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Test Monitoring Center

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ASTM D02.B0.07 Semi-Annual Report Bench Test Monitoring

D874 (SASH), D5133 (GI), D5800 (NOACK), D6082 (HT FOAM), D6335 (TEOST), D6417 (GC VOL), D6557 (BRT), D6594 (HTCBT), D6794 (EOWT), D6795 (EOFT), D7097(MTEOS), D7216 (EOEC/LDEOC) and D7528 (ROBO)

October 1, 2023 – March 31, 2024

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Section	Topic		
Summary Items	Executive	Reference Oil Inventories	Additional Information
Test Area Status	TEST	LABS*	STANDS*
Sulfated Ash	D874	5 (+0)	N/A
Gelation Index (GI)	D5133	9 (+0)	42 (-10)
NOACK Volatility	D5800	14 (+0)	37 (+1)
High Temp Foam	D6082	7 (+0)	11 (+3)
TEOST	D6335	9 (+0)	14 (+1)
GC Volatility	D6417	7 (+1)	10 (+2)
* Between 10/1/2023 and 3/31/2024			

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Section	Topic		
Test Area Status (cont.)	TEST	LABS*	STANDS*
Ball Rust Test (BRT)	D6557	5 (+0)	5 (+0)
HTCBT	D6594	8 (-2)	23 (-7)
EOWT	D6794	6 (+0)	N/A
EOFT	D6795	6 (+0)	N/A
MTEOS	D7097	10 (+0)	37 (-4)
EOEC Elast. Compat.	D7216-E	7 (+1)	N/A
LDEOC Elast. Compat.	D7216-L	8 (+1)	N/A
ROBO	D7528	5 (+0)	27 (-3)
* Between 10/1/2023 and 3/31/2024			

B0.07 Bench Testing Executive Summary

- ▶ **D874 (Sulfated Ash)**
 - ▶ For the fifth consecutive 6-month period, there were no tests which failed to meet acceptance criteria for D874. Reference test results continue trending mild and new Reference Oil 92 has been approved for replacement of Reference Oil 90 (which will now only be a QC oil until supply is consumed).
- ▶ **D5133 (Gelation Index)**
 - ▶ Nine labs are running GI, same as last period, but ten less units were calibrated this semester. GIC18, a new Reference Oil with a performance target close to the Pass/Fail limit of 12, collected 70+ runs (from all 9 labs) and is ready for reassessment / confirmation of reference oil test targets.
- ▶ **D5800 (NOACK)**
 - ▶ Fourteen labs (and one new stand) had successful calibrations this semester. CUSUM slope continues being SEVERE this semester.

B0.07 Bench Testing Executive Summary

- ▶ **D6082 (High Temperature Foam)**
 - ▶ There was ONE test which failed to meet acceptance criteria for HT Foam calibration testing. This is the first fail in several semesters.
- ▶ **D6335 (TEOST)**
 - ▶ Test fail rate worsened to 23.5% after being at 13.3% last semester. Precision continued to improve, but Performance is severe (0.63 s).
- ▶ **D6417 (GC Volatility)**
 - ▶ One more test lab (7) reported data this semester and no failing Calibration Runs in this period for the eight instruments.
- ▶ **D6557 (BRT)**
 - ▶ Average Gray Value (AGV) has returned to a slightly severe trend this semester after a mild run last semester. Continuing to see severe results on RO's 86 & 87 in the current semester led to suspension of assigning them.

B0.07 Bench Testing Executive Summary

- ▶ **D6594 (HTCBT)**
 - ▶ Replacement Reference Oil 44-5 has been assigned final Acceptance limits. Reference Oil 44-4 TESTKEYs are being consumed with no new TESTKEYs to be assigned. Few labs and stands were calibrated this semester.
- ▶ **D6794 (EOWT)**
 - ▶ Change in Flowrate Average (CIFA) continues to trend severe for all water treat rates except 0.6% which went mild this semester.
- ▶ **D6795 (EOFT)**
 - ▶ Change in Flow Average (CIFA) is trending severe with a very consistent CUSUM slope over the past 3.5 years.

B0.07 Bench Testing Executive Summary

▶ D7097 (MTEOS)

- ▶ Precision regressed slightly moving to 6.04 s, whereas Performance continued to improve moving from 0.31 s down to 0.19 s this period. All operationally valid tests this period report using Rod Batch N. Catalyst Batch 20AB was used most often, but five tests used Catalyst Batch 23AB. No labs used Catalyst Batch 19BA.

▶ D7216 (EOEC/LDOEC)

- ▶ All calibrations are using Ref Oil SL-107. Surveillance Panel has agreed to resume Adjustment Factors for EOEC. Several labs participated in Round Robin tests of ACM1 batch 25 vs batch 26 to understand what would be the result of returning to a previous manufacturing method for the Polyacrylate elastomer. Round Robin for new elastomer types have been completed. Limits for four new LDEOC (GF-7) elastomers were established. Limits for new EOEC (PC-12) elastomer to be determined next semester. And, with Surveillance Panel guidance, referencing requirements for EOEC/LDEOC will be documented and published in the LTMS Document.

▶ D7528 (ROBO)

- ▶ Precision improved to 0.17 and is close to target (0.15). Performance remained mild (-0.12) and equal to last semester (-0.11). CUSUM severity plot shows a mild trend that continues into this semester.

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D02.B0.07 TMC Monitored Tests



ASTM D 874

Sulfated Ash

October 1, 2023 – March 31, 2024

Calibrated Labs and Stands*

(change shown in parentheses)

Test	Labs	Stands
D874	5 (+0)	N/A

*As of 3/31/2024

D874: Sulfated Ash

Test Status	Validity Code	No. Tests
Acceptable Calibration Test	AC	11
Total		11

Number of Labs Reporting Data: 5
Fail Rate of Operationally Valid Tests: 0%

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D874: Sulfated Ash

Statistically Unacceptable Tests (OC)	No. Of Tests
No Failed tests	0

- No operationally invalid or statistically unacceptable tests this report period.

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D874: Sulfated Ash

Period Precision and Severity Estimates

Total Deposits, mg	n	df	Pooled s	Mean Δ/s
Current Targets	81	78	0.07	-----
10/1/18 through 3/31/19	8	5	0.04	-0.33
4/1/19 through 9/30/19	8	5	0.04	-0.18
10/1/19 through 3/31/20	7	4	0.04	-0.71
4/1/20 through 9/30/20	8	5	0.03	-0.30
10/1/20 through 3/31/21	8	5	0.02	-0.35
4/1/21 through 9/30/21	10	7	0.15	0.37
10/1/21 through 3/31/22	9	6	0.05	-0.07
4/1/22 through 9/30/22	8	6	0.06	-0.38
10/1/22 through 3/31/23	11	8	0.04	-0.71
4/1/23 through 9/30/23	10	7	0.04	-0.46
10/1/23 through 3/31/24	11	8	0.02	-0.47

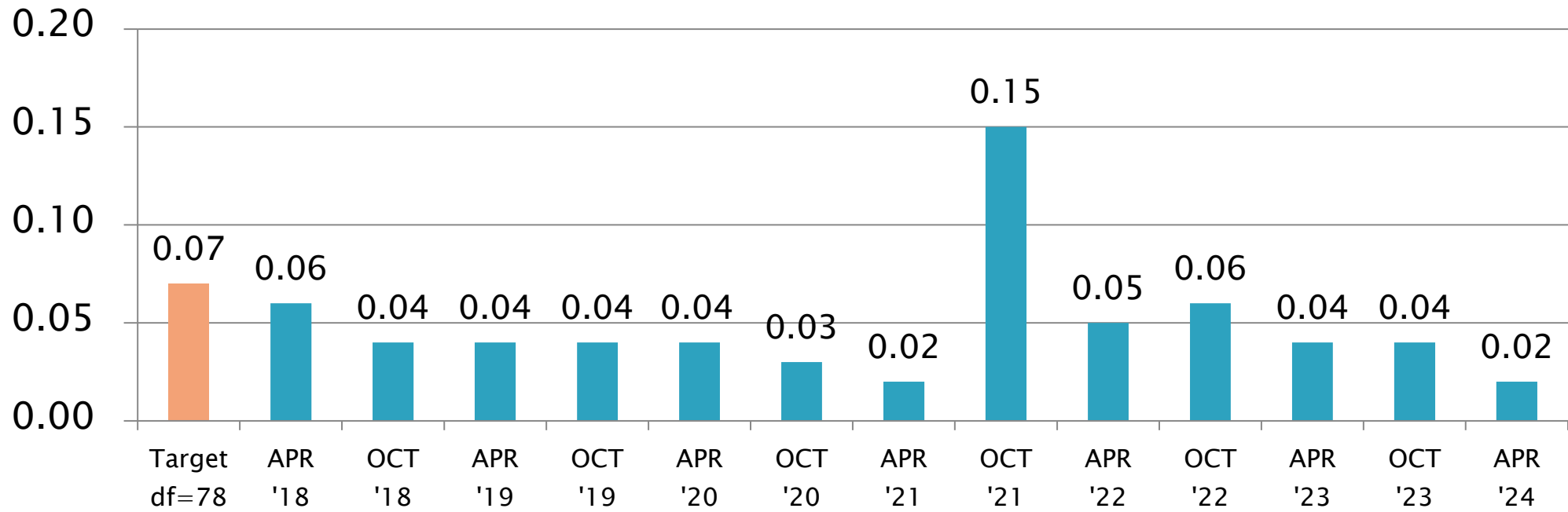
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D874: Sulfated Ash

Sulfated Ash, mass%
Pooled s



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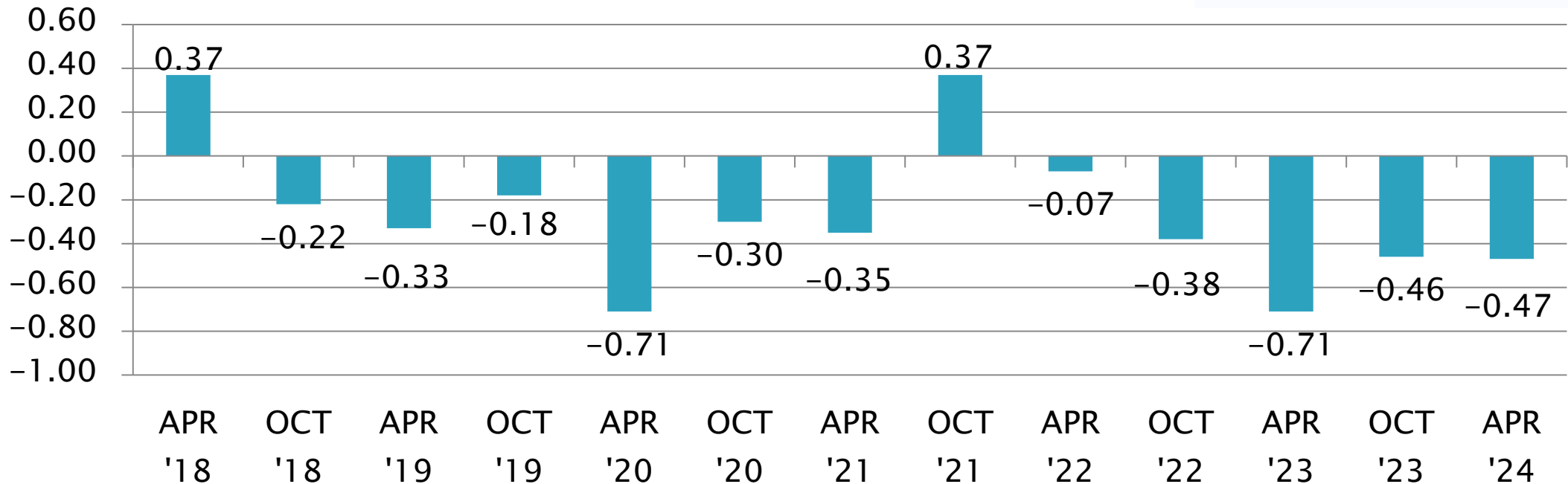
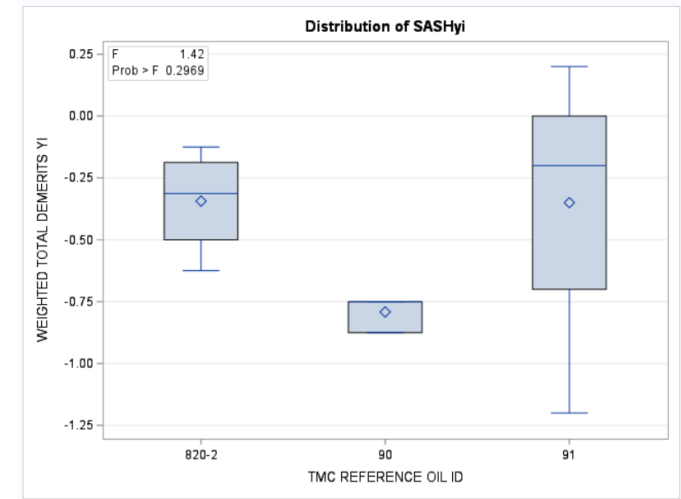
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D874: Sulfated Ash

Sulfated Ash, mass%
Mean Δ/s



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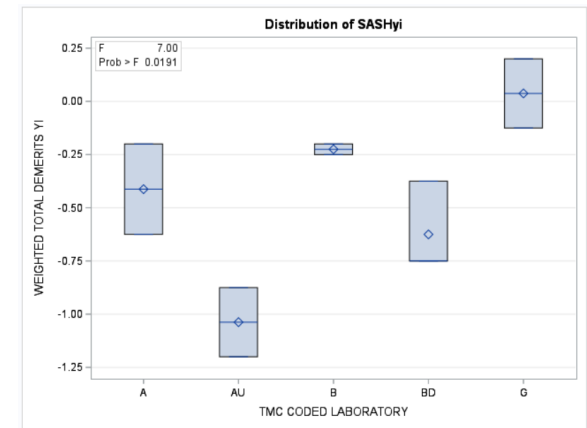
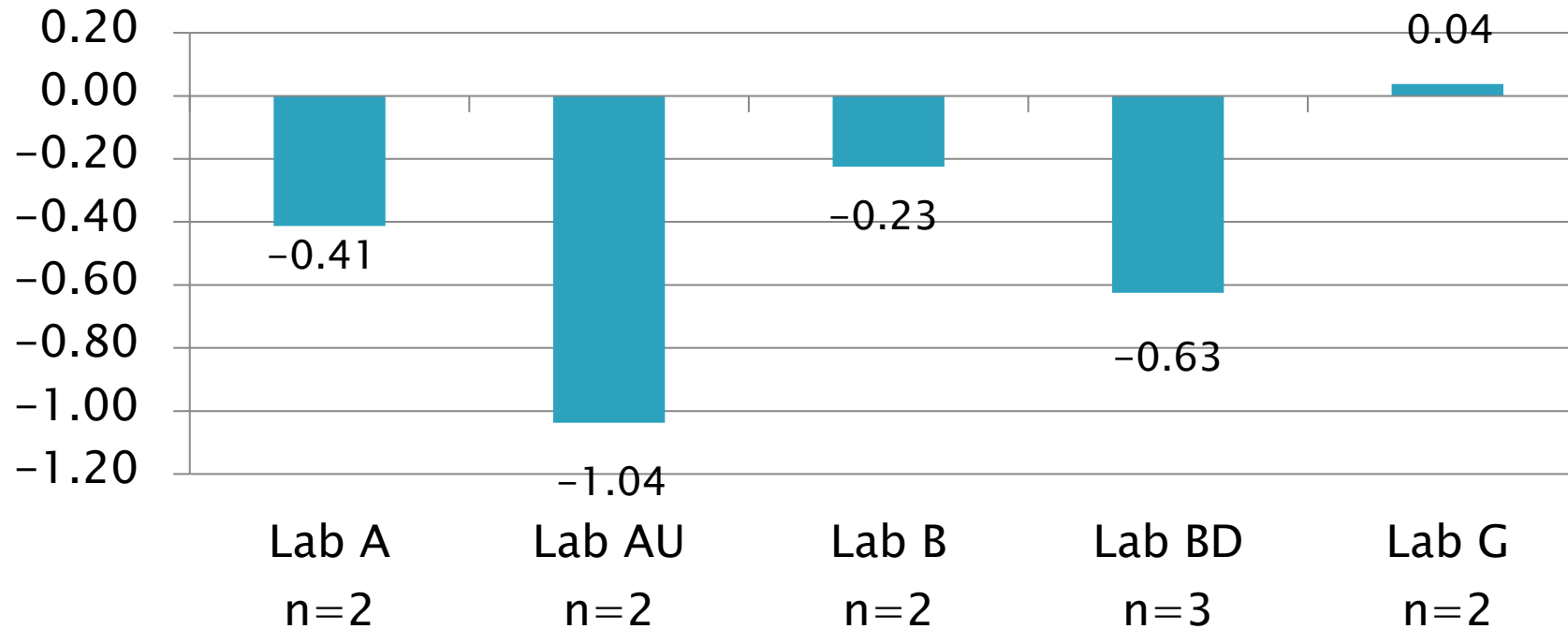
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D874: Sulfated Ash

Sulfated Ash, mass%

Mean Δ/s



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D874 (Sulfated Ash) Status

- ▶ Precision (Pooled s) has improved to 0.02, the best Pooled S value observed since April 2021.
- ▶ Performance (Mean Δ/s) has remained steady at -0.47 s
- ▶ 3.8 gallons of Reference Oil 90 available. Will only be used for D874 Daily QC moving forward.
- ▶ Reference Oil 92 completed Round Robin. Initial targets have been set
 - RO 92 will be assigned (non-blind) until another 10 results can be completed to solidify targets as set forth by Surveillance Panel

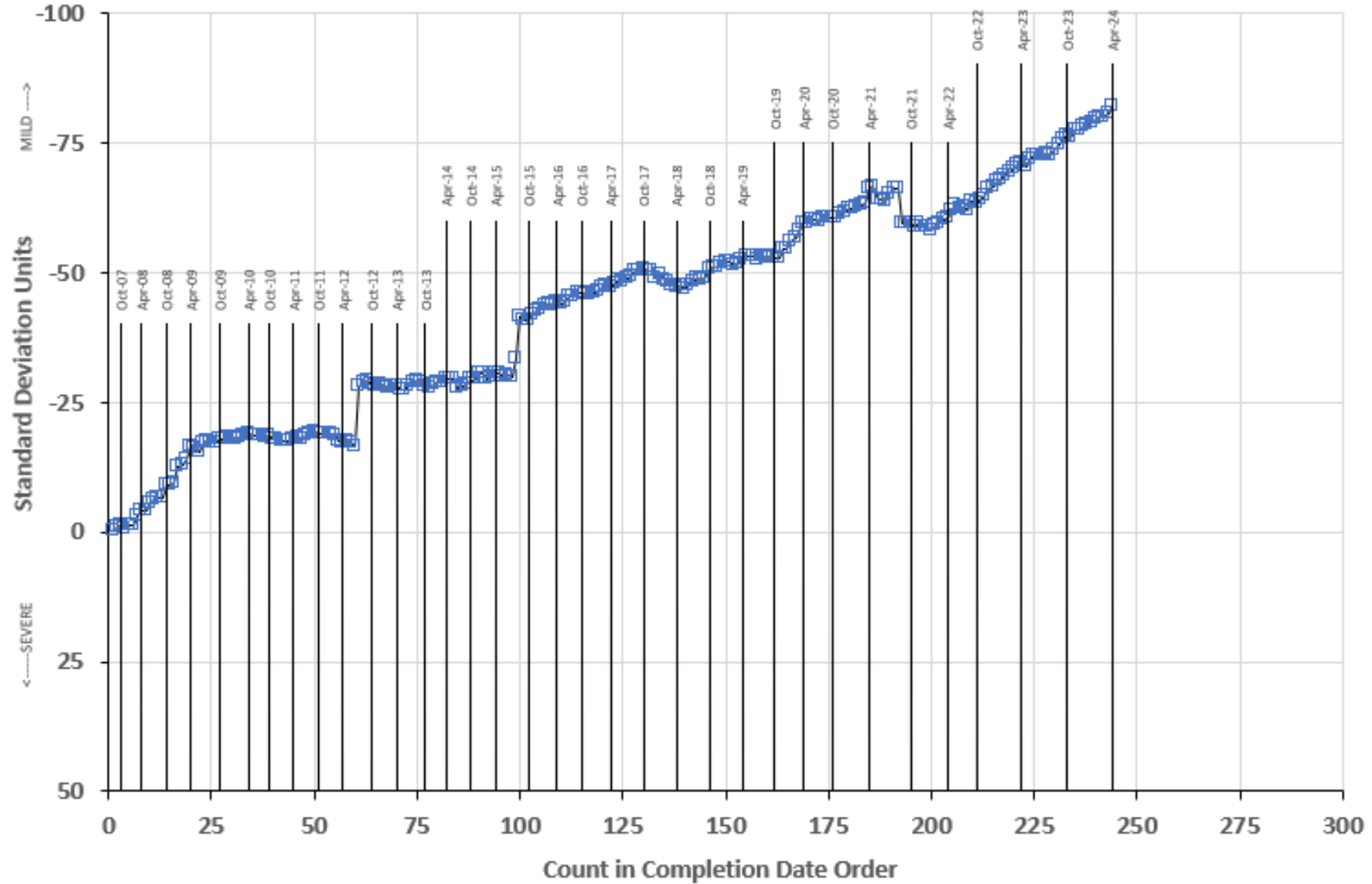
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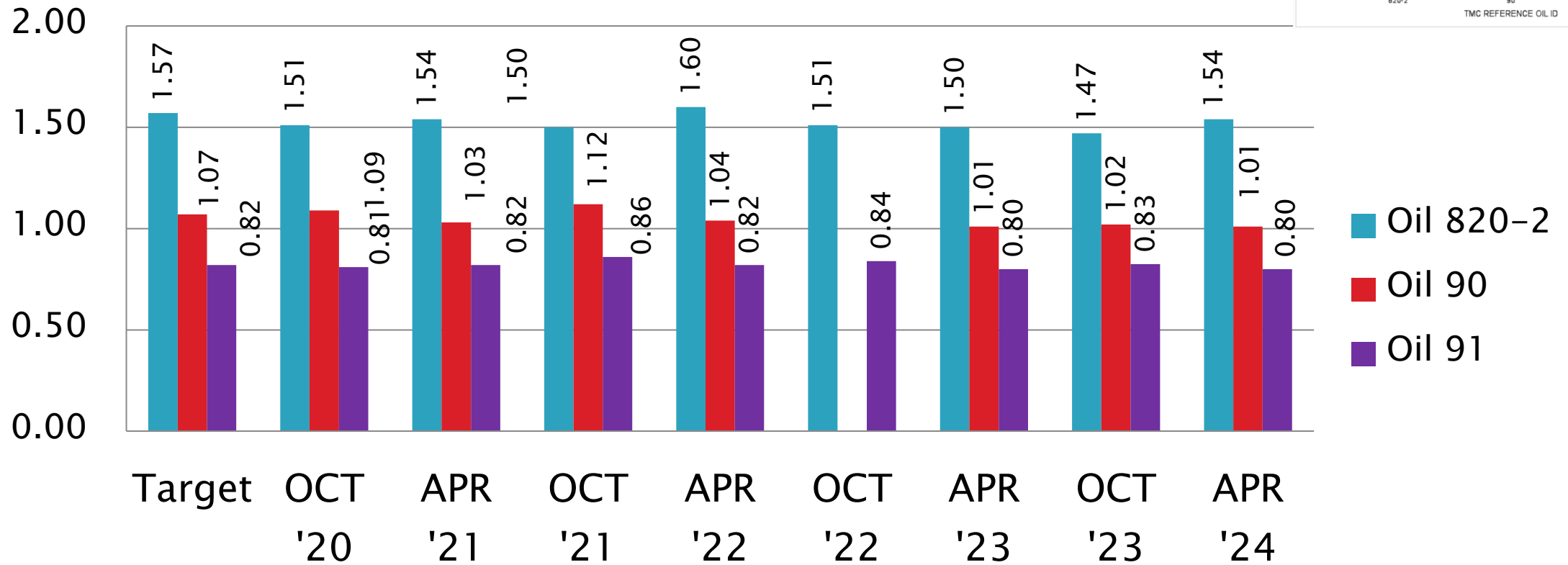
TEST SAMPLE PERCENT SULFATED ASH

