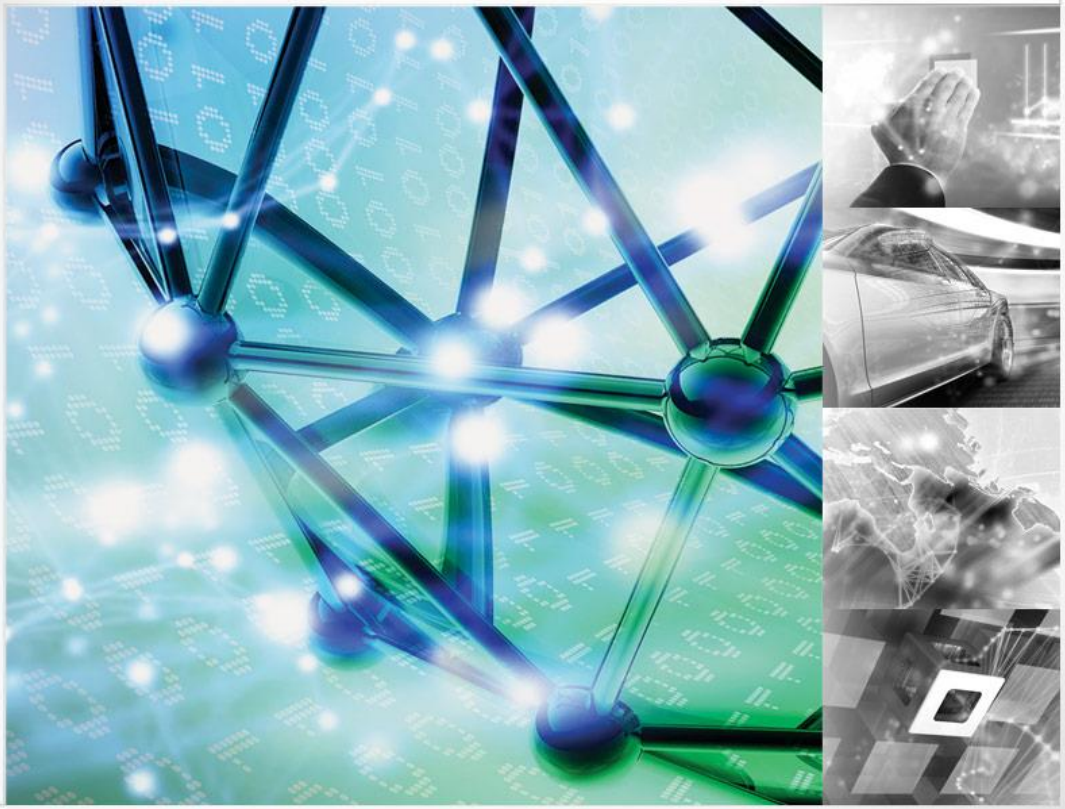


COAT Test Variability

CAT Surveillance Panel Meeting

4/18/16

Lubrizol

Overview

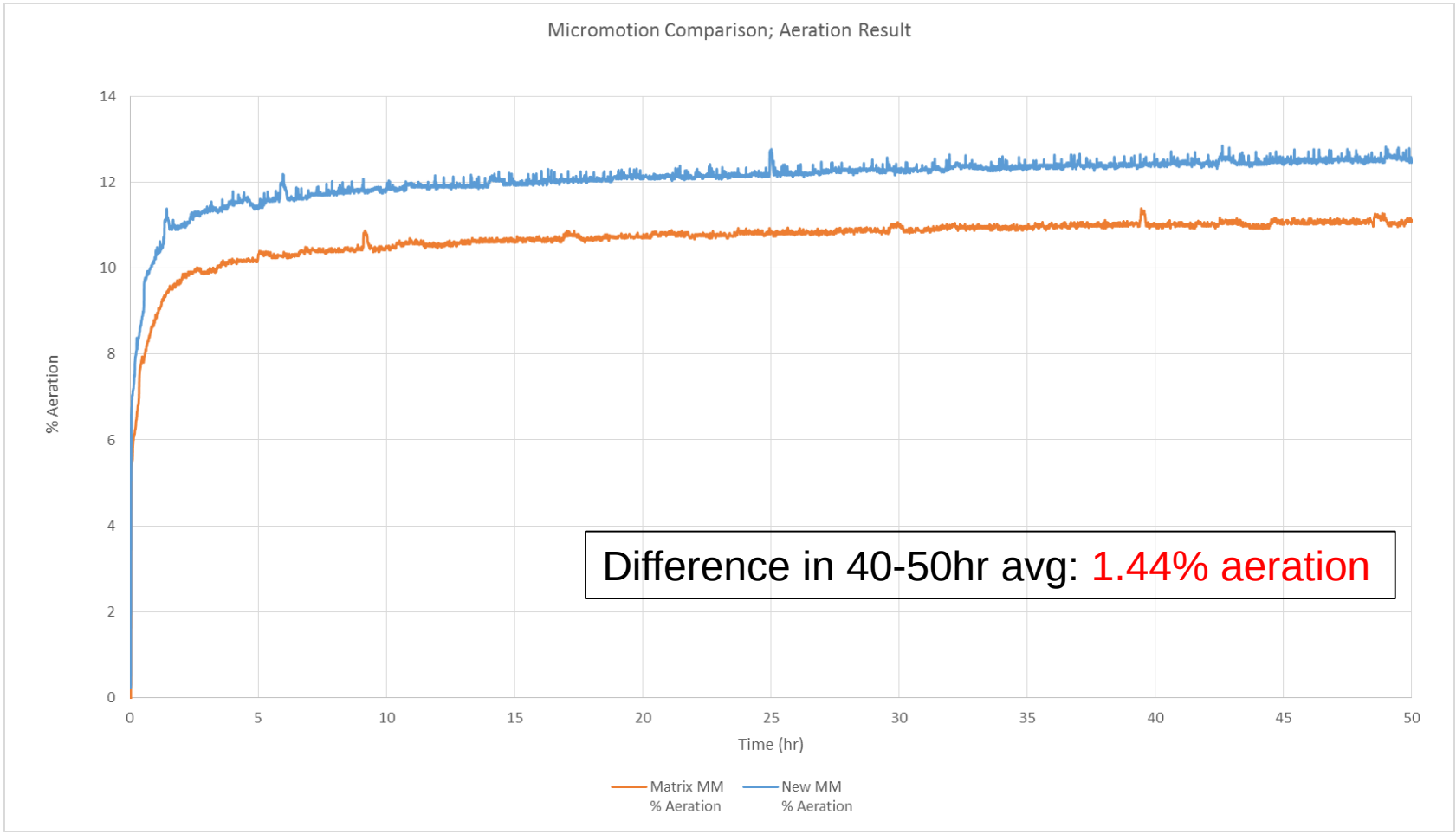
SUCCESS TOGETHER

- Lubrizol introduced a second MicroMotion (MM) instrument to the existing LZ COAT test stand following SP agreement of a one year calibration period on the MM instrument.
- Reference run on the new instrument resulted in a significant severe shift.
- Lubrizol followed-up with an internal experiment to assess the potential variability between manufacturer “calibrated” MM instruments within a single test stand.
  - New MM vs. Matrix MM
- Internal work continued to find potential causes for such variability

