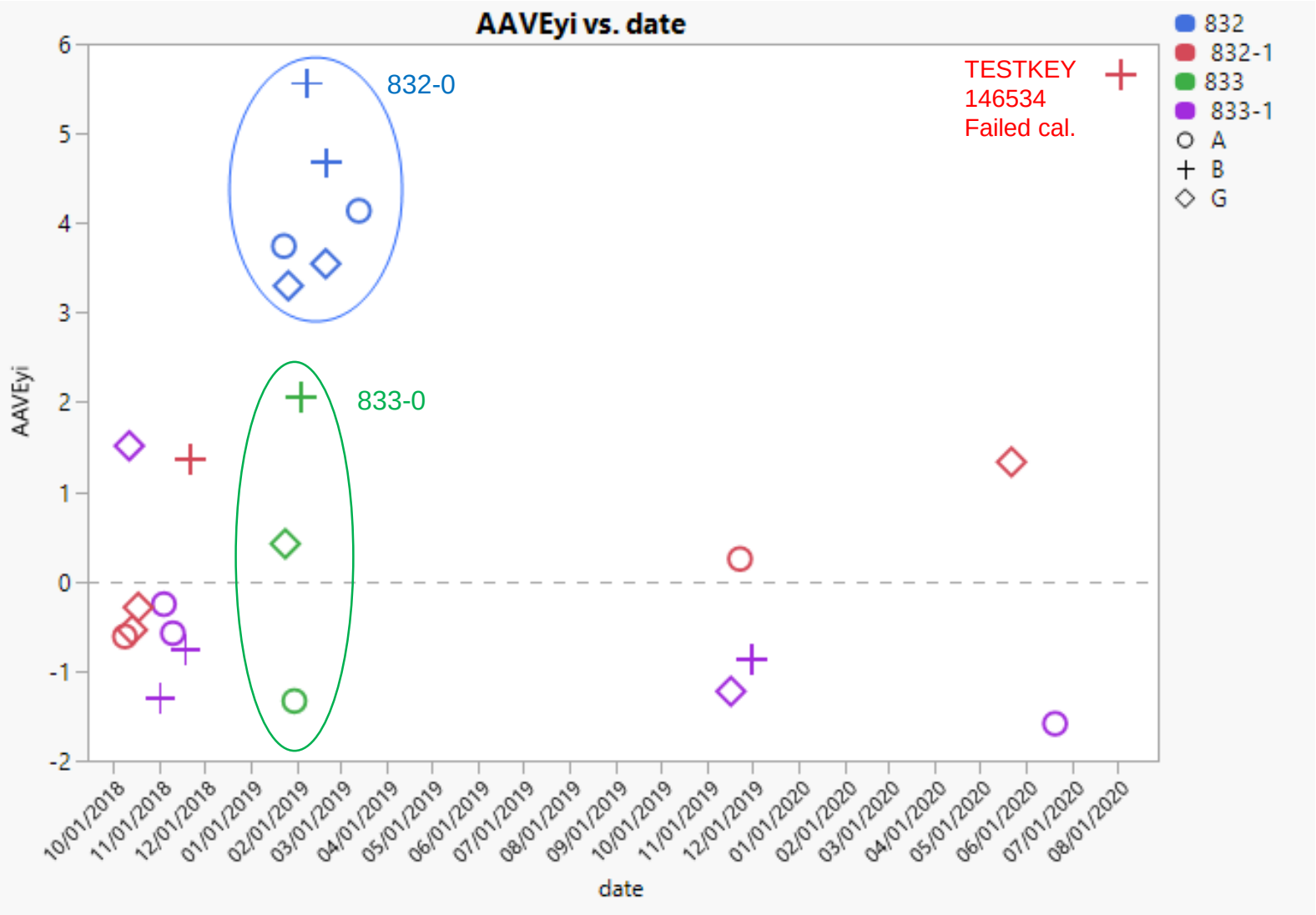
Reference Oil	Mean	Standard Deviation
832	10.67	0.203
832-1	10.23	0.2774
833	11.94	0.285
833-1	11.94	0.2774

The standard deviation highlighted above is based on 18 tests (all data available in April/May 2018), dash zero and dash one oils

40-50 Hr. Average Aeration (%) by Oil and Lab versus time



AAVE yi over time by Oil and Lab



Updated standard deviation

Summary of Fit	
RSquare	0.704858
RSquare Adj	0.660587
Root Mean Square Error	0.404719
Mean of Response	11.37917
Observations (or Sum Wgts)	24

Analysis of Variance				
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	3	7.823631	2.60788	15.9213
Error	20	3.275952	0.16380	Prob > F
C. Total	23	11.099583		<.0001*

Option 1: NOT RECOMMENDED

- n=18+6= 24 (all data after 2018 improvements)
- Model: AAVE explained by Oil
- RMSE = 0.4047 including the high value from B1A for oil 832-1 (12.27% before CF and 11.8% after CF for a target of 10.23%)

Summary of Fit	
RSquare	0.87265
RSquare Adj	0.852542
Root Mean Square Error	0.270477
Mean of Response	11.36087
Observations (or Sum Wgts)	23

Analysis of Variance				
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	3	9.524783	3.17493	43.3983
Error	19	1.390000	0.07316	Prob > F
C. Total	22	10.914783		<.0001*

Option 2: RECOMMENDED

- n=23, excluding very high test result (testkey 146534)
- Model: AAVE explained by Oil
- RMSE = 0.2705 excluding the high value from B1A for oil 832-1 (12.27% before CF and 11.8% after CF for a target of 10.23%)
- Practically, 0.2705 is the same as current standard deviation of 0.2774