CUSUM Severity Analysis



D874: Sulfated Ash

Sulfated Ash, mass%
Mean



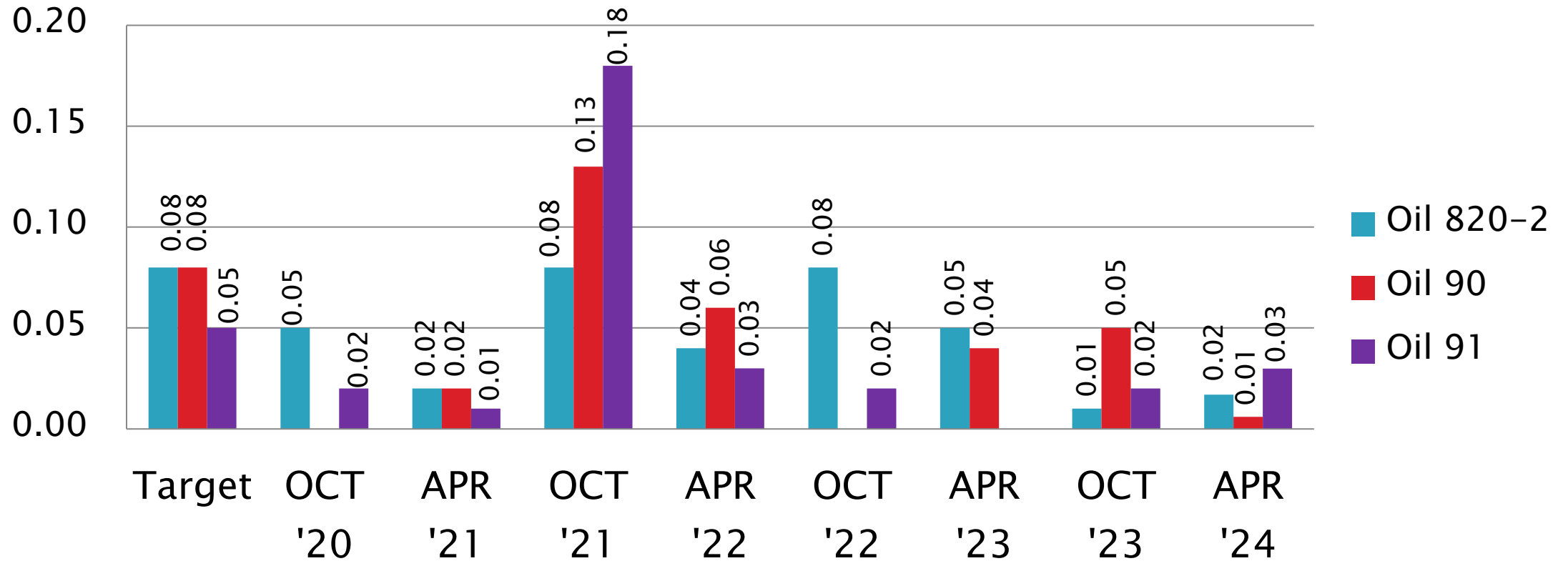
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D874: Sulfated Ash

Sulfated Ash, mass%
Standard Deviation



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D874: Sulfated Ash

Sulfated Ash, mass%
Mean Δ/s

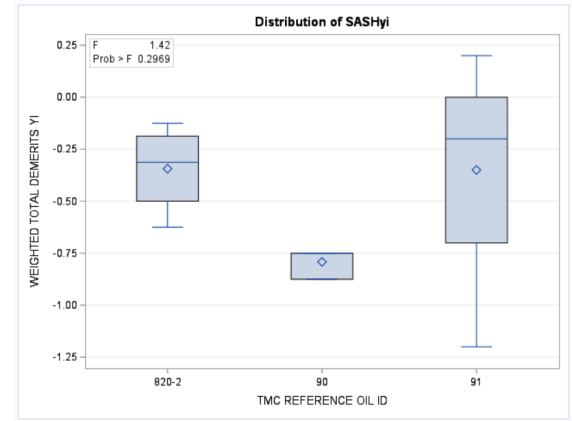
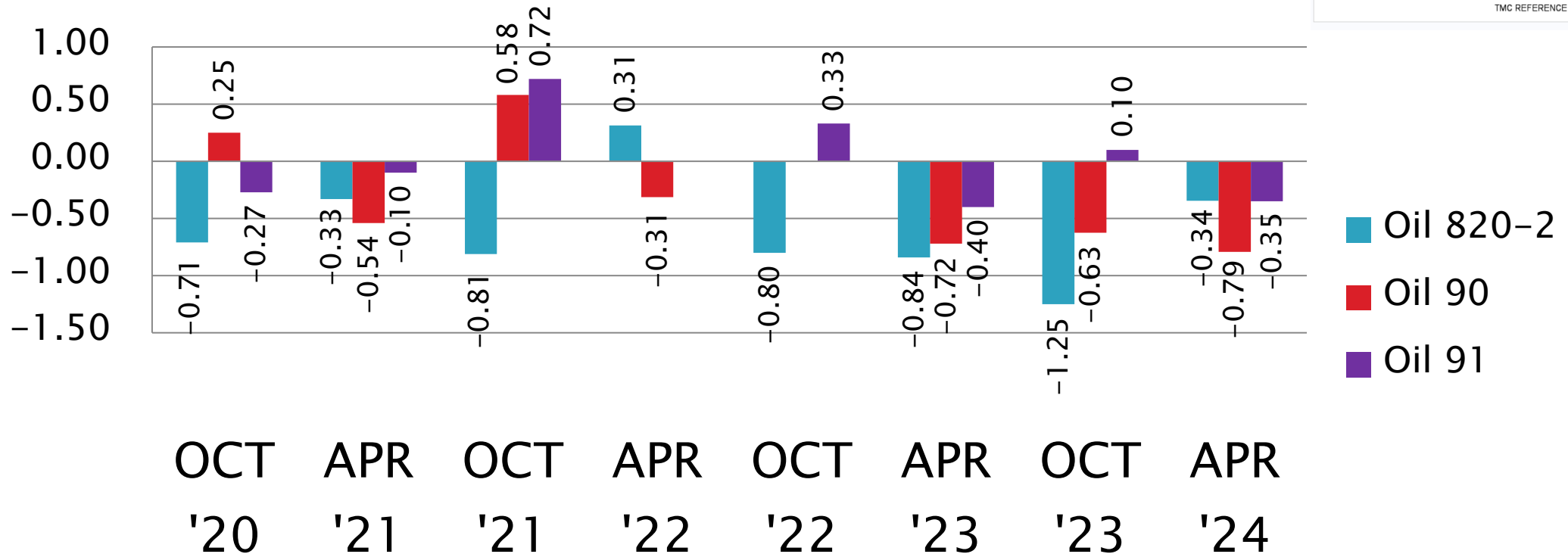


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Reference Oil Inventory

D874

Oil	Year Rec'd By TMC ^A	Tests	TMC Inventory, gallons	Gallons Shipped last 6 months	Estimated Life
820-2	2001	D874	6.01	0.03	5+ years
90 ^B	2005	D874/D874QC	3.81	0.58	1.5 years
91	2006	D874	2.99	0.11	5+ years
92	2020	D874	52.57	0.06	5+ years

^A Integrity of TMC reference oils is confirmed annually by analytical QC testing of chemical and physical properties.

^B D874QC Samples (1L sizes) could quickly deplete Reference Oil 90 availability.

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D02.B0.07 TMC Monitored Tests



ASTM D 5133

Gelation Index (GI)

October 1, 2023 – March 31, 2024

Calibrated Labs and Stands*

(change since last Semi-Annual Report)

Test	Labs	Stands
D5133	9 (+0)	42 (-10)

*As of 3/31/2024

D5133: Gelation Index

Test Status	Validity Code	No. Tests
Acceptable Calibration Test	AC	49
Failed Calibration Test	OC	8
Operationally Invalidated by Lab	LC / LS / XC / XS	2
Operationally Invalidated After Initially Reported as Valid	RC/RS	0
Acceptable Discrimination Tests	AS	34
Failed Discrimination Tests	OS	4
Informational Runs	NN / MN	10
Total		107

Number of Labs Reporting Data: 9 (previous 9)
Fail Rate of Operationally Valid Calibration Tests: 14.0% (previous 8.8%)
Fail Rate of Operationally Valid Discrimination Tests: 0.0% (previous 0%)

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D5133: Gelation Index

Statistically Unacceptable Calibration Tests (OC)	No. Of Tests
Gelation Index Severe	6
Gelation Index Mild	2
Total	8

- Of the Eight “OC” tests
 - 3-GIC18
 - 2-GIA17
 - 3-1009
- Two between -1.96 and -3.0 sd from target
- Five between $+1.96$ and $+3.0$ sd from target
- One greater than $+3.0$ sd from target

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D5133: Gelation Index

Statistically Unacceptable Discrimination Tests (OS)	No. Of Tests
Gelation Index Severe (> 7.2)	4
Total	4

- There were FOUR Failing Discrimination Runs

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D5133: Gelation Index

Tests Excluded From Statistics (Operationally or Otherwise)	Validity Code	No. Tests
Invalidated Runs	LC, LS, RC, RS	1
Aborted Runs	XC, XS	1
Informational Runs (Acceptable Result)	NN	6
Informational Runs (Unacceptable Result)	MN	4
Total		12

- ONE Invalidated Run (Power Outage)
- ONE Aborted Run (Lost Sample)
- TEN requests for Informational (non-blind) runs

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D5133: Gelation Index

Period Precision and Severity Estimates

Gelation Index	n	df	Pooled s	Mean Δ/s
Targets Updated 20201001 ¹	34	32	1.44	-----
10/1/18 through 3/31/19	27	24	1.65	0.13
4/1/19 through 9/30/19	47	44	1.40	-0.25
10/1/19 through 3/31/20	41	37	2.45	-0.24
4/1/20 through 9/30/20	52	48	2.23	-0.11
10/1/20 through 3/31/21 ²	116	113	3.74	-0.86
4/1/21 through 9/30/21	75	73	1.71	-0.20
10/1/21 through 3/31/22	61	59	1.55	-0.84
4/1/22 through 9/30/22	57	55	1.28	-0.41
10/1/22 through 3/31/23	84	80	3.83	-0.08
4/1/23 through 9/30/23	62	59	1.34	-0.21
10/1/23 through 3/31/24	57	54	1.64	-0.03

¹Target precision updated to current reference oils GIA17 and 1009 only

²Changed from bath to head-based monitoring scheme 10/1/20

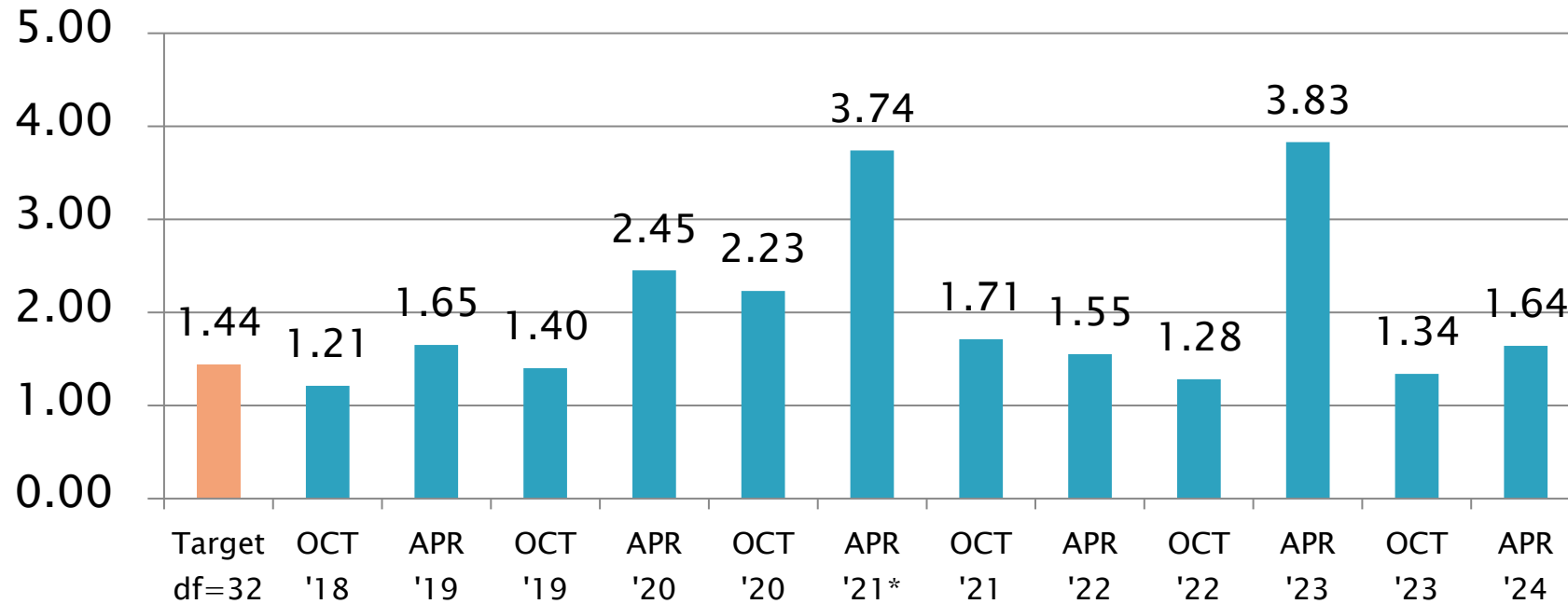
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D5133 Precision Estimates

Gelation Index Pooled s



*Changed from bath to head-based monitoring scheme

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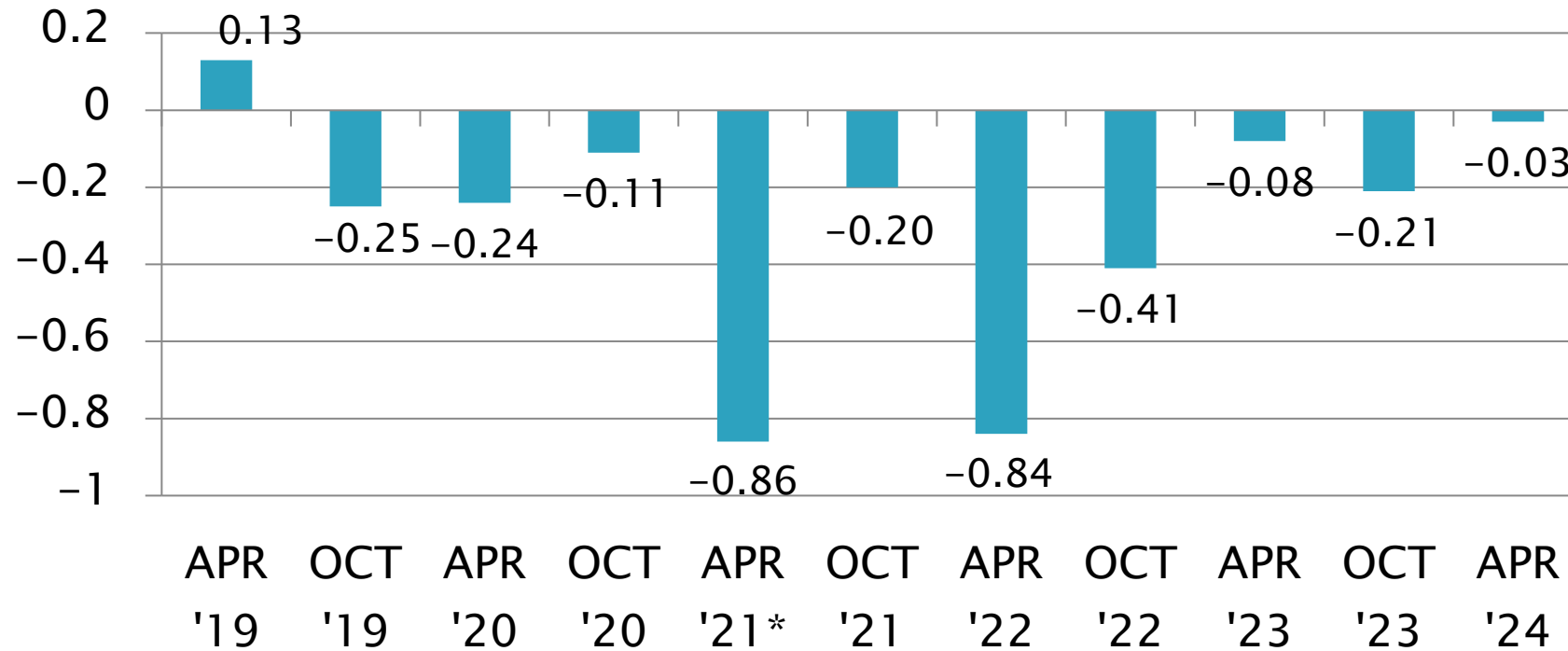


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D5133 Severity Estimates

Gelation Index

Mean Δ/s



*Changed from bath to head-based monitoring scheme

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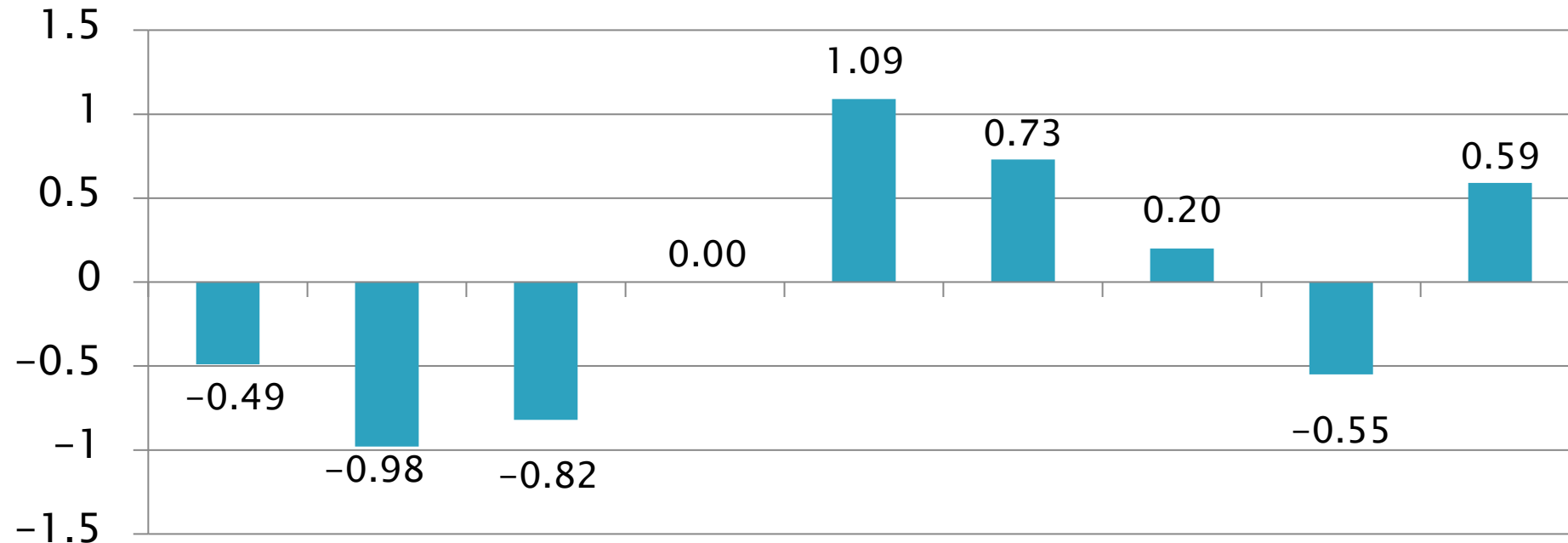
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D5133 Lab Severity Estimates