Lubrizol

Internal Reference:OS265386

SUCCESS TOGETHER



New Micromotion TEST RESULT	Average	StDev
40-50 Hour Average % Aeration	12.4981	0.072515
Final Test Hour Average % Aeration	12.5818	0.062921

Matrix Micromotion TEST RESULT	Average	StDev
40-50 Hour Average % Aeration	11.0519	0.058479
Final Test Hour Average % Aeration	11.0638	0.044397

Lubrizol

Conclusion

SUCCESS TOGETHER

Manufacturer “calibrated” MicroMotion instruments that are compliant with the COAT procedure can yield significantly different COAT results in evaluating an identical oil.

Lubrizol

Micromotion Temperature Experiment

SUCCESS TOGETHER

- MM temperature is not a recorded parameter for the COAT procedure

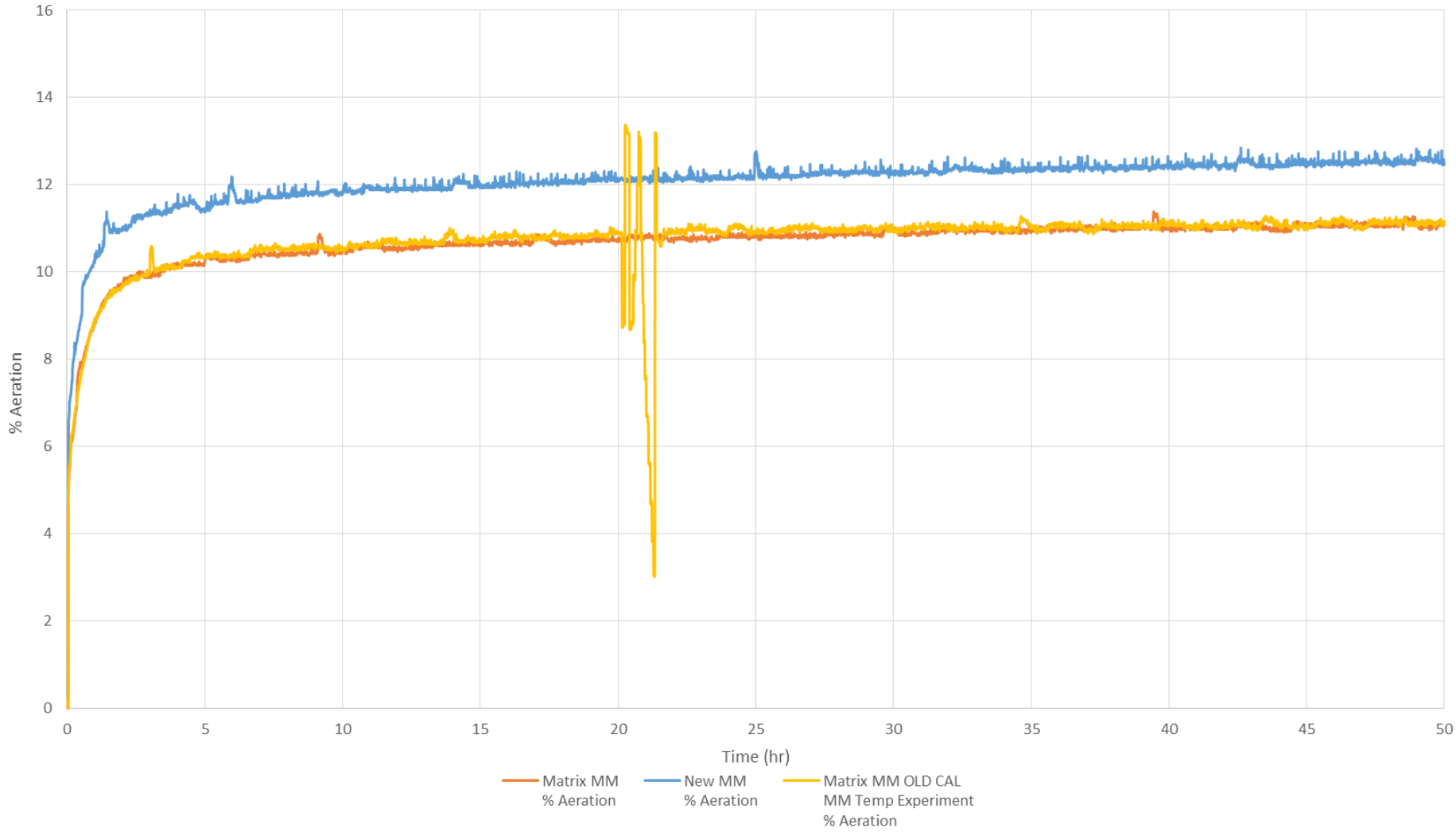
- Calibration of the MM temperature is not required for the COAT procedure

Summary of Actions:

- Started a COAT test as per the procedure (OS265386)
- Once the aeration value had “stabilized”, communication to the instrument was achieved via manufacturer supplied ProLINK III software
- Temperature reading was manipulated by changing the calibration slope and offset values