Appendix

Simple mean and standard deviation for data after 10/2018 (excluding dash zero oils)

- N=15

IND	N Rows	Mean(AAVE)	Std Dev(AAVE)
832-1	7	10.53	0.5992
833-1	8	11.775	0.2816

- N=14

IND	N Rows	Mean(AAVE)	Std Dev(AAVE)
832-1	6	10.32	0.2317
833-1	8	11.775	0.2816

Simple mean and standard deviation for data after 10/2018 (dash zero and dash one oils)

- N=24

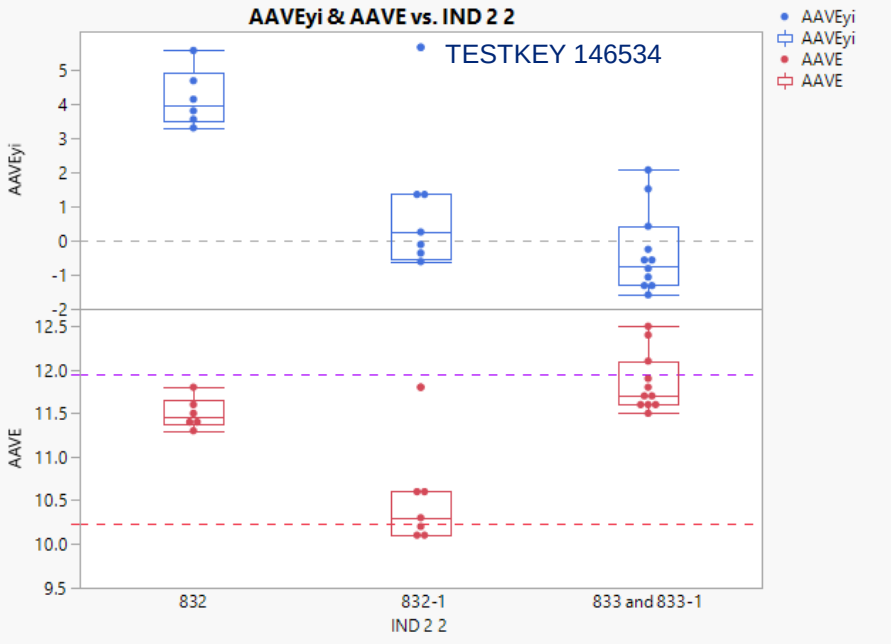
IND	N Rows	Mean(AAVE)	Std Dev(AAVE)
832	6	11.5	0.1789
832-1	7	10.53	0.5992
833	3	12.07	0.4509
833-1	8	11.775	0.2816

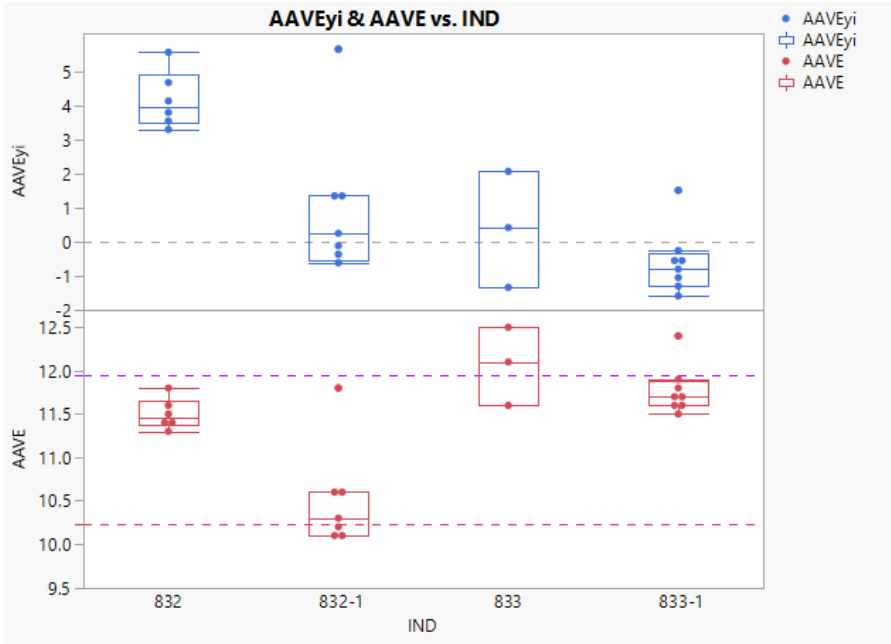
- N=23

IND	N Rows	Mean(AAVE)	Std Dev(AAVE)
832	6	11.5	0.1789
832-1	6	10.32	0.2317
833	3	12.07	0.4509
833-1	8	11.775	0.2816

All data after 10/2018: 833 & 833-1 comb; 832 and 832-1

Combining 833 and 833-1





Summary of Fit

RSquare	0.855645
RSquare Adj	0.841209
Root Mean Square Error	0.280678
Mean of Response	11.36087
Observations (or Sum Wgts)	23

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	2	9.339177	4.66959	59.2736
Error	20	1.575606	0.07878	Prob > F
C. Total	22	10.914783		<.0001*

Summary of Fit

RSquare	0.688136
RSquare Adj	0.658435
Root Mean Square Error	0.406
Mean of Response	11.37917
Observations (or Sum Wgts)	24

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	2	7.638025	3.81901	23.1685
Error	21	3.461558	0.16484	Prob > F
C. Total	23	11.099583		<.0001*

CATERPILLAR OIL AERATION TEST INDUSTRY OPERATIONALLY VALID D

FINAL AVERAGE OIL AERATION OVER TEST HOURS 40-50