Gelation Index

Mean Δ/s



Lab A	Lab AU	Lab AY	Lab B	Lab BE	Lab D	Lab E1	Lab G	LAB S
n=16	n=3	n=5	n=6	n=7	n=11	n=2	n=6	n=1

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D5133: Gelation Index

- ▶ Fail rate of operationally valid tests rose to 14% this period
 - Fail rate last period was 8.8%
 - FOUR operationally valid discrimination runs failed this period
- ▶ Precision (Pooled s) increased slightly compared to last semester but remains close to target.
- ▶ Performance (Mean Δ/s) is right on-target at -0.03 s
- ▶ Reference Oil GIC18 has now been included in calibration testing for three semesters and all labs have at least one run with GIC18
 - GIC18 replaced RO 58 which was reclassified as a discrimination oil
 - GIC18 Acceptance Limits will be reviewed in the next semester

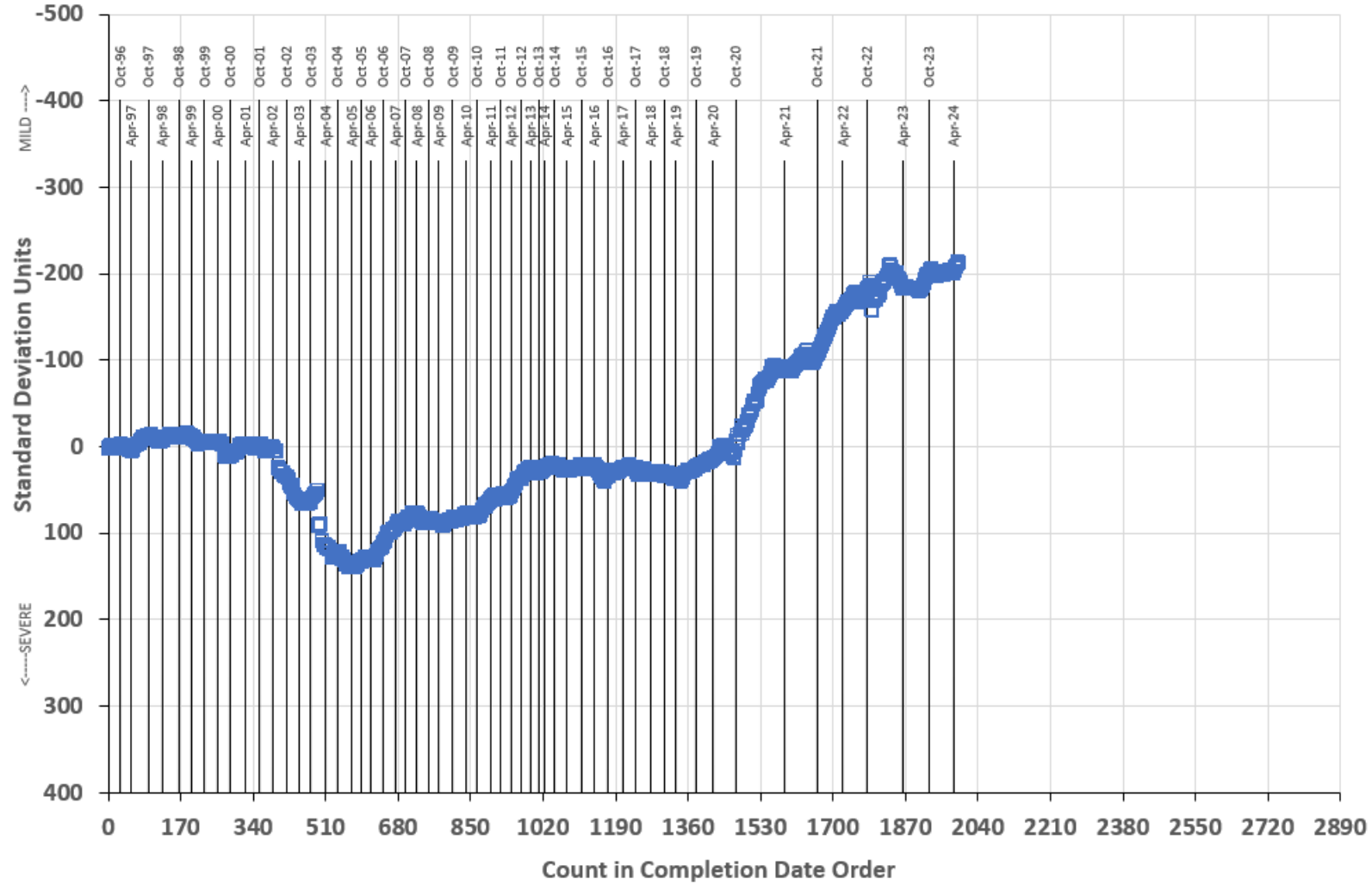
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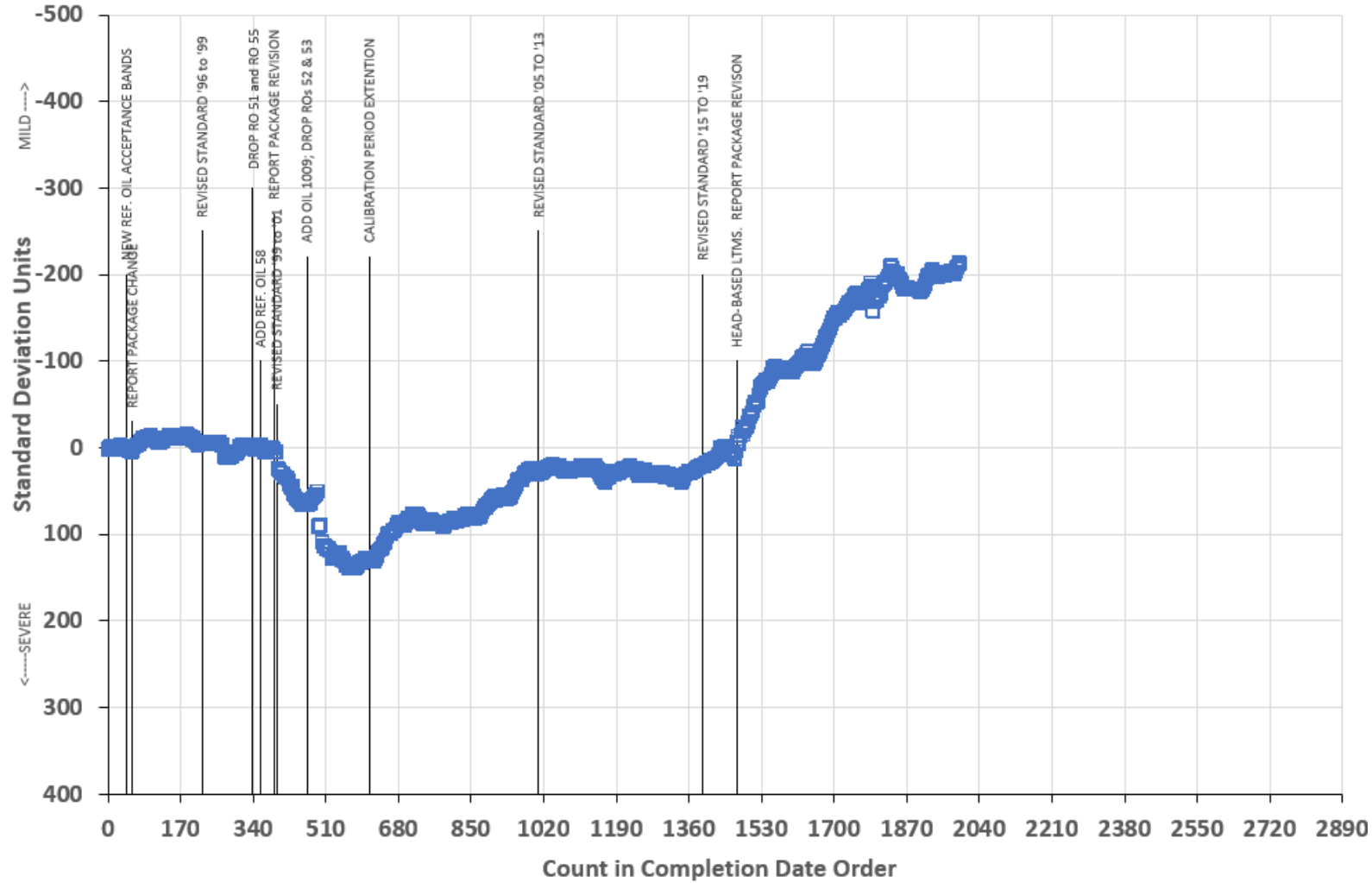
GELATION INDEX

CUSUM Severity Analysis



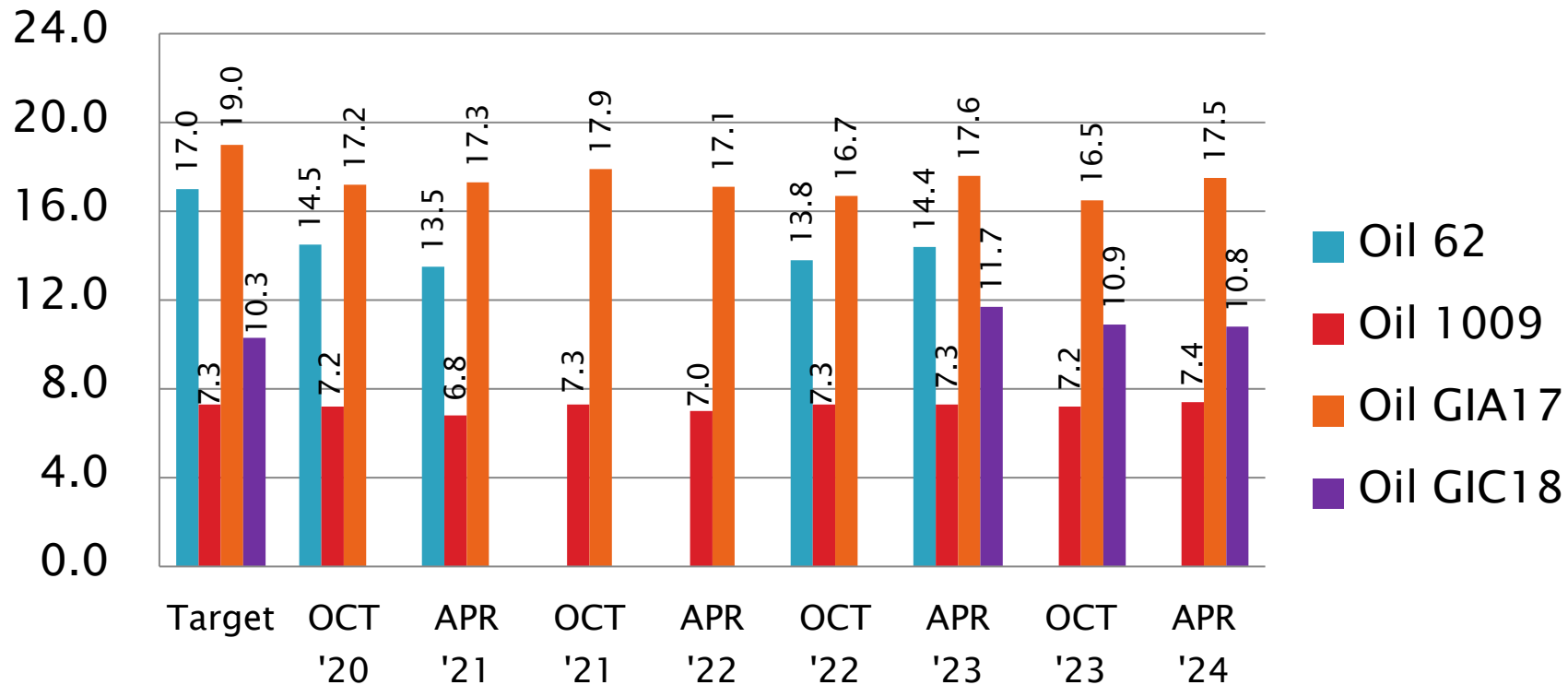
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CUSUM Severity Analysis



D5133 Performance by Oil

Gelation Index Mean



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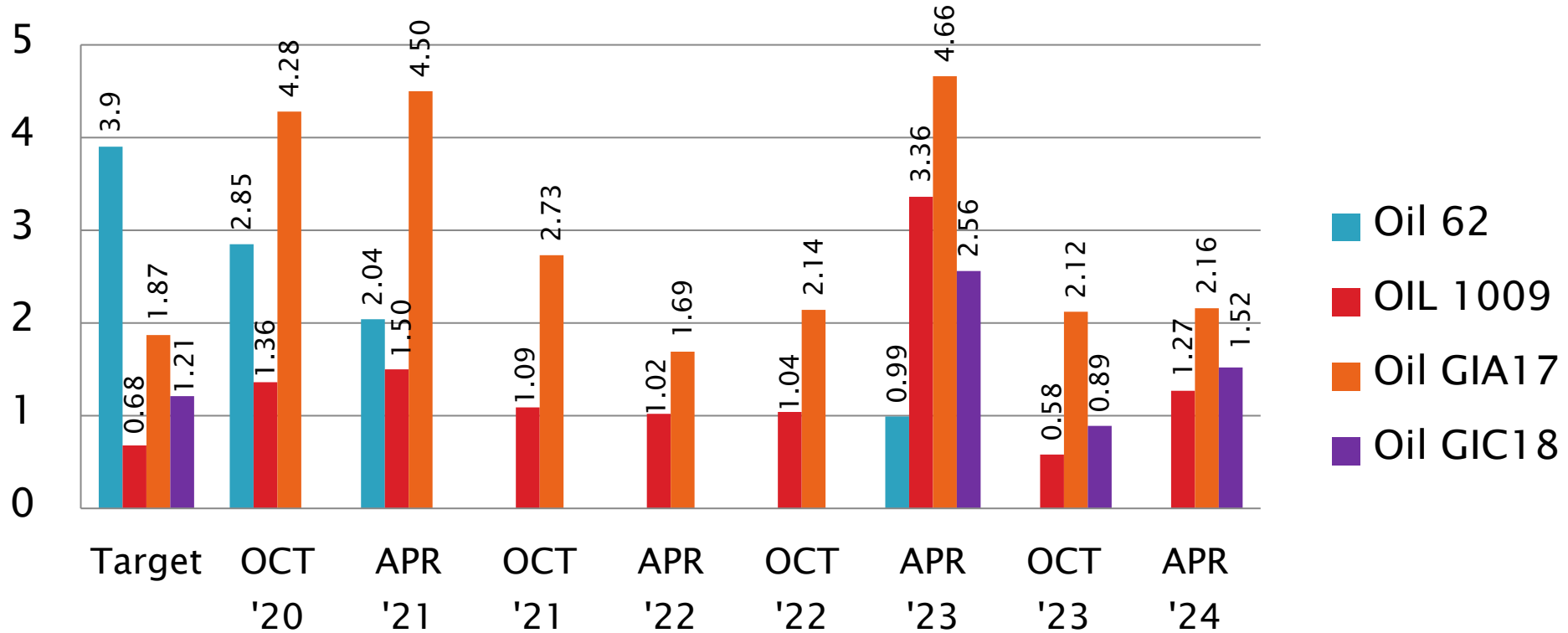


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D5133 Performance by Oil

Gelation Index

S_R

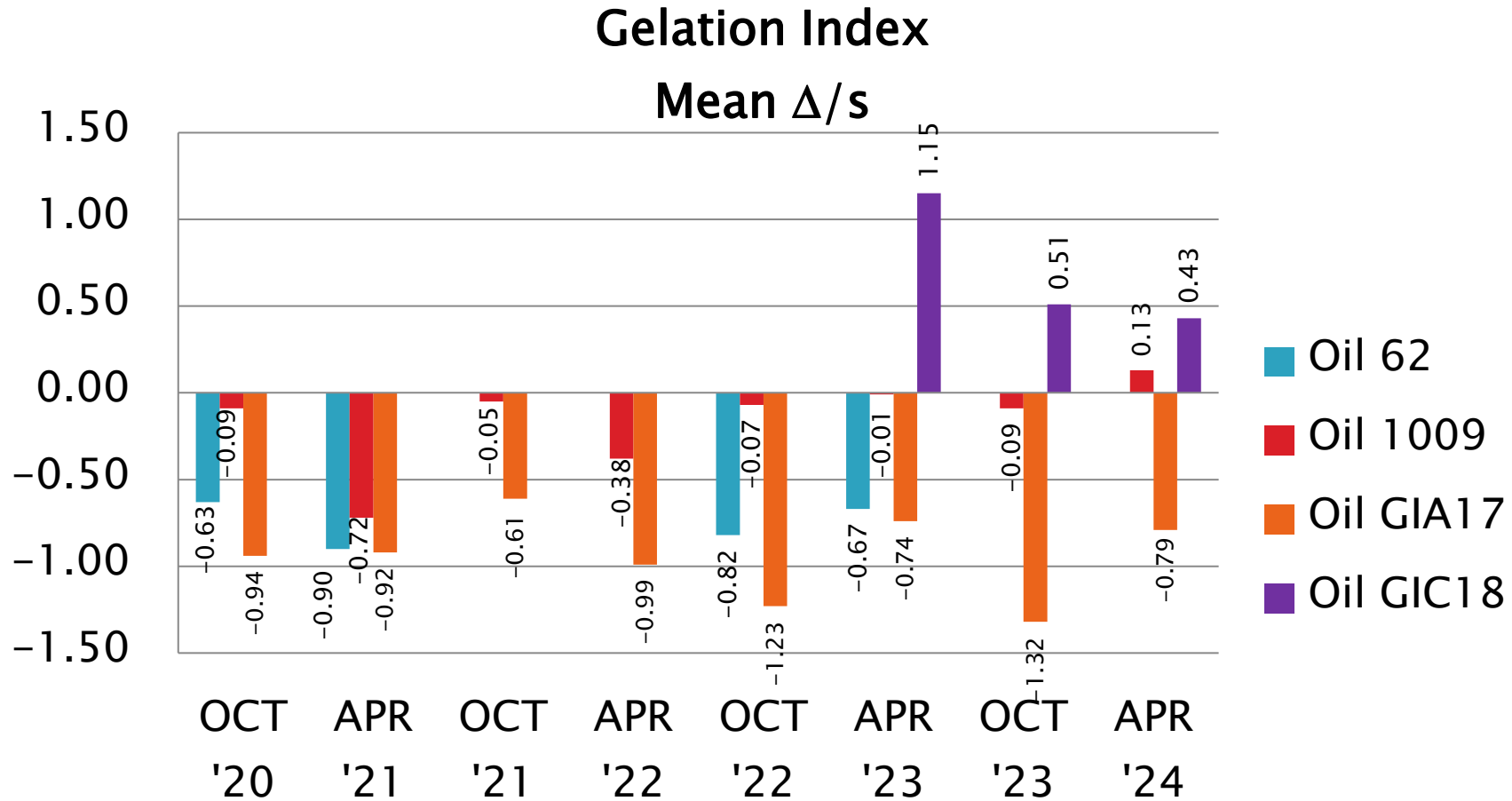


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D5133 Performance by Oil



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ASTM D5133 (GI): OCT23 – MAR24 Results