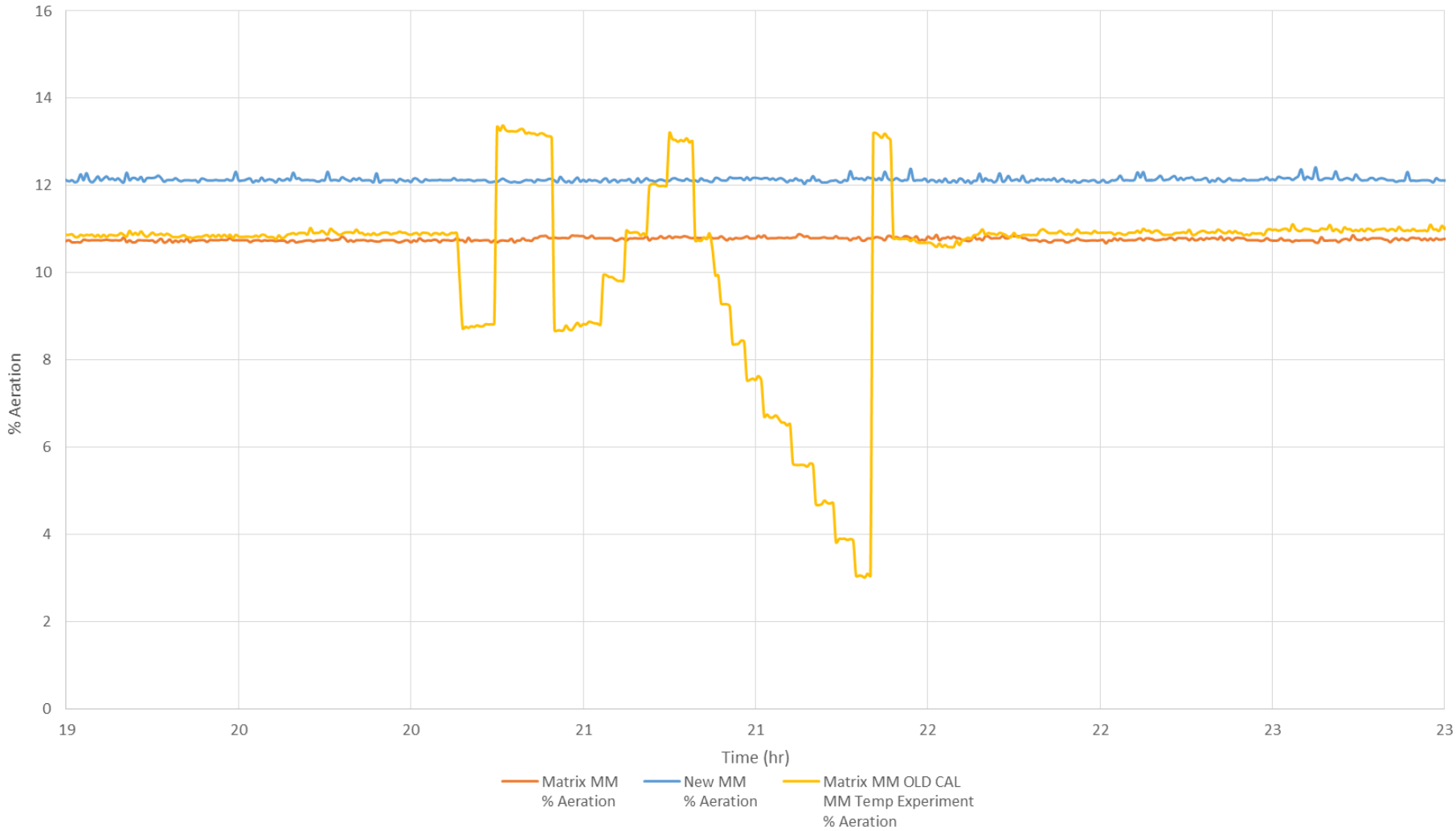
Lubrizol

MicroMotion Temperature Calibration



MicroMotion Temperature Calibration

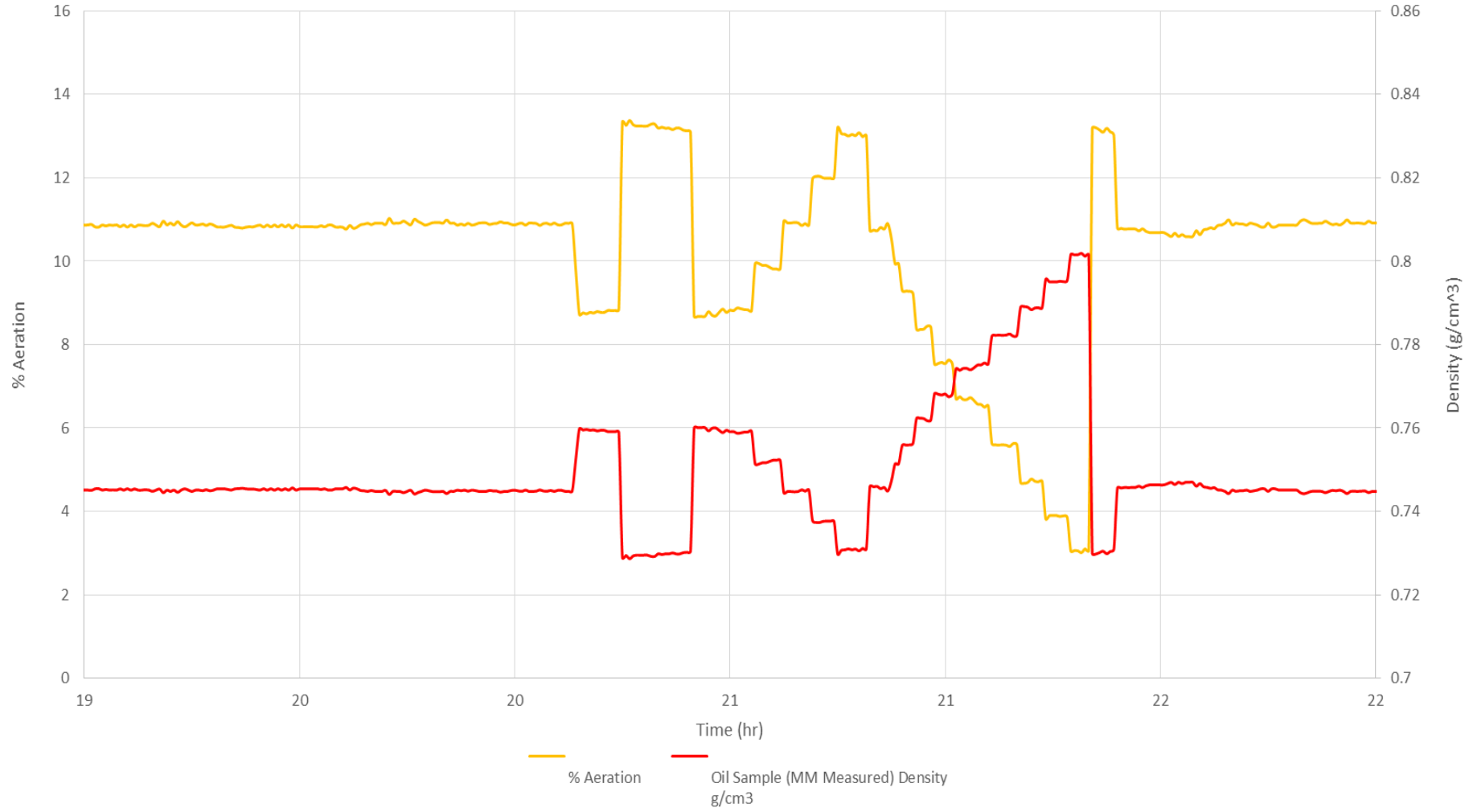
SUCCESS TOGETHER



Lubrizol

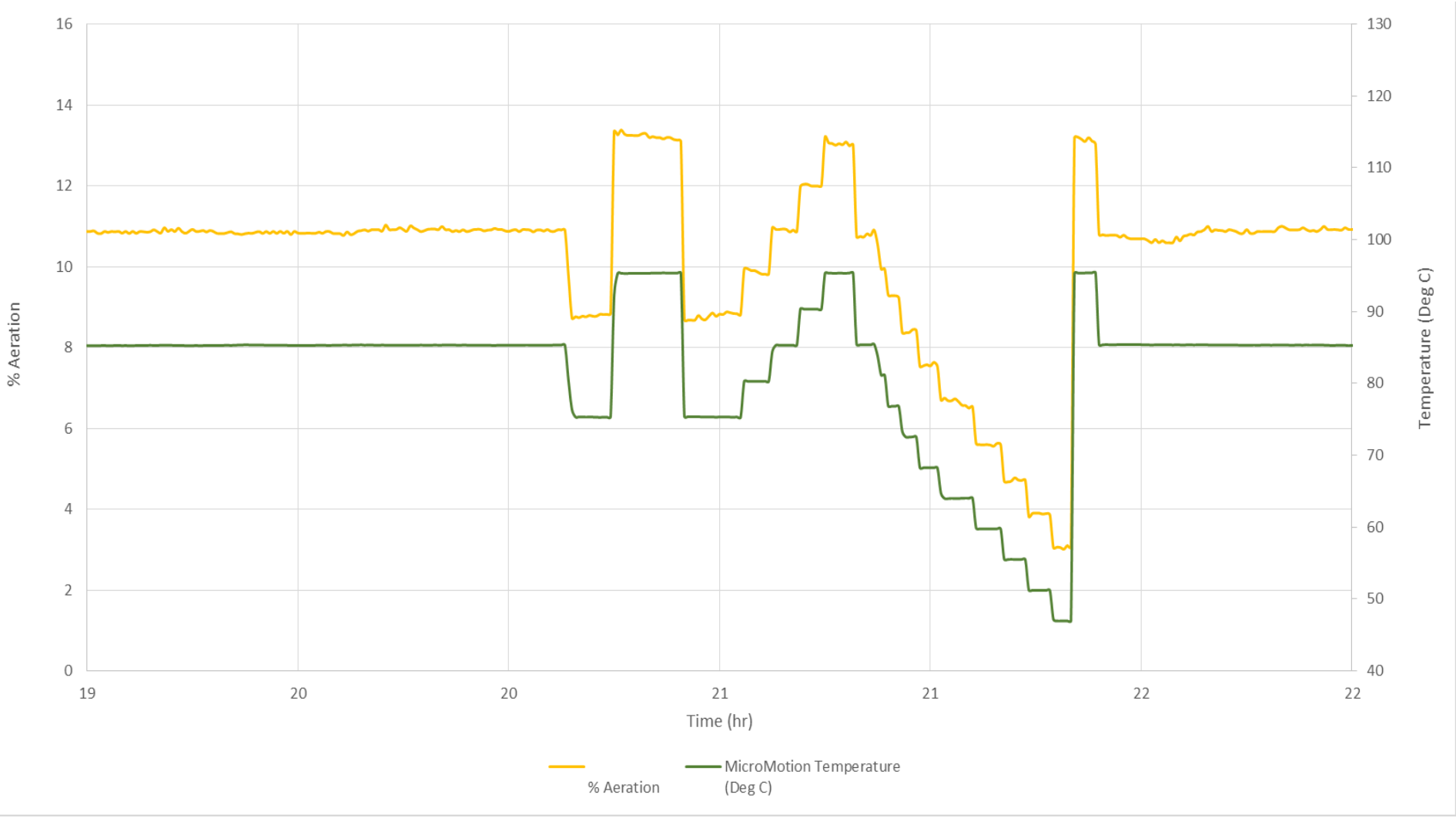
MicroMotion Temperature Calibration

SUCCESS TOGETHER



Lubrizol

MicroMotion Temperature Calibration



Conclusion

SUCCESS TOGETHER

- The internal MicroMotion (MM) temperature and associated calibration has an effect on the following parameters:
  - Sample density
  - Volumetric sample flow

Note: MM temperature and temperature calibration was proved to effect the aeration result, but may not be the only contributor to test variability.