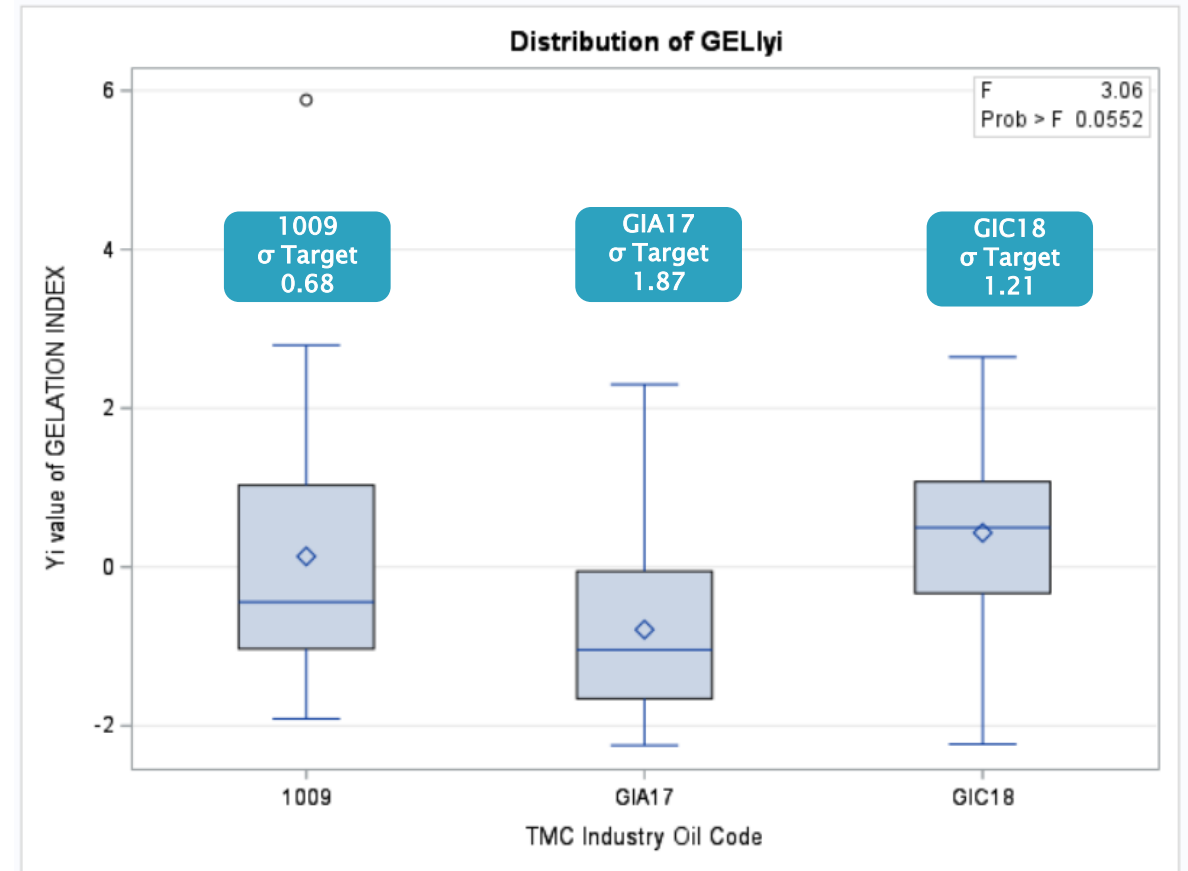
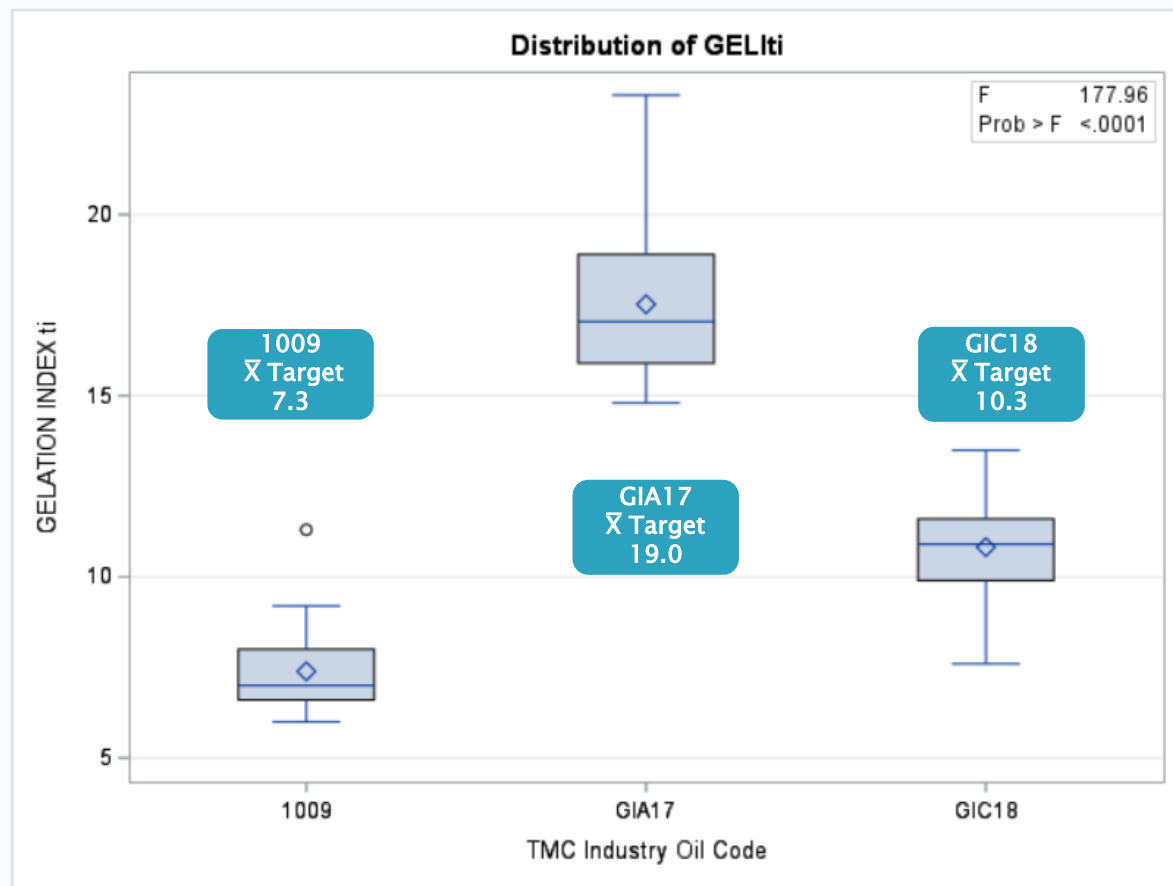


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Reference Oil Inventory

GI (D5133)

Oil	Year Rec'd By TMC ^A	Tests	TMC Inventory, gallons	Gallons Shipped last 6 months	Estimated Life
58	1998	GI	110.19	0.47	5+ years
GIA17	2017	GI	5.53	0.42	5+ years
GIC18	2018	GI	8.15	0.38	5+ years
1009	2002	GI	33.58	0.36	5+ years

^A Integrity of TMC reference oils is confirmed annually by analytical QC testing of chemical and physical properties.

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D02.B0.07

TMC Monitored Tests



ASTM D 5800

NOACK Volatility

October 1, 2023 – March 31, 2024

Calibrated Labs and Stands*

(change since last Semi-Annual Report)

Test	Labs	Stands
D5800	14 (+0)	37 (+1)

*Between 10/1/2023 and 3/31/2024

D5800: Evaporation Loss of Lubricating Oil by Noack Method

Test Status	Validity Code	No. Tests
Acceptable Calibration Test	AC	164
Failed Calibration Test	OC	10
Operationally Invalidated by Lab	LC	3
Acceptable Shakedown Run	NN	0
Unacceptable Shakedown Run	MN	0
Total		177

Number of Labs Reporting Data: 14
Fail Rate of Operationally Valid Tests: 5.75%

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D5800: Evaporation Loss of Lubricating Oil by Noack Method

Statistically Unacceptable Tests (OC)	No. Of Tests
Ei Level 3 Alarm Severe	3
Ei Level 3 Alarm Mild	3
Zi Level 2 Severity Alarm Severe	3
Zi Level 2 Severity Alarm Mild	1

- The 10 OC tests were on eight different rigs at six labs.
- Three operationally valid tests exceeded ± 3.0 s this period.

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D5800: Evaporation Loss of Lubricating Oil by Noack Method

Failed (OC) Details	Procedure	Model	No. Tests
Zi Level 2 Alarm: Rig (AZ1) Severe	B	NCK25G	2
Zi Level 2 Alarm: Rig (AZ2) Severe	B	NCK25G	1
Zi Level 2 Alarm: Rig (G10) Mild	D	NS2	1
Ei Level 3 Alarm Severe: Rig (D9) too imprecise to predict SA	D	NS2	1
Ei Level 3 Alarm Mild: Rig (D5) too imprecise to predict SA	D	NS2	1
Ei Level 3 Alarm Mild & Severe: Rig (A17) too imprecise to predict SA	D	NS2	2
Ei Level 3 Alarm Mild: Rig (BD5) too imprecise to predict SA	D	NS2	1
Ei Level 3 Alarm Severe: Rig (B8) too imprecise to predict SA	B	NCK25G	1
Total			10
Fail Rate of Operationally Valid Tests: 5.75%			

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D5800: Evaporation Loss of Lubricating Oil by Noack Method

Operationally Invalid Tests (LC)

Three different labs invalidated three calibration runs this period

- Test was invalidated due to pressure fluctuations
- Test invalidated due to air pressure failure
- Test invalidated due to spilled sample

D5800 Technical Memos

No D5800 technical memos were issued by the TMC this period.

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D5800: Evaporation Loss of Lubricating Oil by Noack Method

Period Precision and Severity Estimates

Sample Evaporation Loss, mass %	n	df	Pooled s	Mean Δ/s
Targets Effective 02/07/20 ¹	78	75	0.0465	-----
4/1/19 through 9/30/19	164	161	0.81	0.65
10/1/19 through 3/31/20 ¹	146	143	0.0503	0.54
4/1/20 through 9/30/20 ¹	136	133	0.0659	0.35
10/1/20 through 3/31/21 ¹	140	137	0.0495	0.53
4/1/21 through 9/30/21 ¹	136	133	0.0510	0.45
10/1/21 through 3/31/22 ¹	139	136	0.0463	0.24
4/1/22 through 9/30/22 ¹	136	133	0.0469	-0.10
10/1/2022 through 3/31/23 ¹	136	133	0.0545	-0.15
4/1/2023 through 9/30/23 ¹	169	166	0.0586	0.33
10/1/2023 through 3/31/24 ¹	174	171	0.0576	0.37

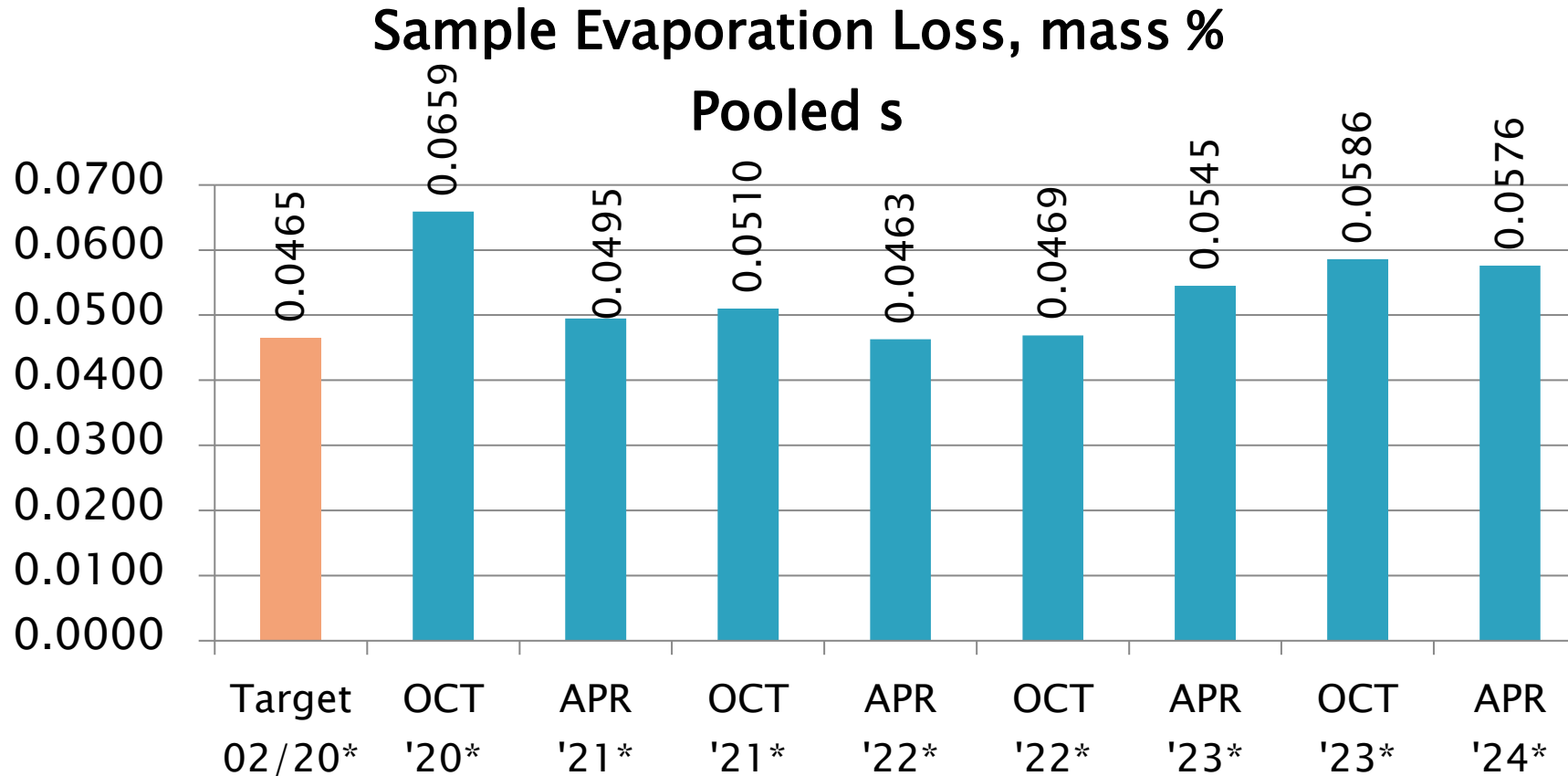
¹Began monitoring natural log transformed test results on 20200207 making logarithmic scale changes for target and period precision estimates starting April 2020 report period

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D5800 Precision Estimates



*Began monitoring natural log transformed test results on 20200207 making logarithmic scale changes for target and period precision estimates starting April 2020 report period.

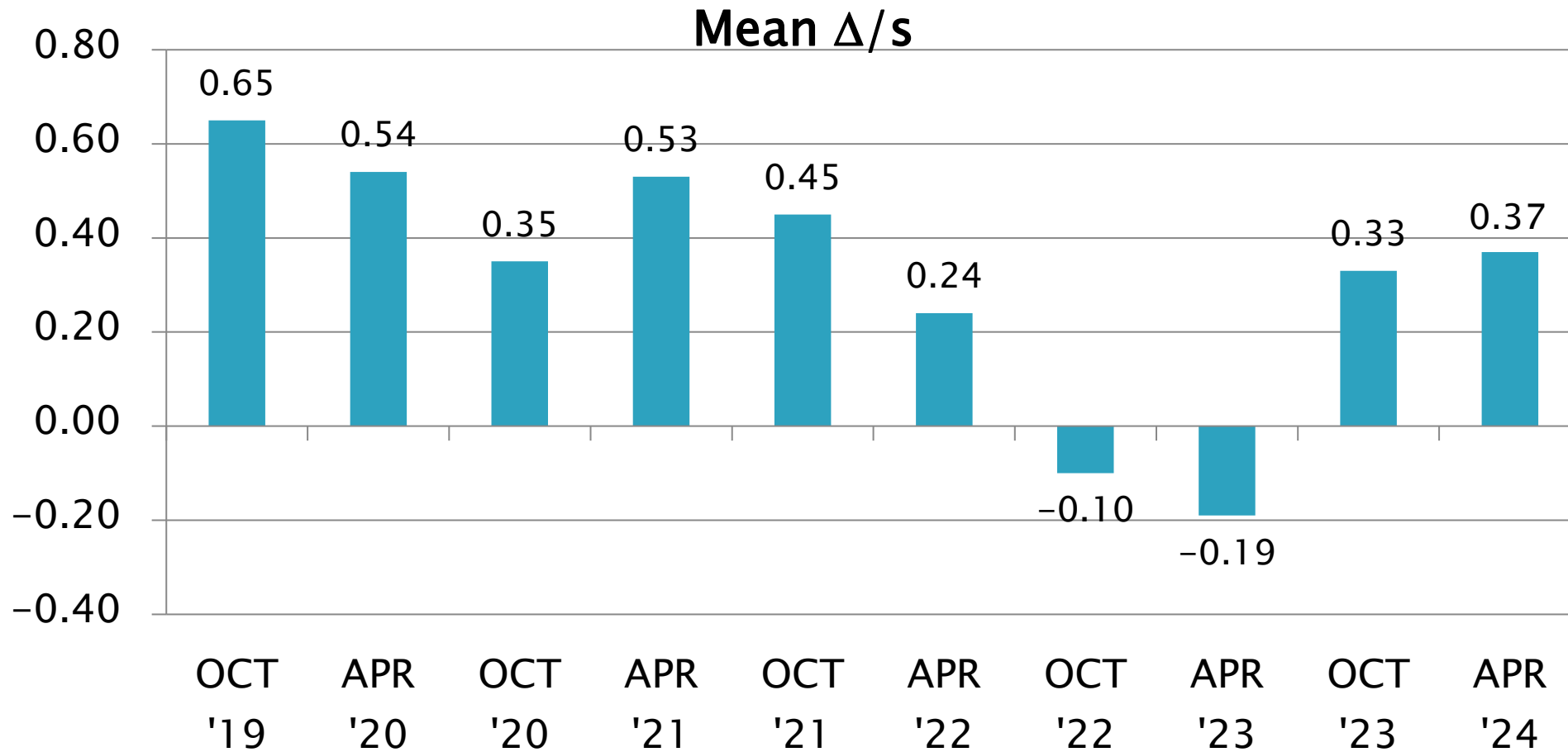
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D5800 Severity Estimates

Sample Evaporation Loss, mass %



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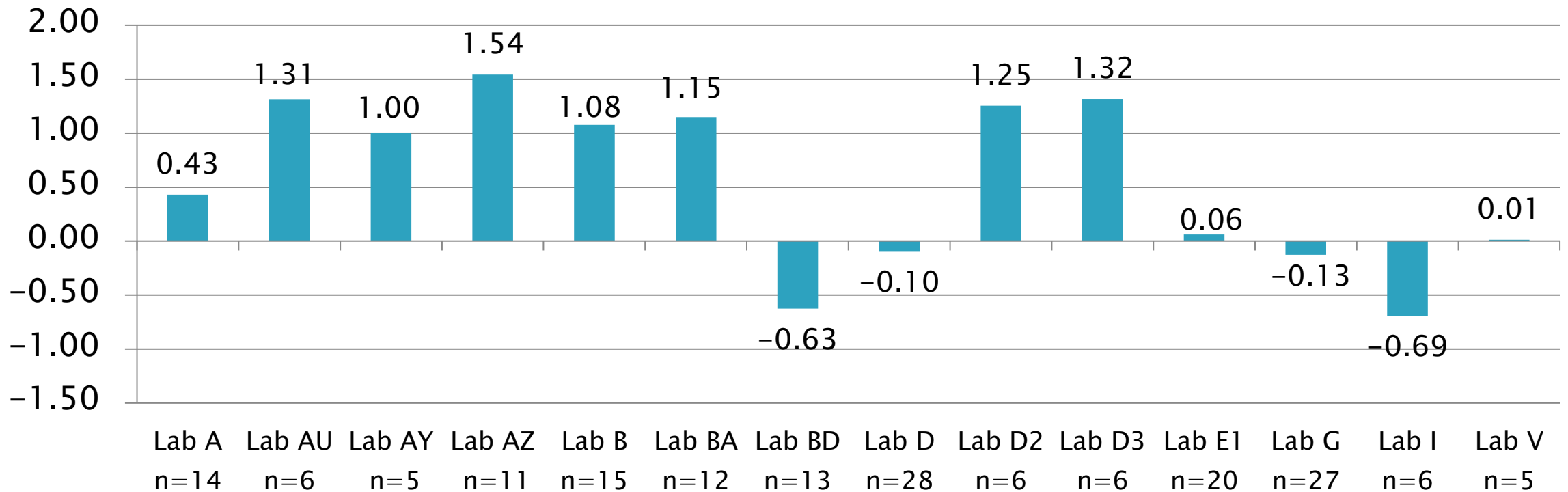


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D5800 Lab Severity Estimates

Sample Evaporation Loss, mass %

Mean Δ/s



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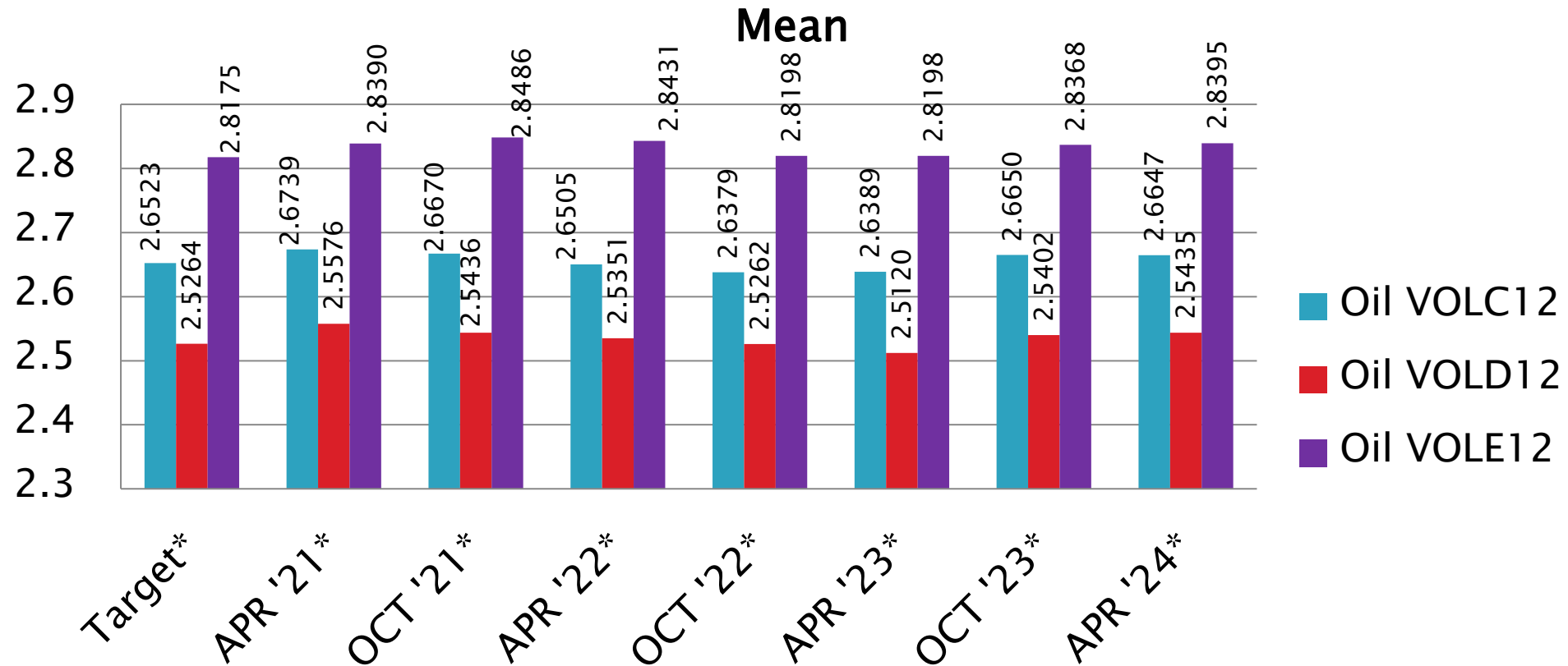
Test Monitoring Center
<https://www.astmtmc.org>



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D5800 Performance by Oil

Sample Evaporation Loss, mass %



*Results transformed to natural log per updated LTMS 20200207

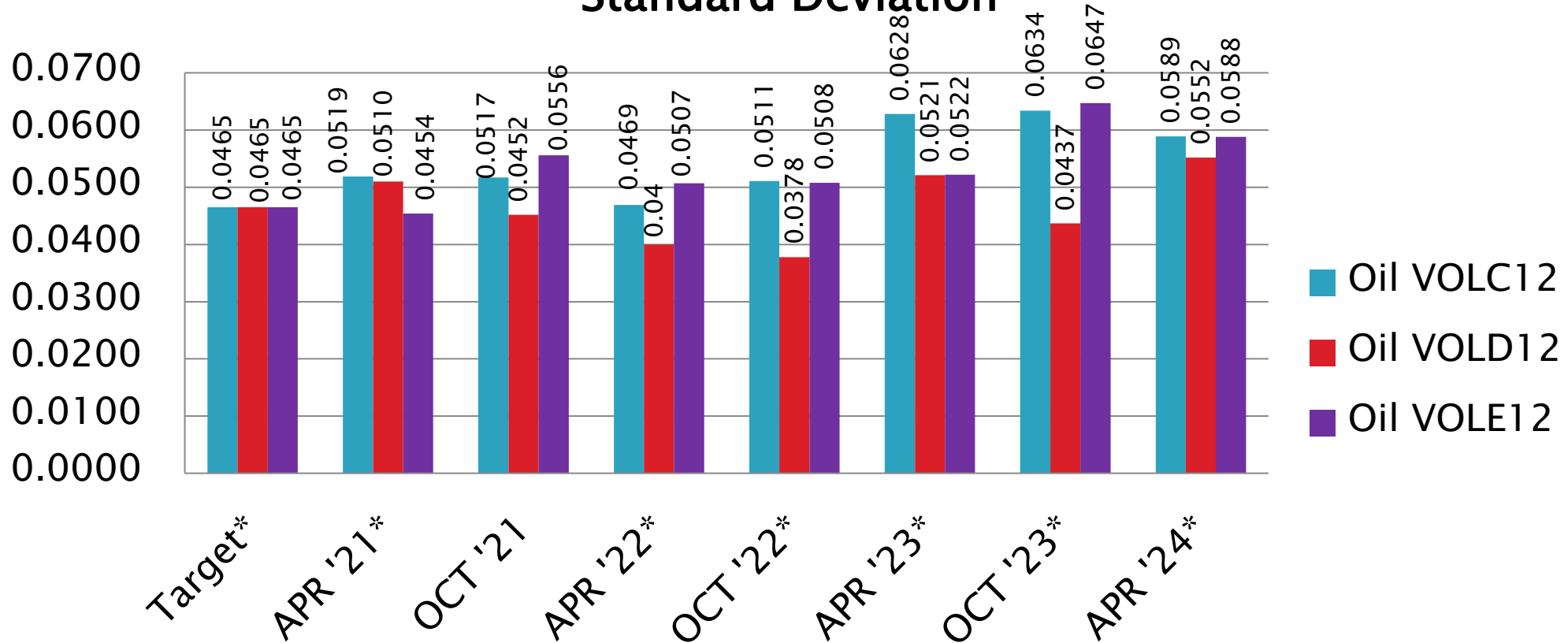
October 1, 2023 - March 31, 2024

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D5800 Performance by Oil

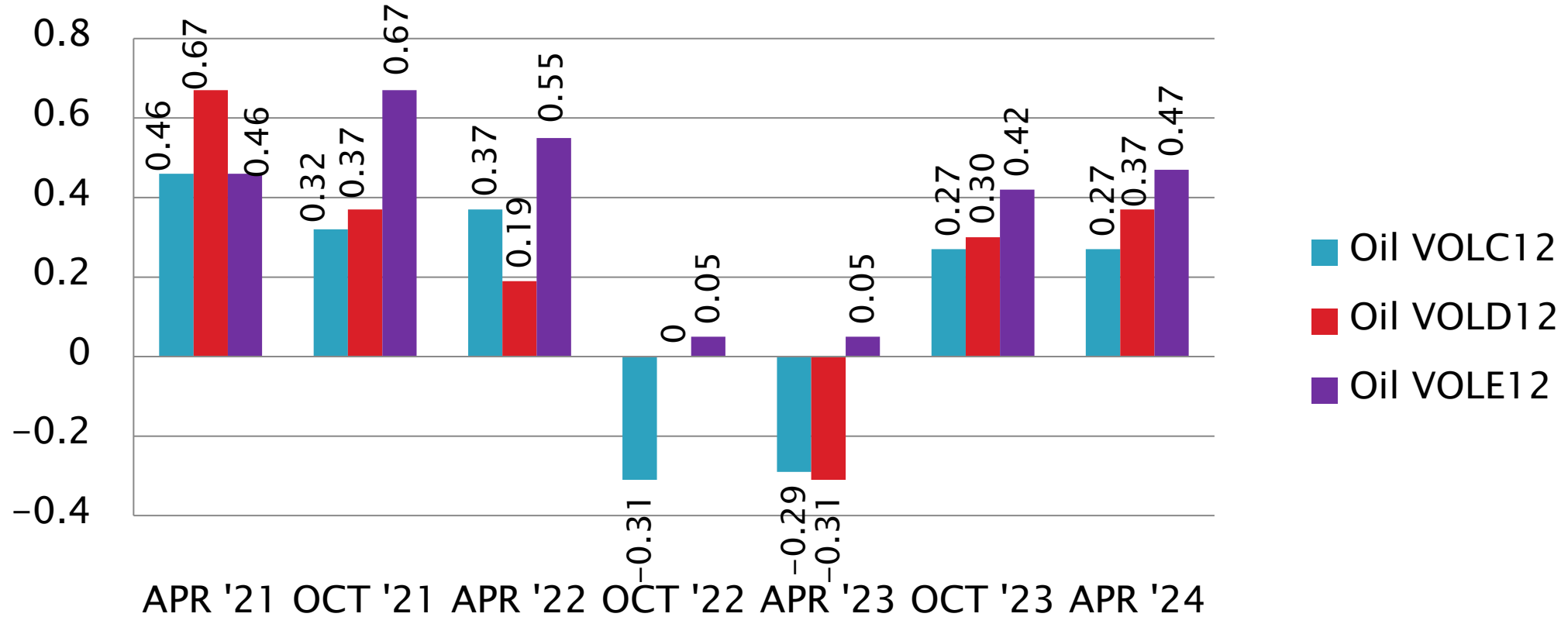
Sample Evaporation Loss, mass %
Standard Deviation



*Results transformed to natural log per updated LTMS 20200207

D5800 Performance by Oil

Sample Evaporation Loss, mass %
Mean Δ/s



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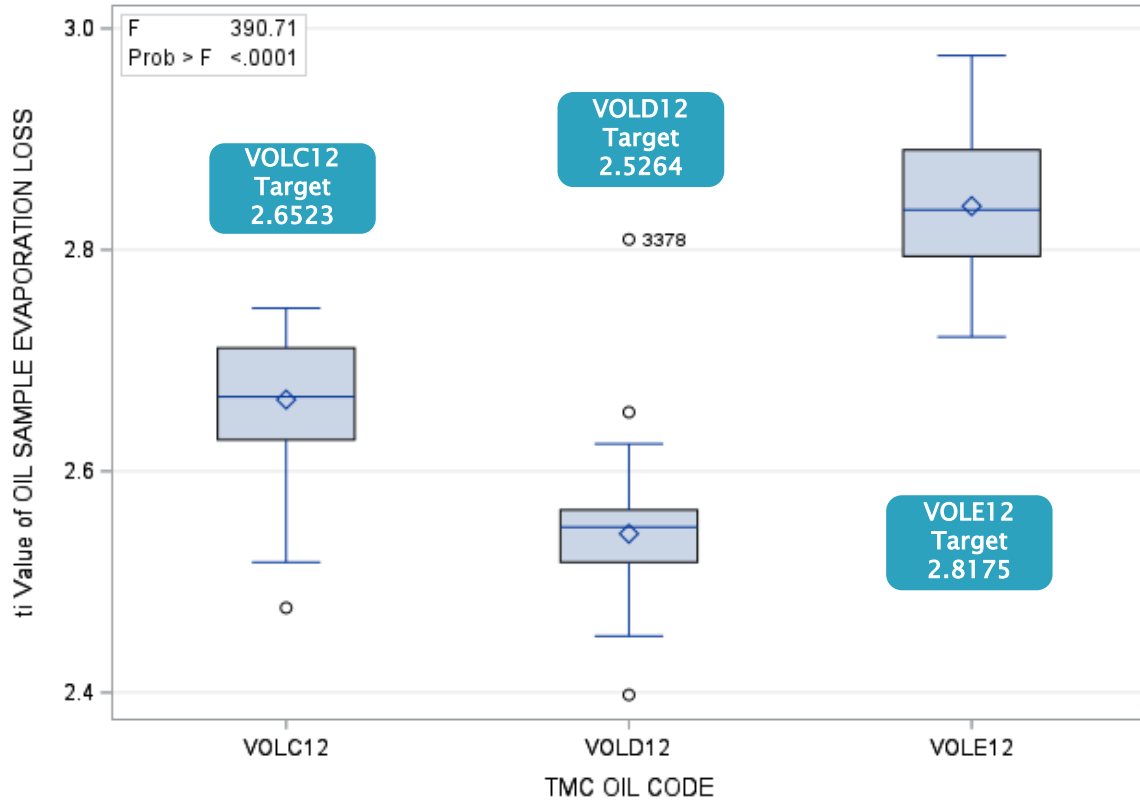
Test Monitoring Center
<https://www.astmtmc.org>



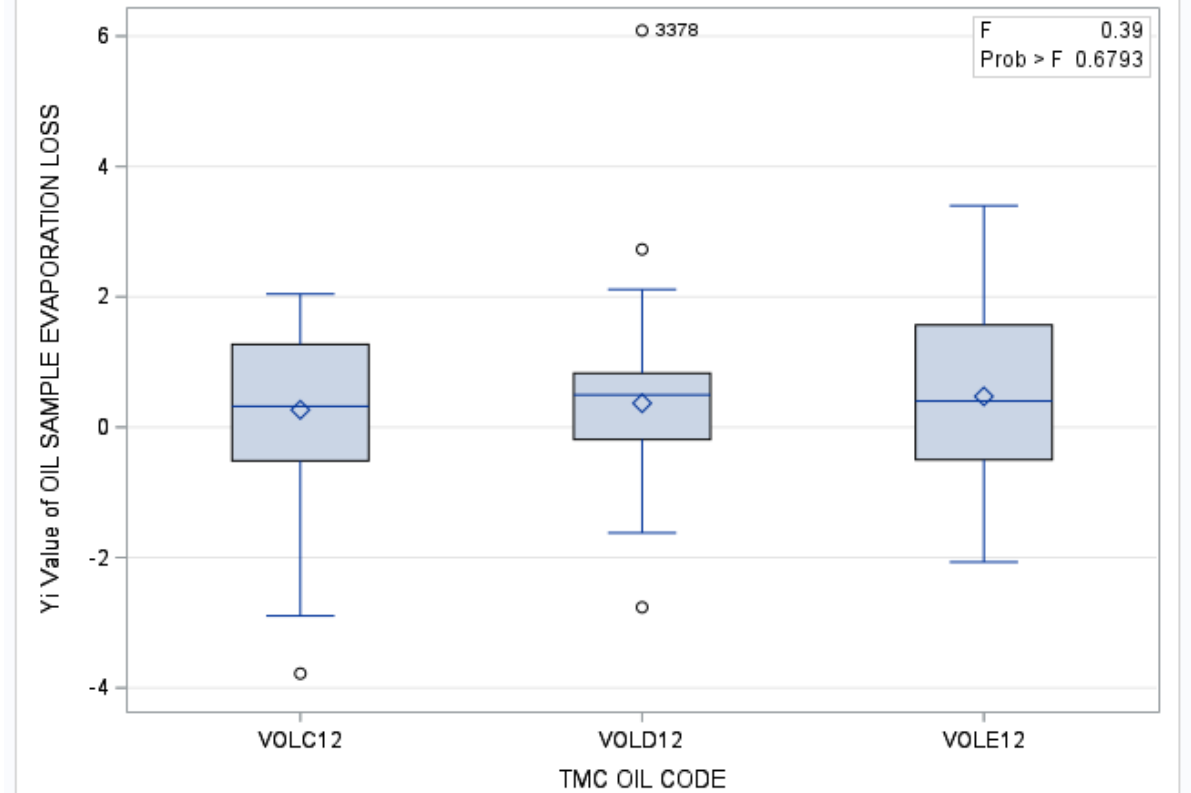
ALL

All Procedures: OCT23 – APR24 Results

Distribution of EVALti



Distribution of EVALyi



October 1, 2023 – March 31, 2024

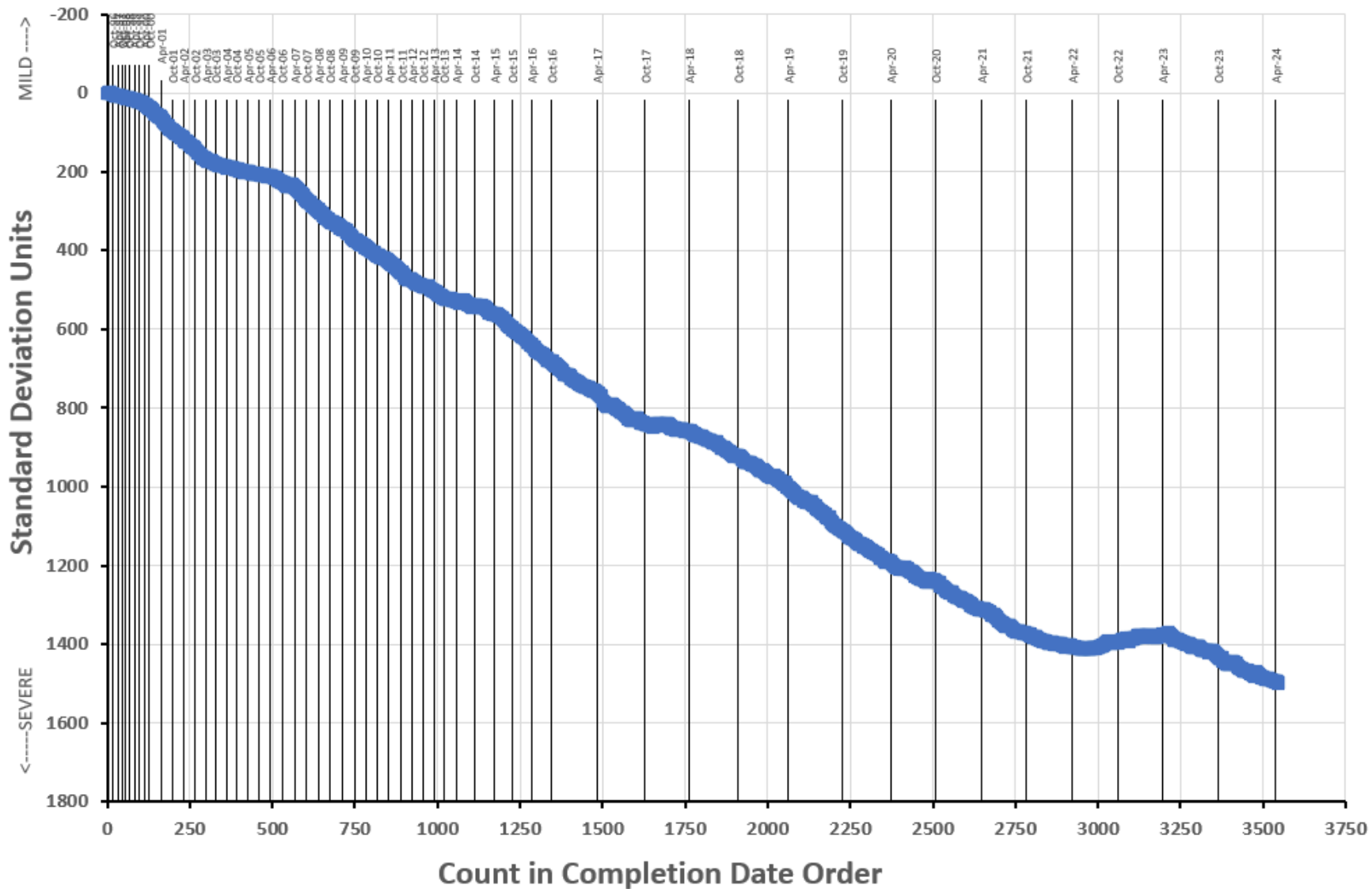
Test Monitoring Center
<https://www.astmtmc.org>



ALL

EVAPORATION LOSS, MASS%

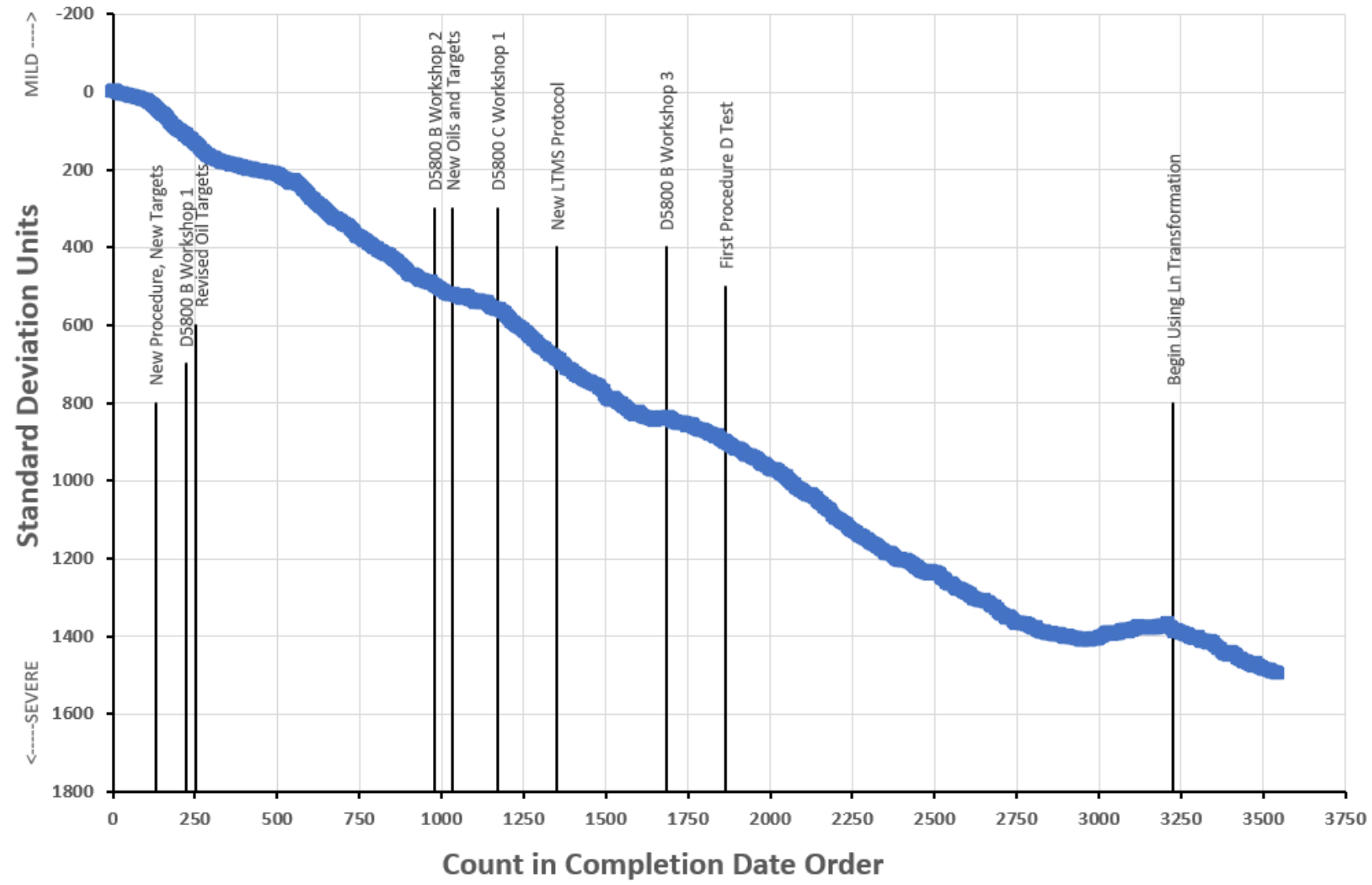
CUSUM Severity Analysis



ALL

EVAPORATION LOSS, MASS%

CUSUM Severity Analysis



D5800: Evaporation Loss of Lubricating Oil by Noack Method and Rig Model

Performance Comparison
Sample Evaporation Loss, Mass %

Procedure	n	df	Pooled s	Mean Δ/s
Procedure B (NCK2, NCK25G)	94	91	0.0423	0.86
Procedure D (NS2)	80	77	0.0610	-0.20