Lubrizol

Overview of Experiment #2

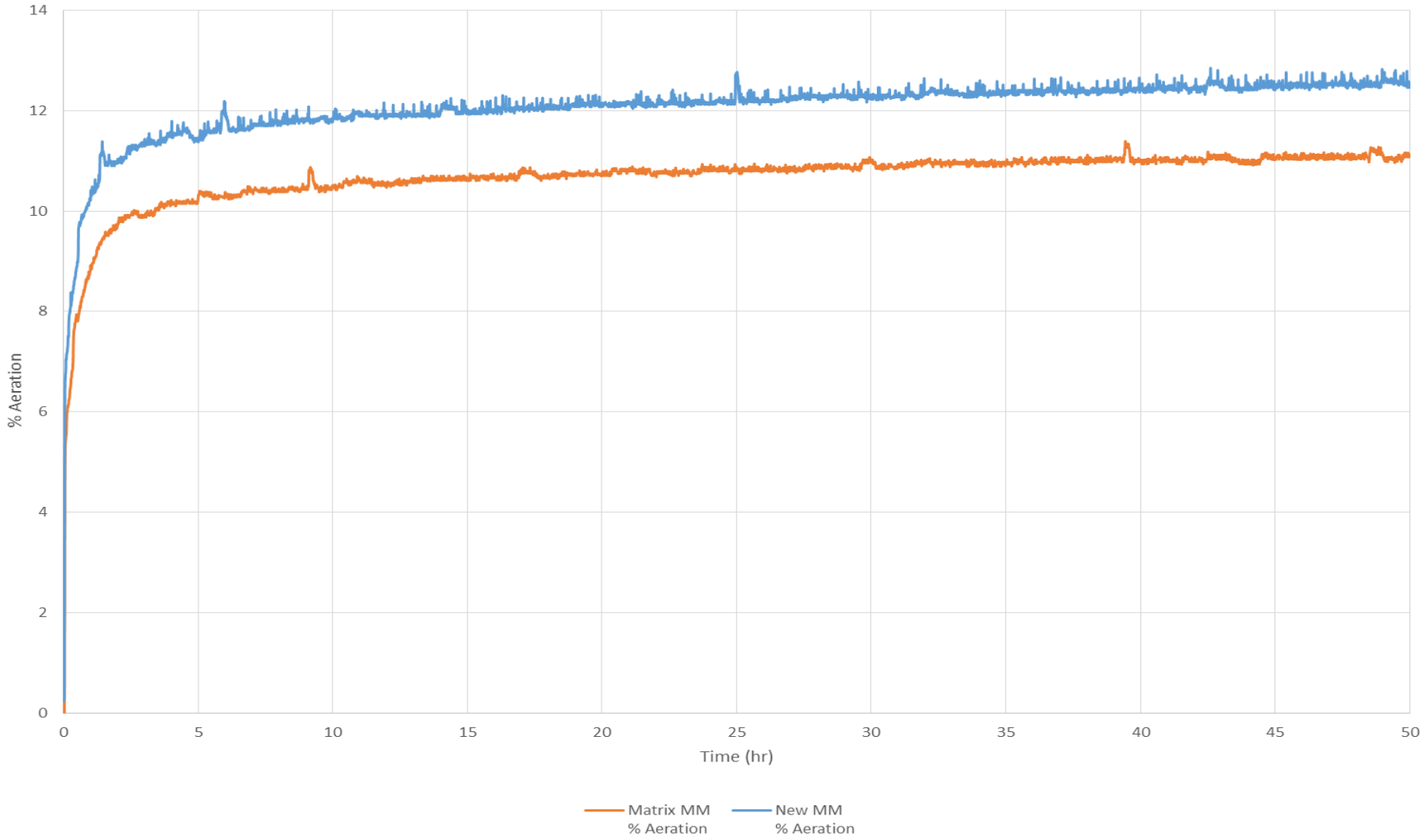
SUCCESS TOGETHER

Test#	Test Oil	MicroMotion	Model # (Sensor / Transmitter)
1	OS265386	Matrix MM	CMF025M319NU / RFT9739E4SUJ
2	OS265386	New MM	CMF025M319NBAEZZZ / PUCK800

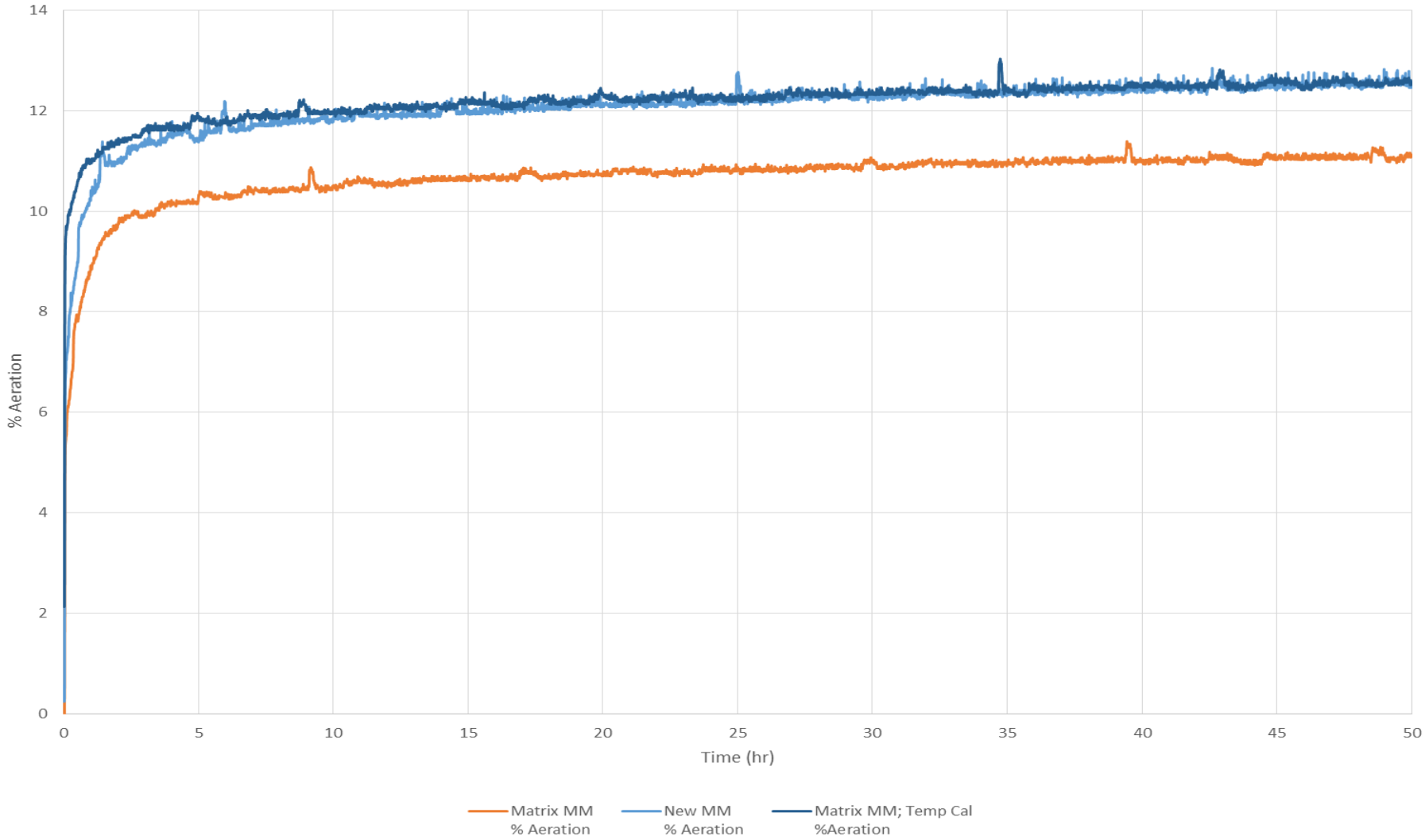
- Two tests were completed
- MM temperature was calibrated by a two point calibration (near room temp and 90C during engine warm-up).
- Slight deviation from COAT procedure: length of test warm-up was increased by 31 min in order for MM temperature reading to stabilize for 90C adjustment.
- GOAL: Determine if test-to-test variability can be reduced between MM systems by conducting MM temperature calibration