Model	n	df	Pooled s	Mean Δ/s
NCK2 (B)	6	3	0.0202	-0.19
NCK25G (B)	88	85	0.0415	0.93
NS2 (D)	80	77	0.0610	-0.20

1 (+0) Procedure B NCK2 Rig
22 (+0) Procedure B NCK25G Rigs
14 (+1) Procedure D NS2 Rigs

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D5800: Evaporation Loss of Lubricating Oil by Noack Method: Industry Procedure B

Test Status	Validity Code	No. Tests
Acceptable Calibration Test	AC	90
Failed Calibration Test	OC	4
Total		94

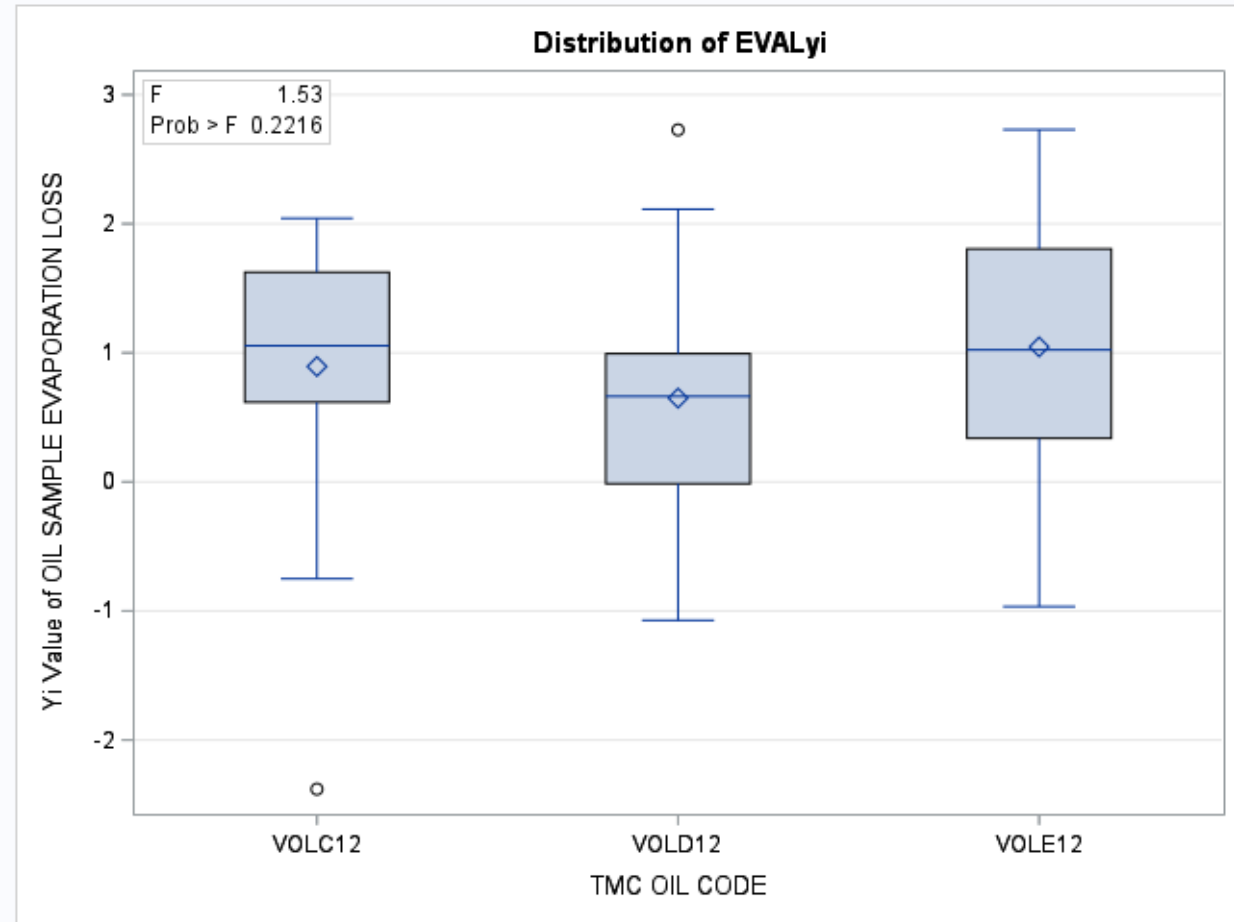
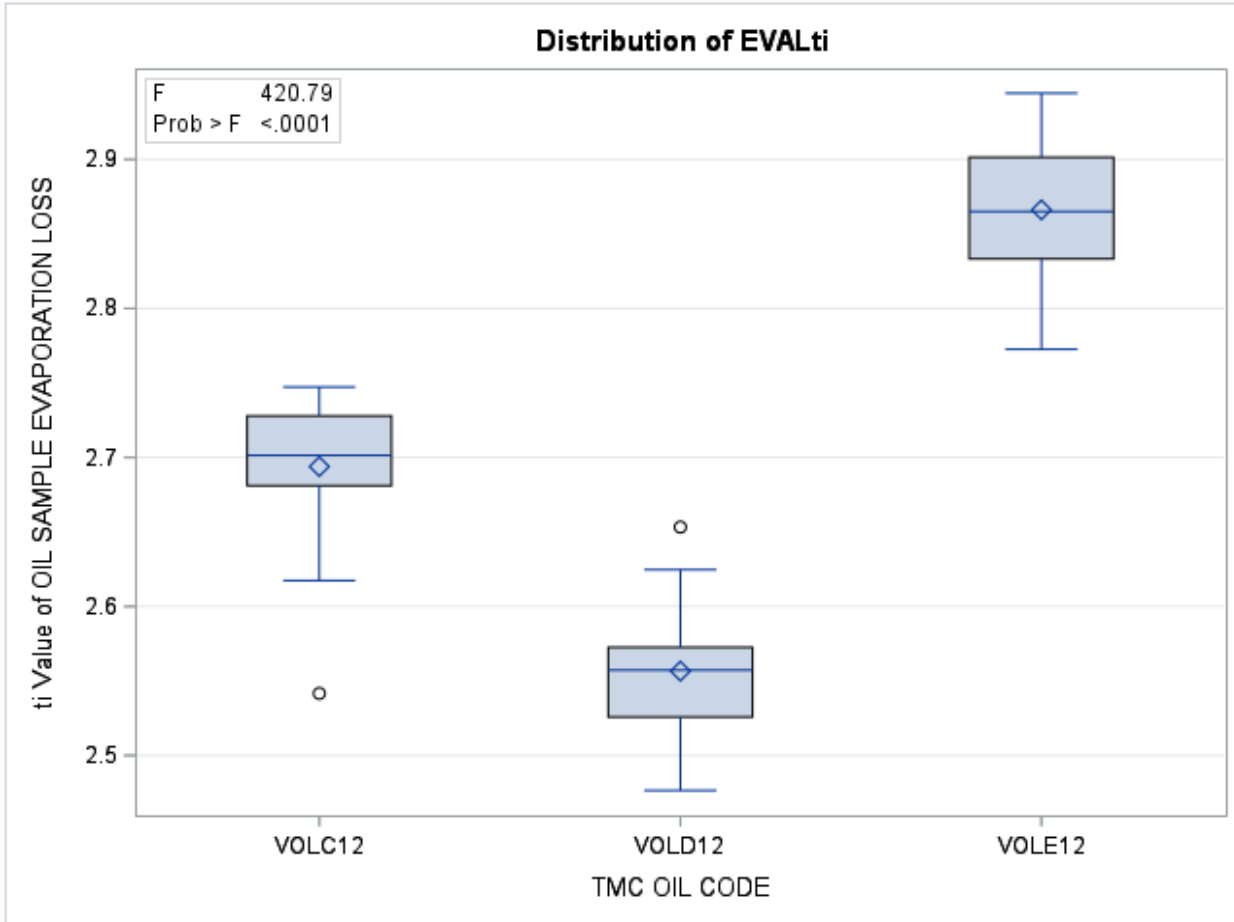
Number of Labs Reporting Data: 10
Fail Rate of Operationally Valid Tests: 4.26%

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Procedure B: OCT2023 – APR2024 Results



October 1, 2023 – March 31, 2024

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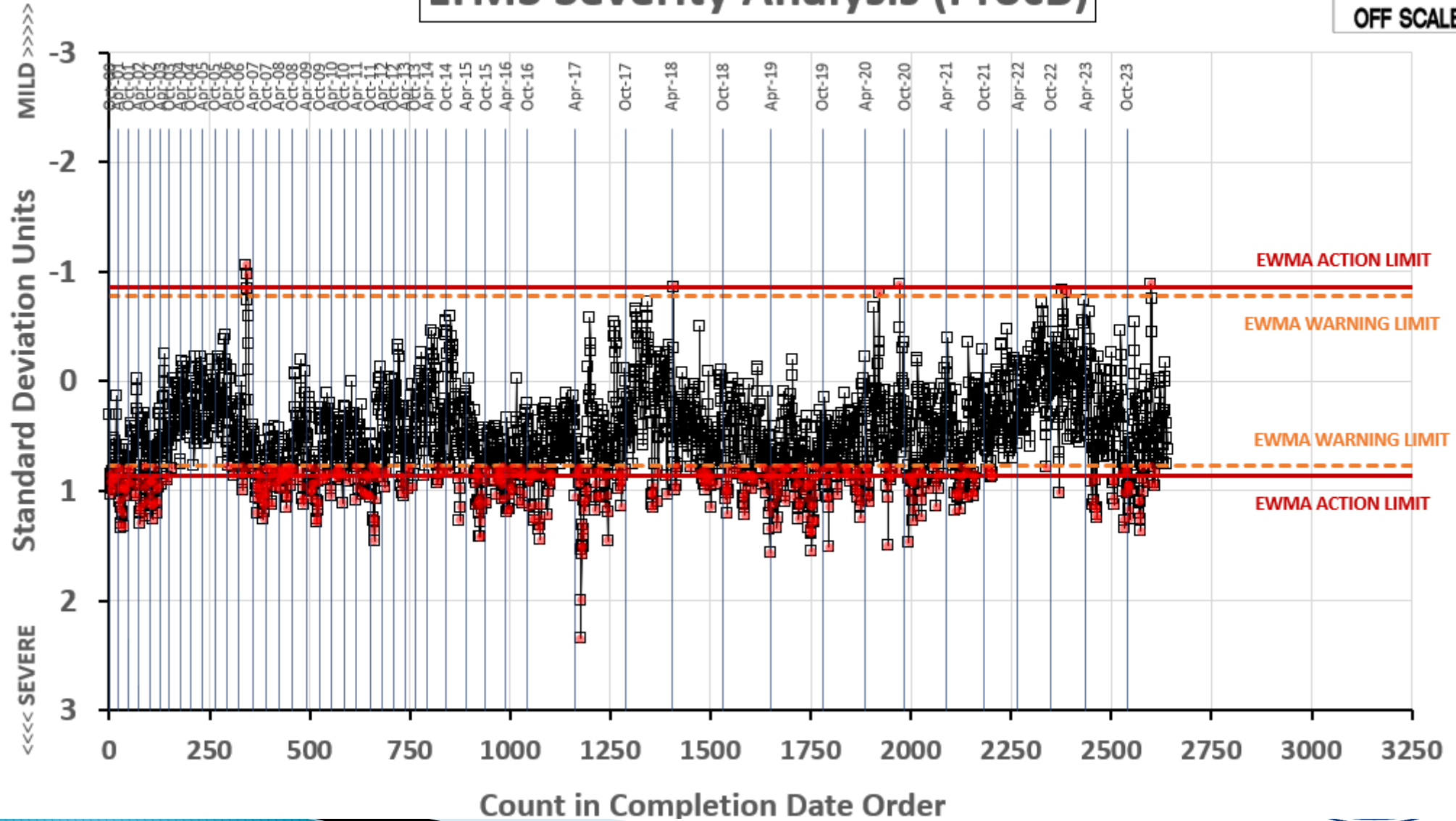
B only

D5800 VOLATILITY BY NOACK INDUSTRY OPERATIONALLY VALID DATA
PROCEDURE B ONLY
EVAPORATION LOSS, MASS%



LTMS Severity Analysis (ProcB)

EWMA 
OFF SCALE 

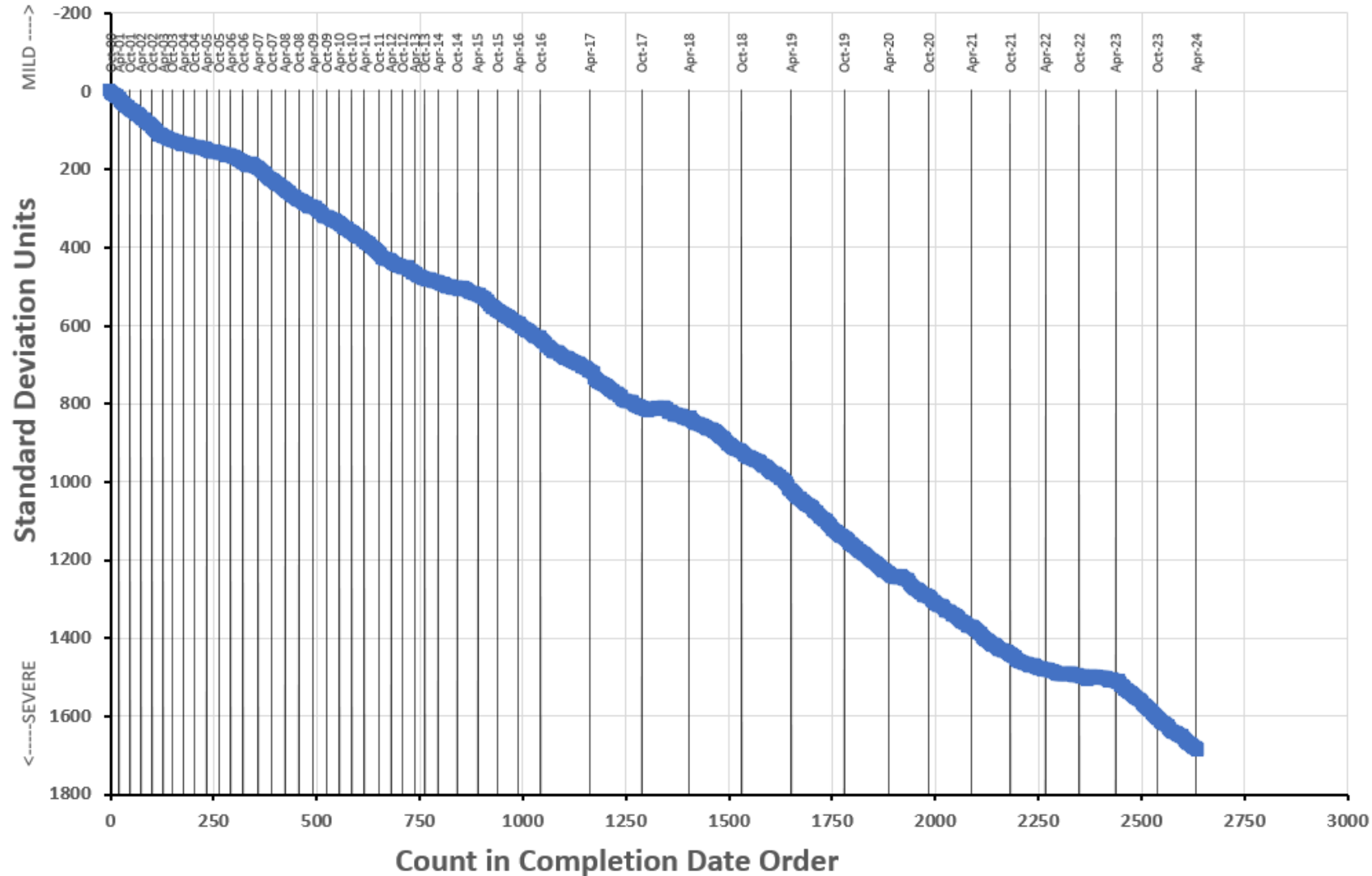


B only

D5800 VOLATILITY BY NOACK INDUSTRY OPERATIONALLY VALID DATA PROCEDURE B ONLY EVAPORATION LOSS, MASS%



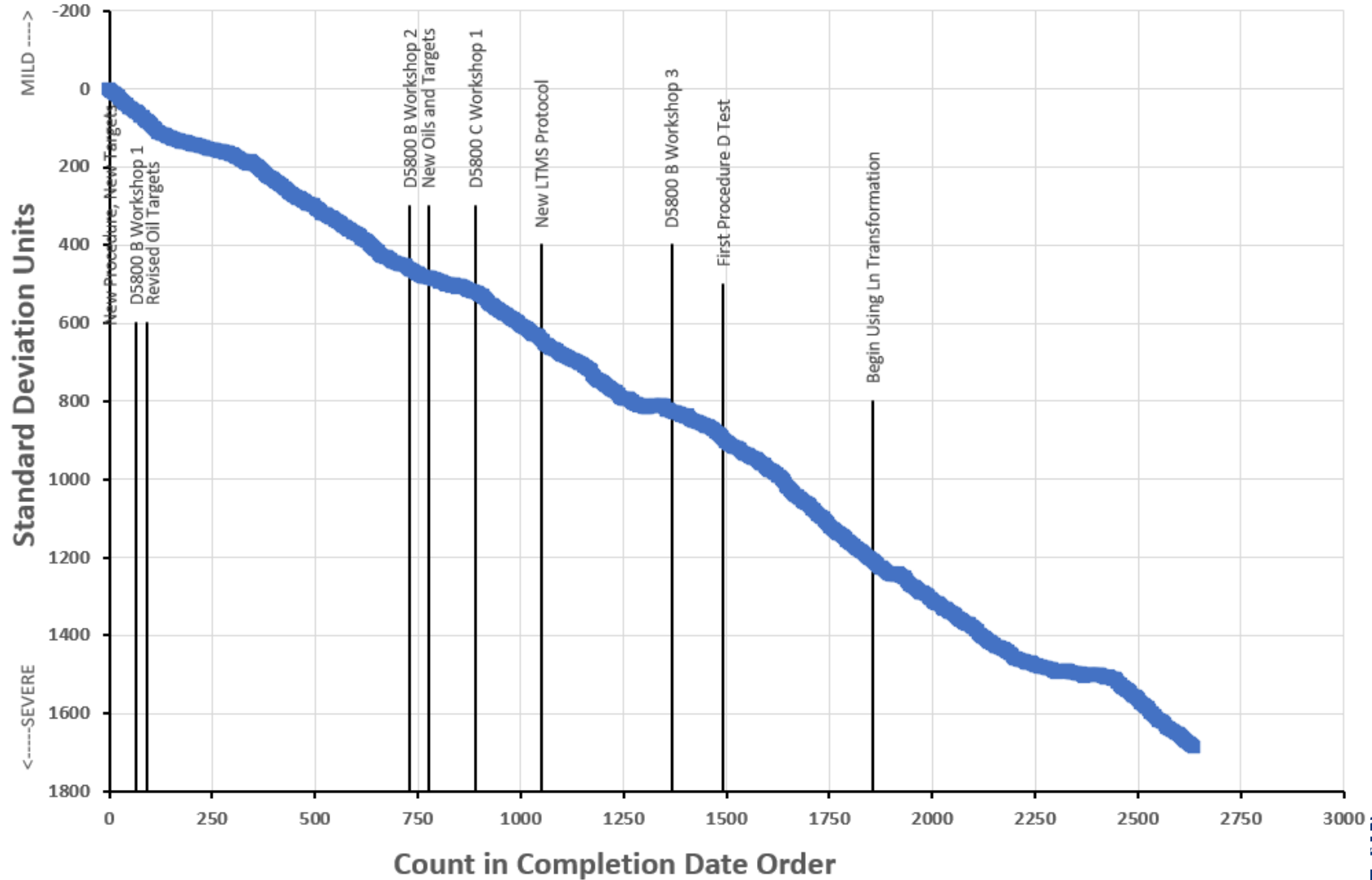
Procedure B CUSUM Severity Analysis



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**D5800 VOLATILITY BY NOACK INDUSTRY OPERATIONALLY VALID DATA
PROCEDURE B ONLY
EVAPORATION LOSS, MASS%**