Lubrizol

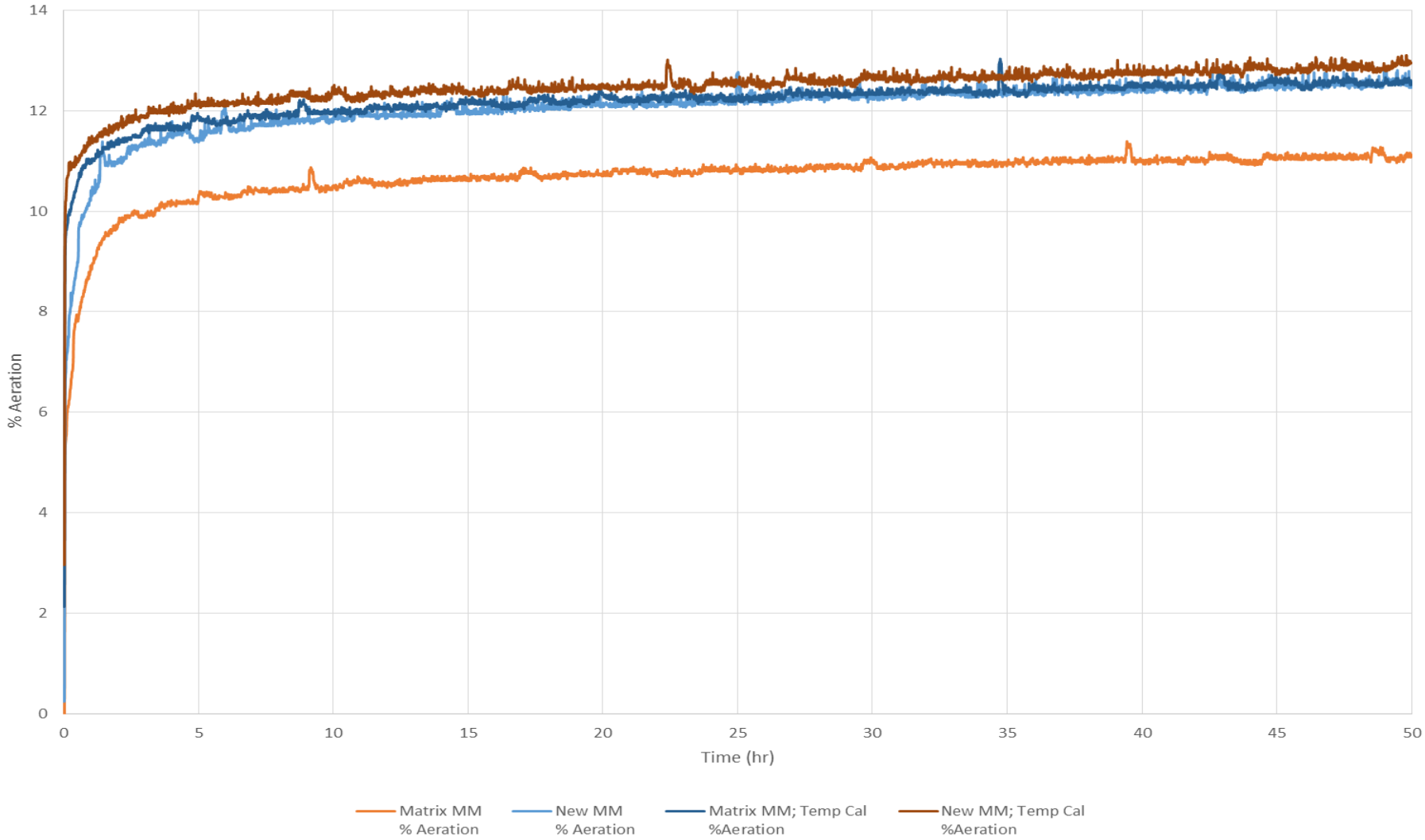
Results – Difference without Temp calibration



Results – Matrix MM w/ Temp Calibration



Results – New MM w/ Temp Calibration



Observations & Conclusions

SUCCESS TOGETHER

- Density measurement in “older” model MM sensors/transmitters **ARE** affected by the MM temperature calibration.
- Density measured in the “newer” model MM sensors/transmitters **ARE NOT** affected by the MM temperature calibration.
- MM temperature measurement on newer MM units is more responsive; i.e. faster time response.
- “Older” units were utilized for the COAT Precision Matrix.

Lubrizol

Industry MM Usage

SUCCESS TOGETHER

Lab		Sensor Model #	Transmitter Model #	Date Installed	Flange Description
SwRI	MicroMotion used during COAT Precision Matrix	CMF025M319NU	RFT9739E4SMA	4/15/2013 is the date that the first test data was recorded.	319 is #8 VCO fitting
SwRI	Active MicroMotion used in test stand	Same	Same	Reinstalled after calibration at Emerson on 2/1/2016	319 is #8 VCO fitting
ICES	MicroMotion used during COAT Precision Matrix	CMF025M313NU	RFT9739E4SUJ	7/2014 Started; 1/2015 Ended	313 is 1/2" Weld Neck Flange
ICES	MicroMotion used during Aeration Testing	CMF025M313NU	RFT9739E4SUJ	7/30/2015 Removed after seeing a density shift during 50 hour test and could not determine cause.	313 is 1/2" Weld Neck Flange
ICES	MicroMotion used during COAT VGRA Matrix	CMF025M313N2 BAE3ZZ	5700R12ABAAZZZ w/ PUCK800	8/21/2015 Installed; 10/2015 started VGRA; 12/2015 ended VGRA	313 is 1/2" Weld Neck Flange
ICES	Active MicroMotion used for test stand	CMF025M313N2 BAE3ZZ	5700R12ABAAAZZZ w/ PUCK800	Next MM Calibration expected in 8/2016	313 is 1/2" Weld Neck Flange
LZ	MicroMotion used during COAT Precision Matrix	CMF025M319NU	RFT9739E4SUJ	Installed July 2014 and utilized for both the Prove-Out and Precision Matrix	319 is #8 VCO fitting
LZ	NEW MicroMotion (Acquired Jan 2016)	CMF025M319NB AEZZZ	PUCK800	Newly Acquired (not utilized for testing)	319 is #8 VCO fitting

Lubrizol

Proposed Next Step Experiment

SUCCESS TOGETHER

Goal: To confirm LZs observations that the internal MM temperature calibration temperature can effect the density/aeration measurement and to determine calibration method going forward.

Demonstrate the temperature calibration sensitivity with existing stand's MM (could be run on the last candidate run after 50hrs)

- 40-50hrs record the MM internal temperature during a candidate run
- Run experiments after the 50hrs, extend the test length for 10hrs
  1) Extend test conditions for 1hr (baseline)
  2) Adjust the MM internal temperature to 90C for 1hr
  3) Experiment with large temperature swings (110, 90, 70, 50) 10 minutes at each set point.
  4) Increase the MM pressure to 150kpa and sweep temperature (50, 70, 90) internal MM temperature with 10 minutes at each set point.
  5) Return all the MM internal temperature calibration settings back to the original with the pressure back at 84kpa and run for one hour collecting data.
- Need to talk with the customers to get their approval. The data will be normalized so it doesn't reveal any customer information.

Potential next step: Run warm-up MM temperature calibration LZ experiment (run with LZ oil and calibration procedure)