Procedure B CUSUM Severity Analysis



D5800: Evaporation Loss of Lubricating Oil by Noack Method: Industry Procedure D (NS2)

Test Status	Validity Code	No. Tests
Acceptable Calibration Test	AC	74
Failed Calibration Test	OC	6
Total		80

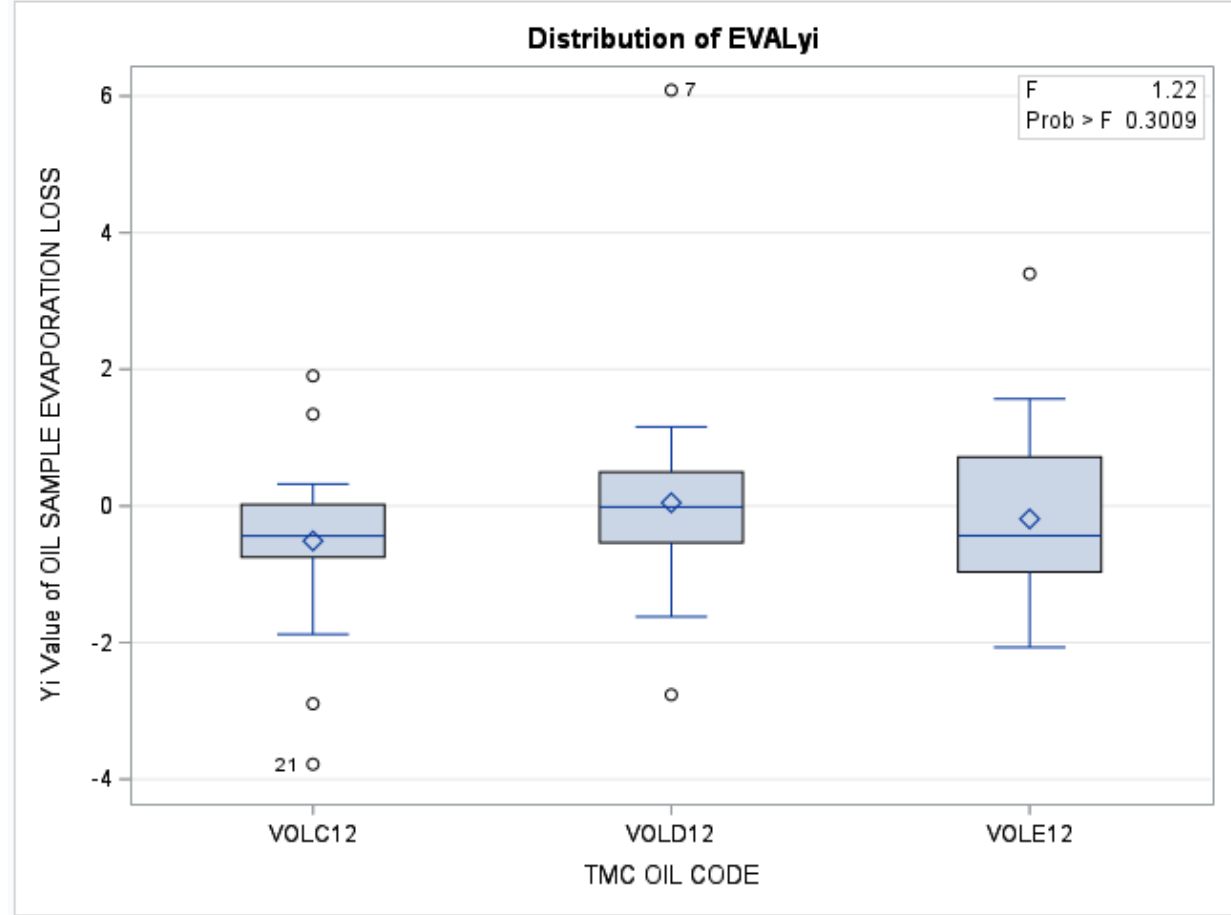
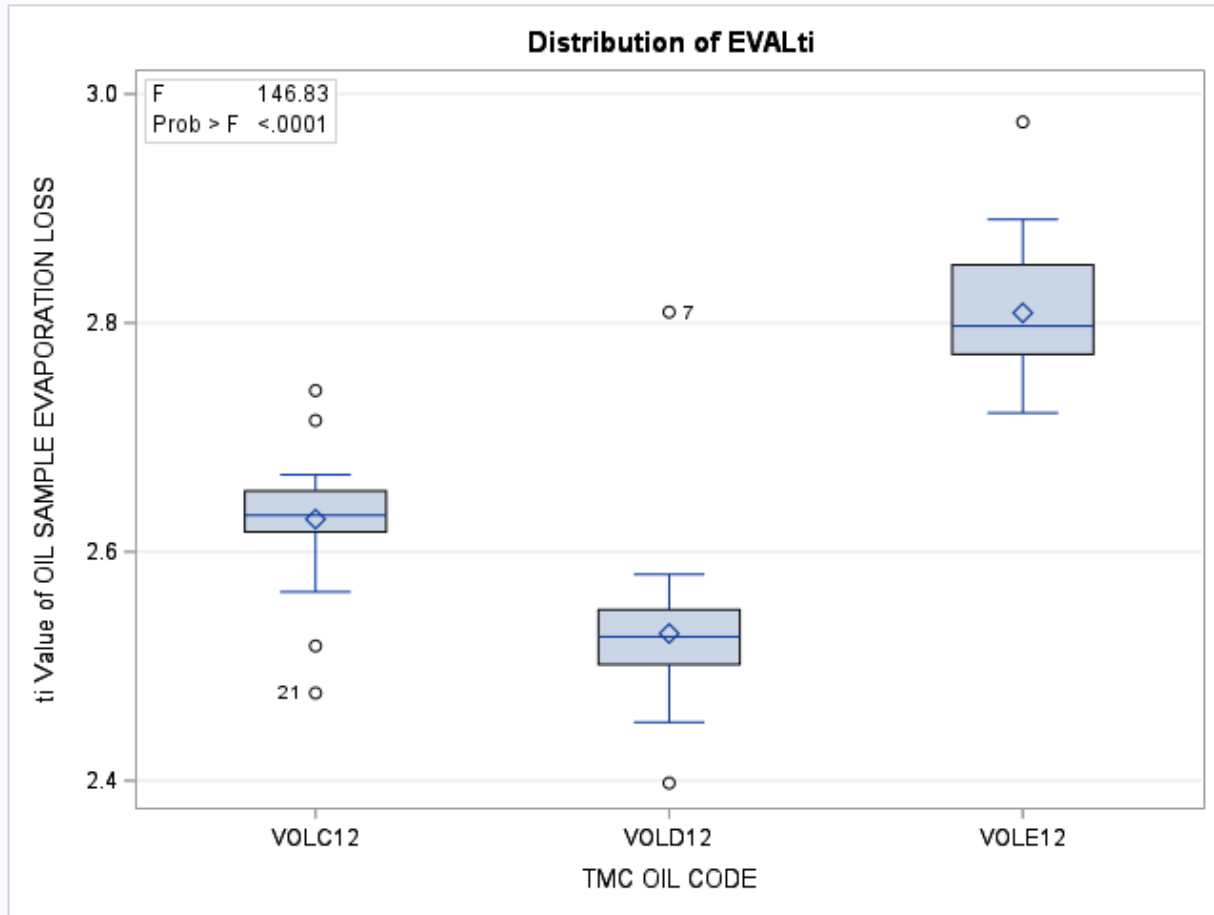
Number of Labs Reporting Data: 6
Fail Rate of Operationally Valid Tests: 7.50%

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Procedure D (NS2): OCT2023 - APR2024 Results



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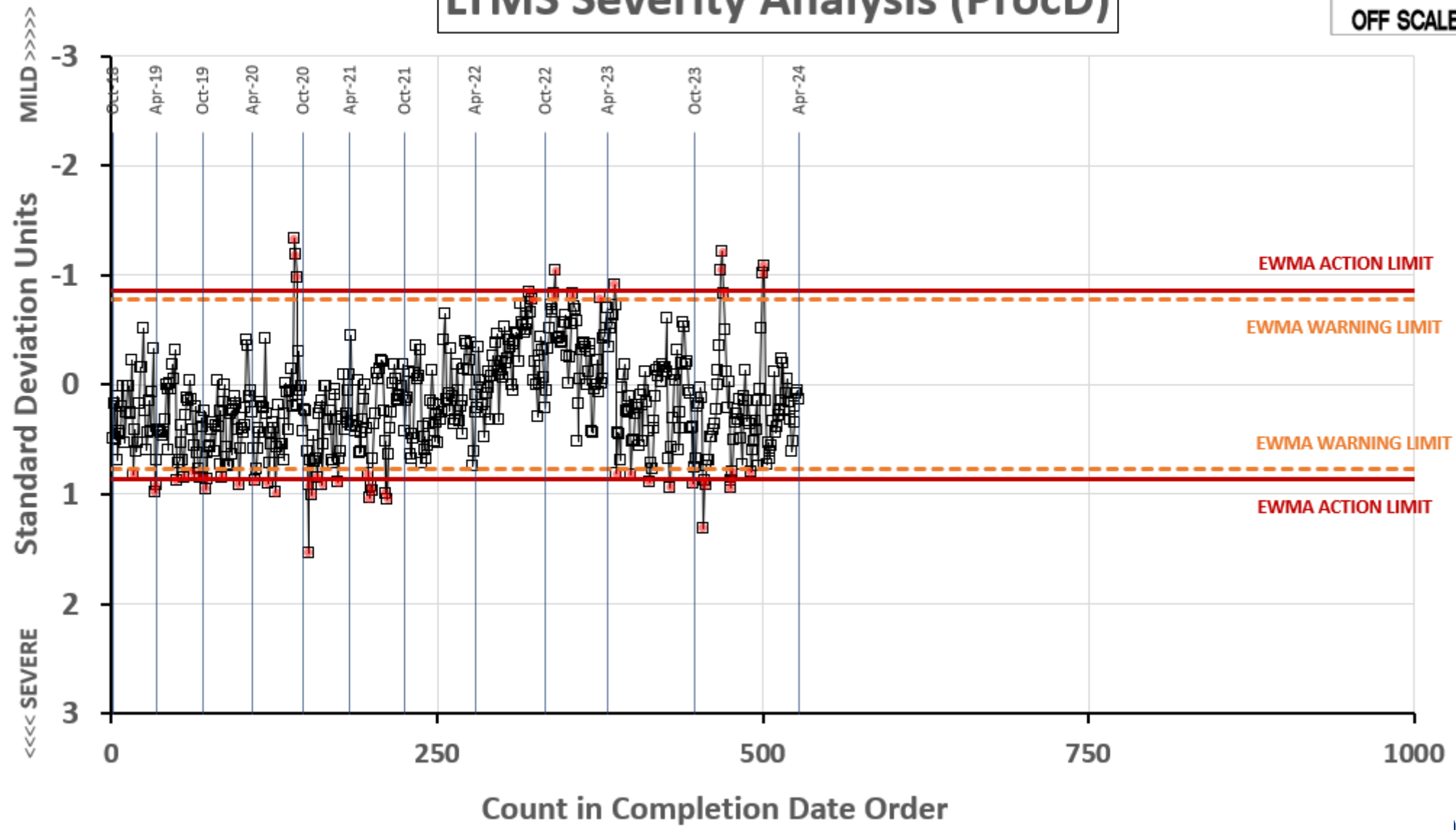
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D only (NS2)

Procedure D Only
EVAPORATION LOSS, MASS%

LTMS Severity Analysis (ProcD)

EWMA	
OFF SCALE	

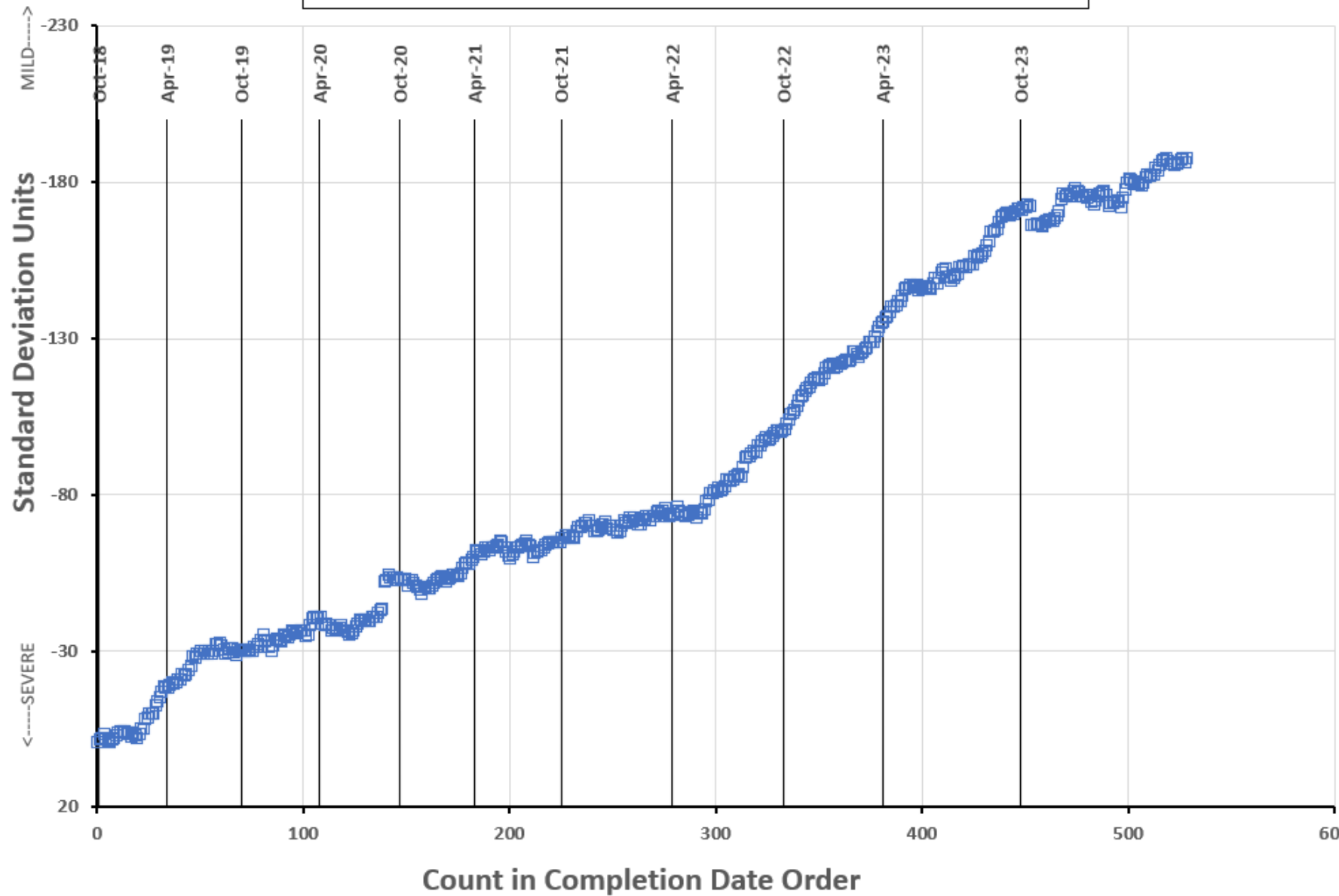


Procedure D Only

D only
(NS2)

Procedure D Only
EVAPORATION LOSS, MASS%

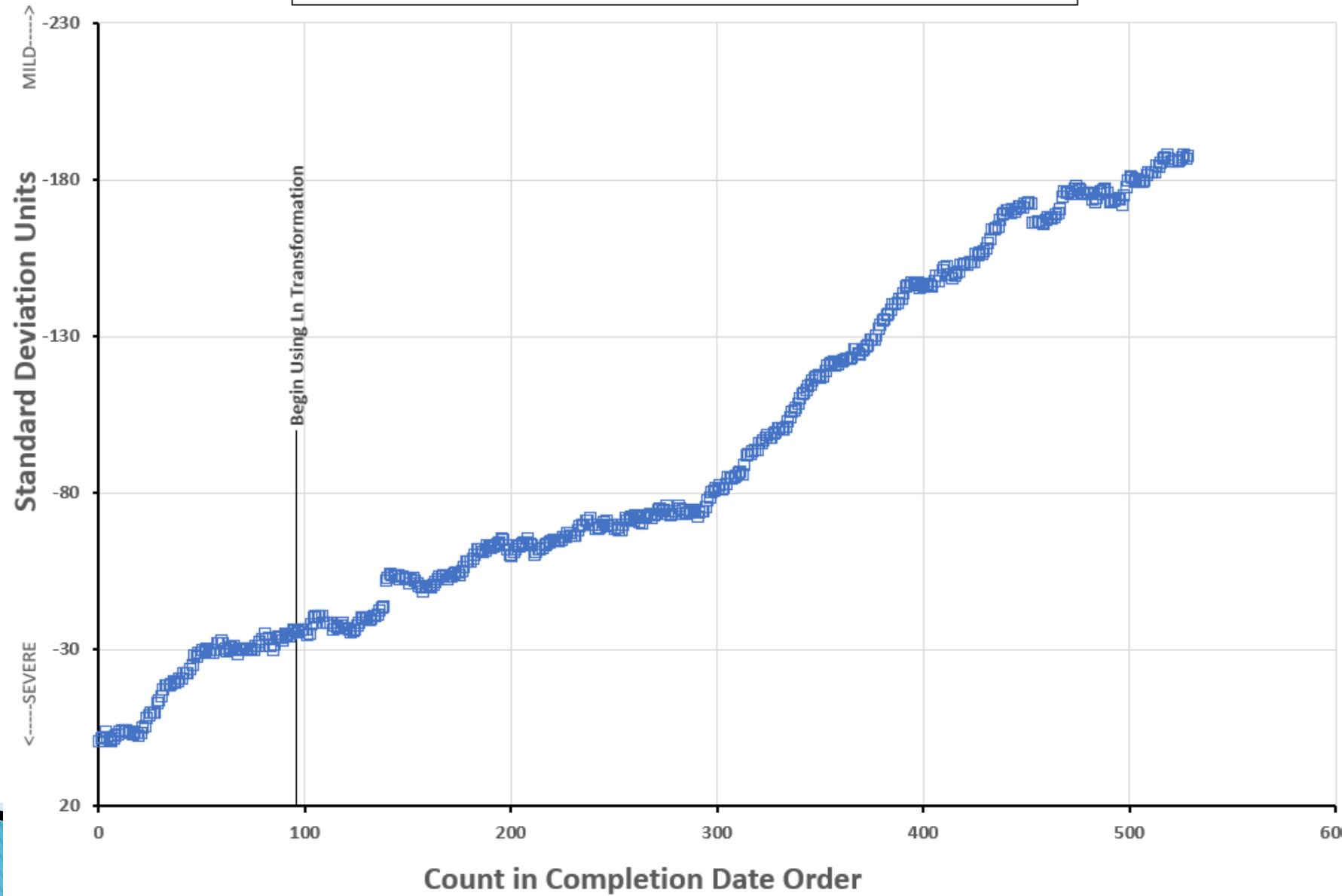
Procedure D CUSUM Severity Analysis



D only
(NS2)

Procedure D Only
EVAPORATION LOSS, MASS%

Procedure D CUSUM Severity Analysis



D5800: Evaporation Loss of Lubricating Oil by Noack Method: Industry Model NCK2

Test Status	Validity Code	No. Tests
Acceptable Calibration Test	AC	6
Failed Calibration Test	OC	0
Total		6