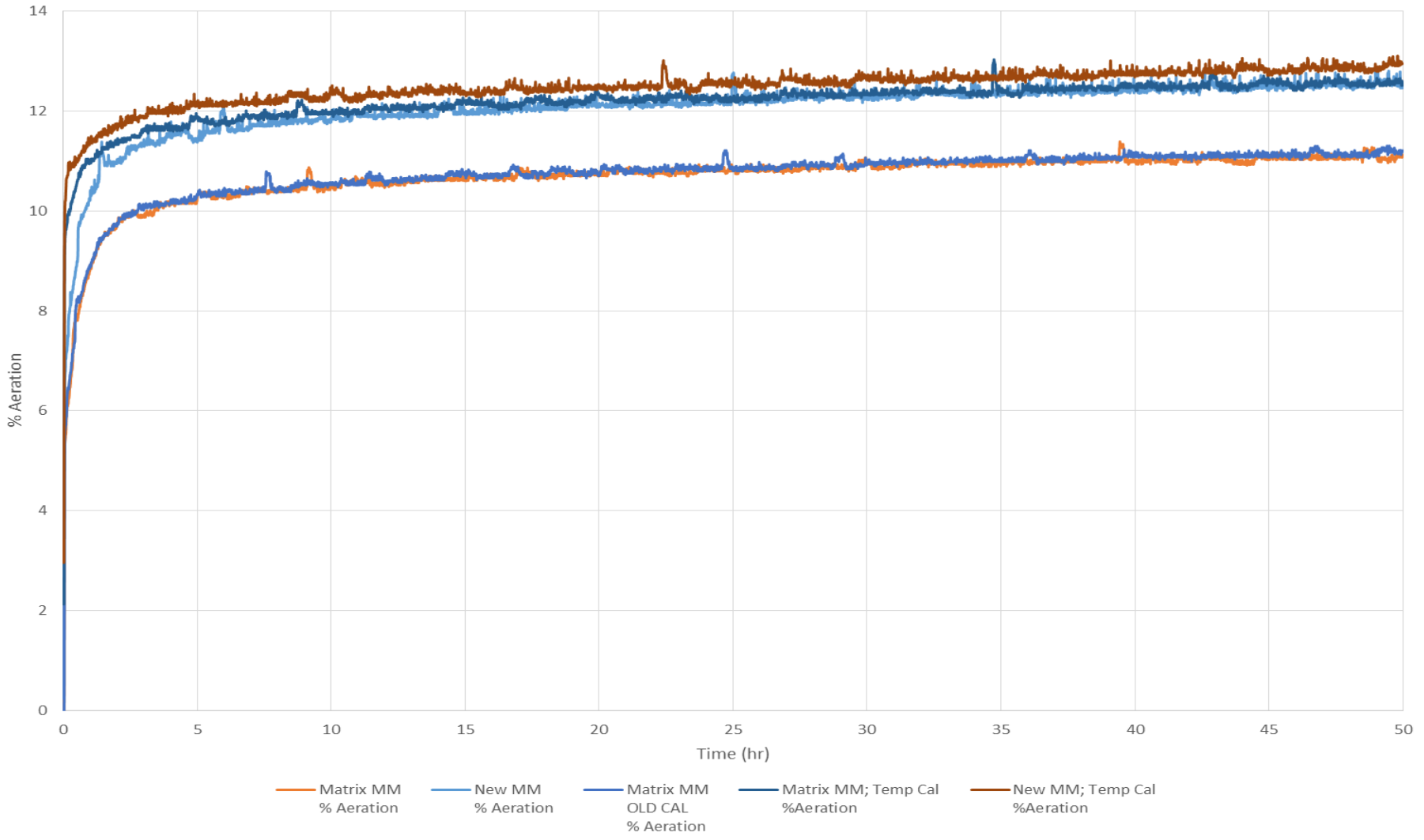
Lubrizol

SUCCESS TOGETHER

APPENDIX

Lubrizol

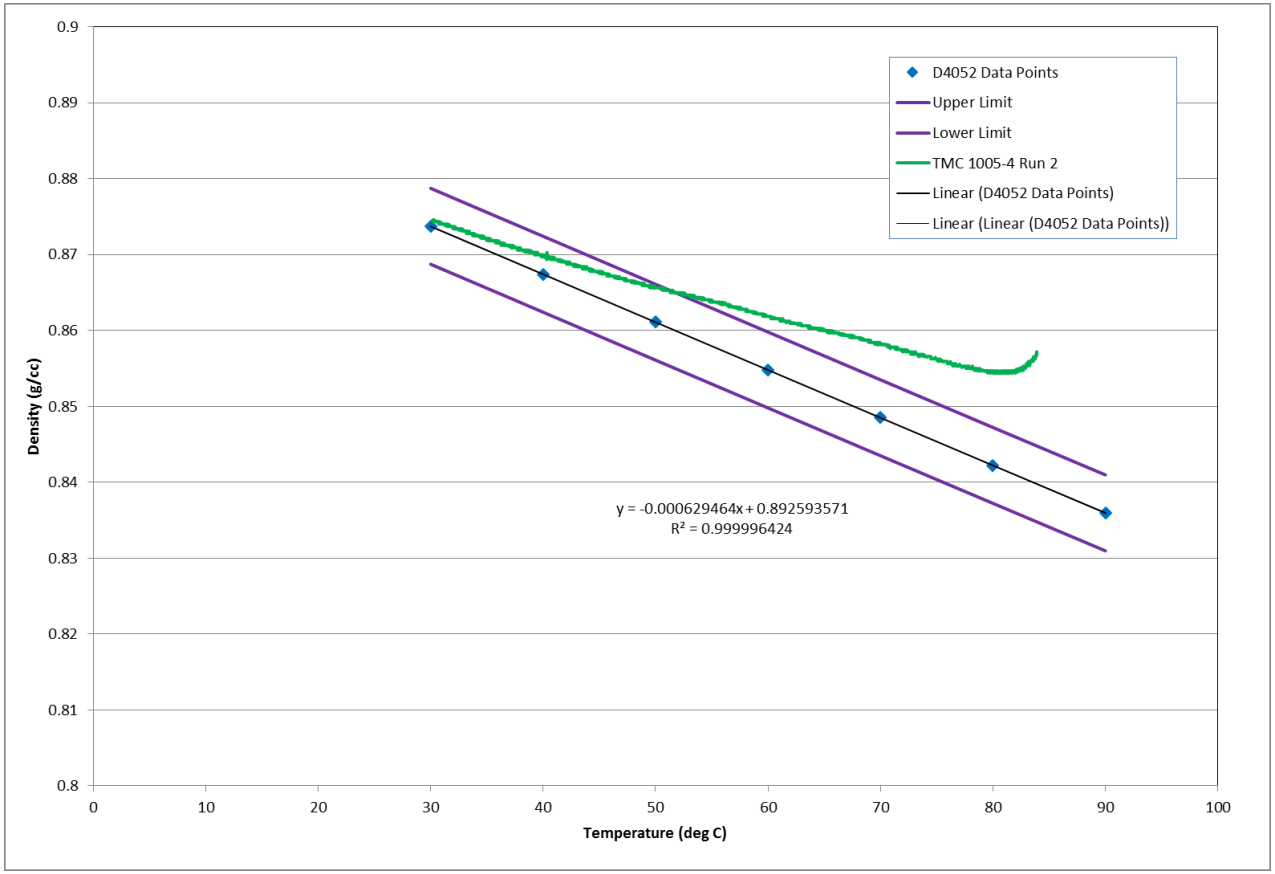
Results – Repeat of Matrix MM w/o Temp Calibration



Continued Work

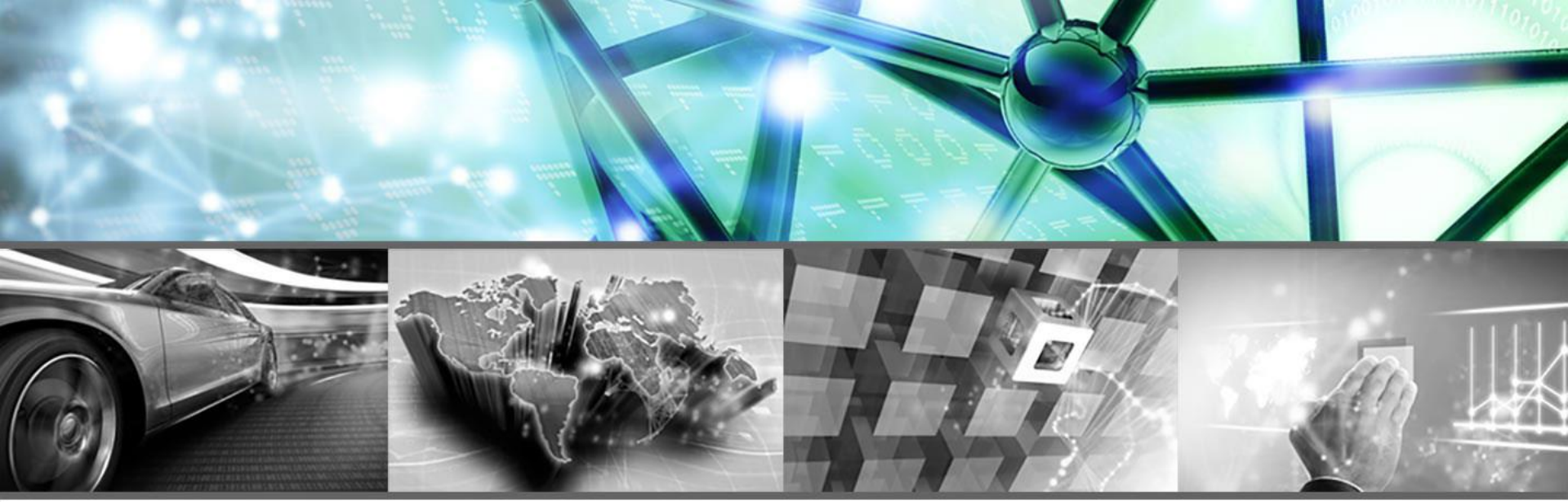
SUCCESS TOGETHER

- Internal Lubrizol work is ongoing in investigating avenues for COAT test variability.



Baseline density comparison from prove-out work

Lubrizol



SUCCESS TOGETHER

Working together, achieving great things

When your company and ours combine energies, great things can happen. You bring ideas, challenges and opportunities. We'll bring powerful additive and market expertise, unmatched testing capabilities, integrated global supply and an independent approach to help you differentiate and succeed.

Lubrizol