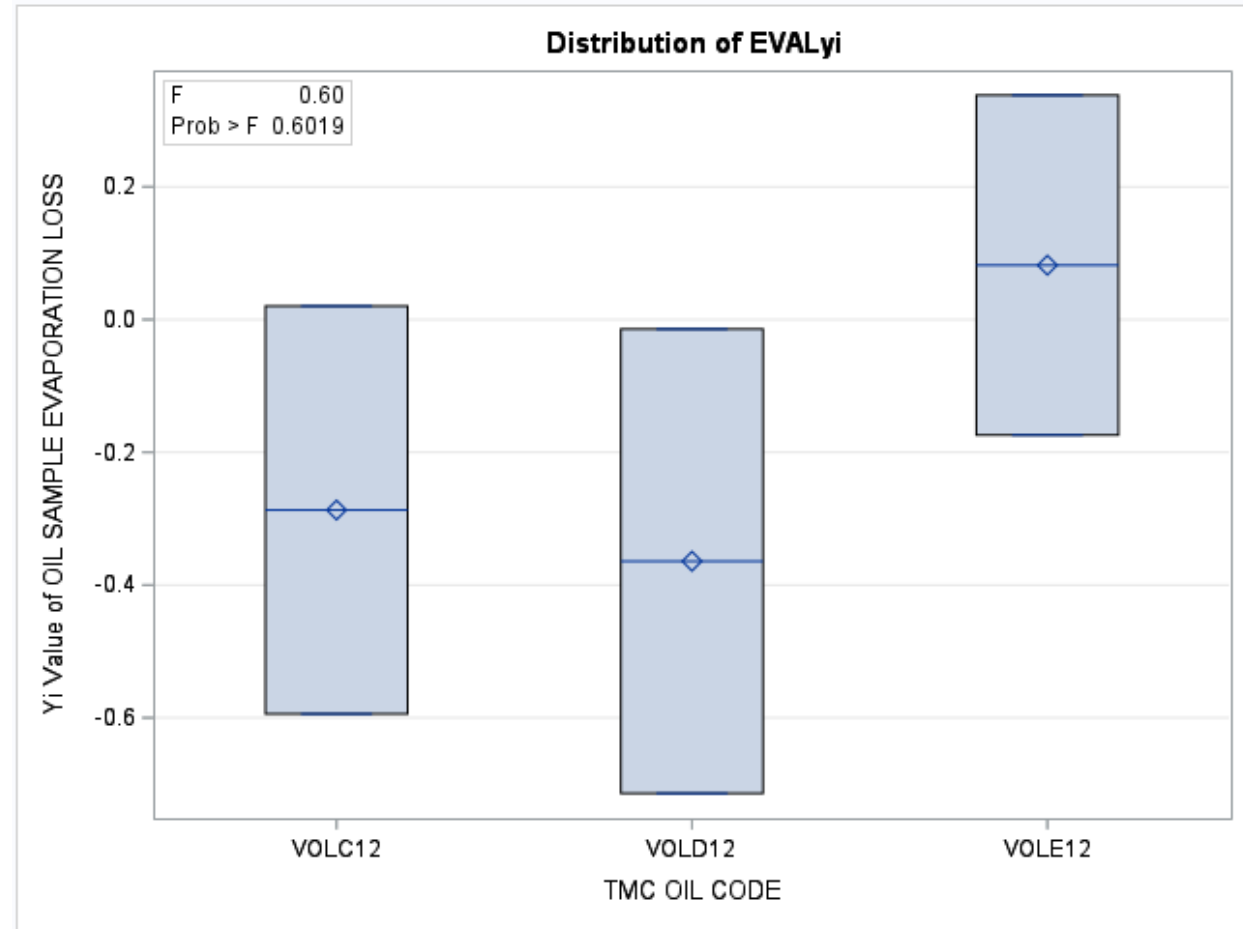
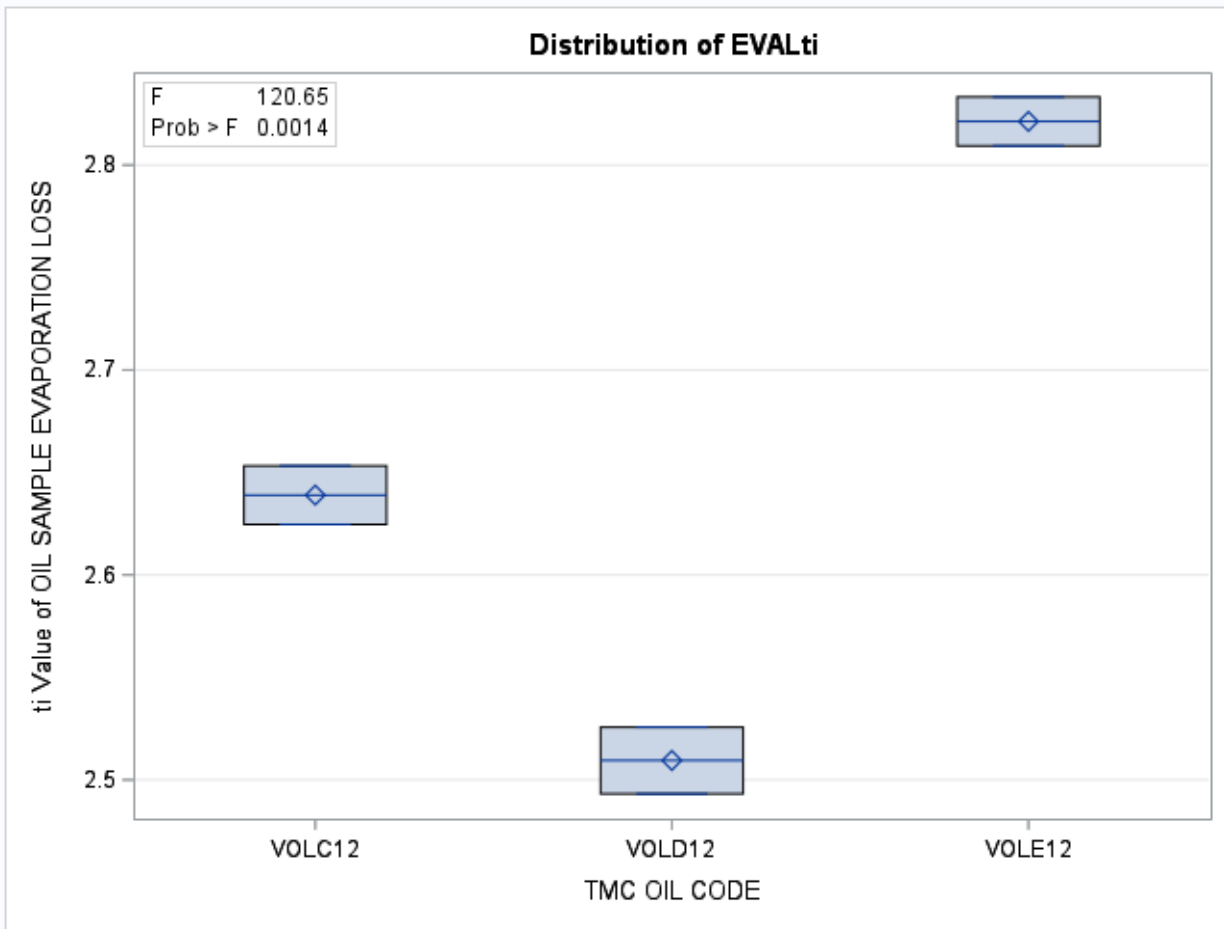
Number of Labs Reporting Data: 1
Fail Rate of Operationally Valid Tests: 0.0 %

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MODEL NCK2: OCT2023 – ARP2024 Results



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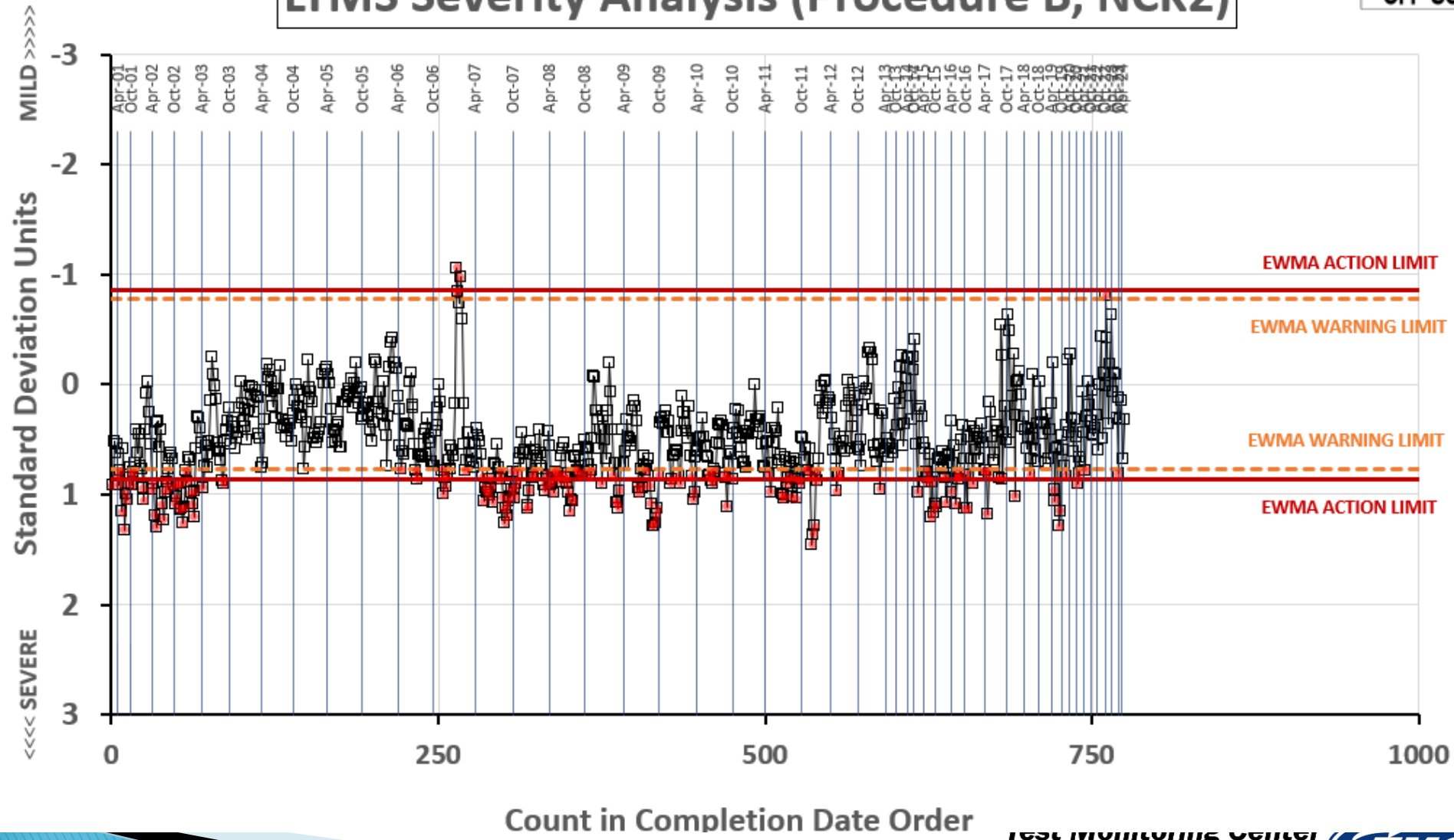


NCK2
 only

LTMS Severity Analysis (Procedure B, NCK2)

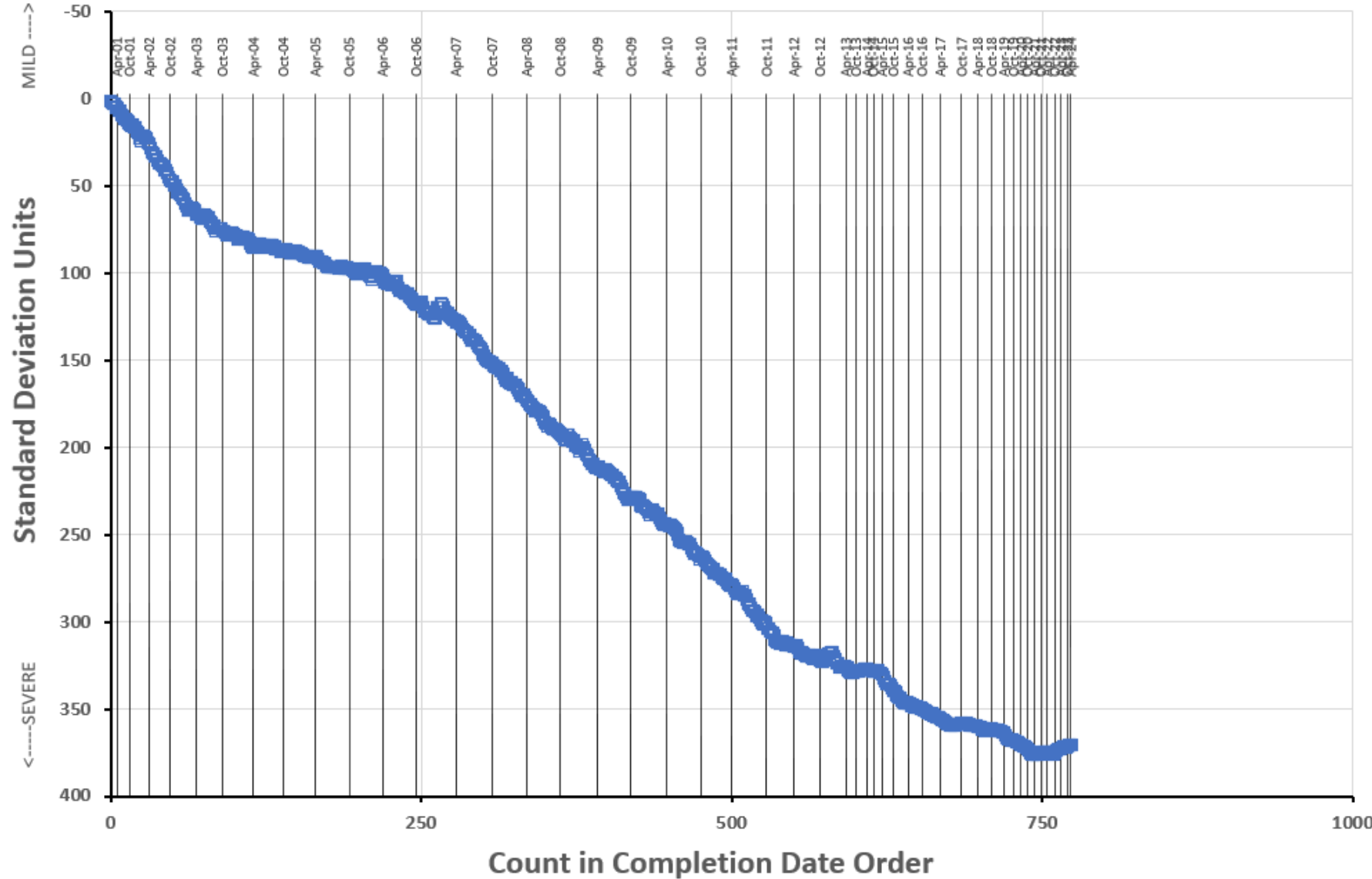
EWMA

OFF SCALE



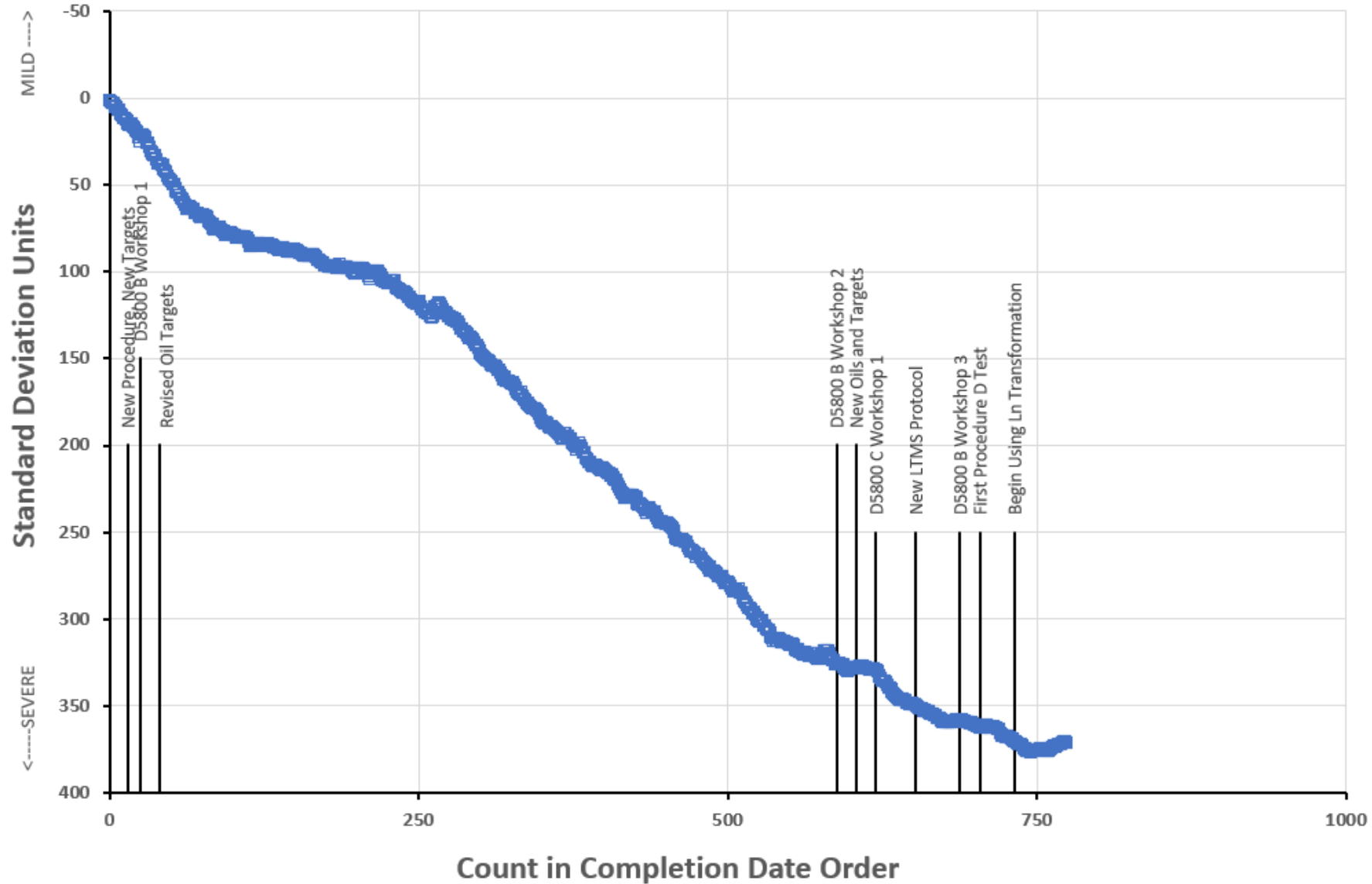
NCK2
only

Procedure B (NCK2) CUSUM Severity Analysis



NCK2
only

Procedure B (NCK2) CUSUM Severity Analysis



D5800: Evaporation Loss of Lubricating Oil by Noack Method: Industry Model NCK25G

Test Status	Validity Code	No. Tests
Acceptable Calibration Test	AC	84
Failed Calibration Test	OC	4
Total		88

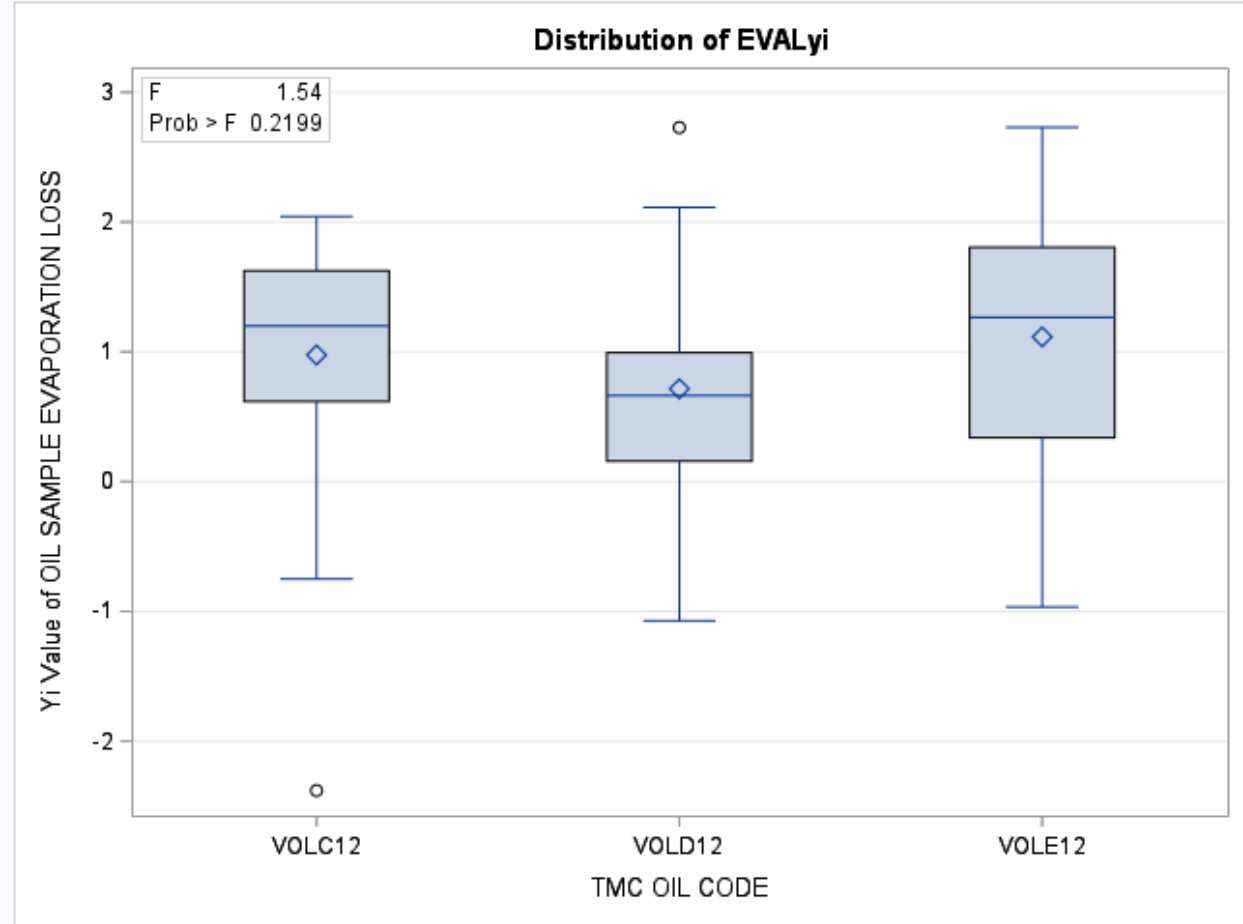
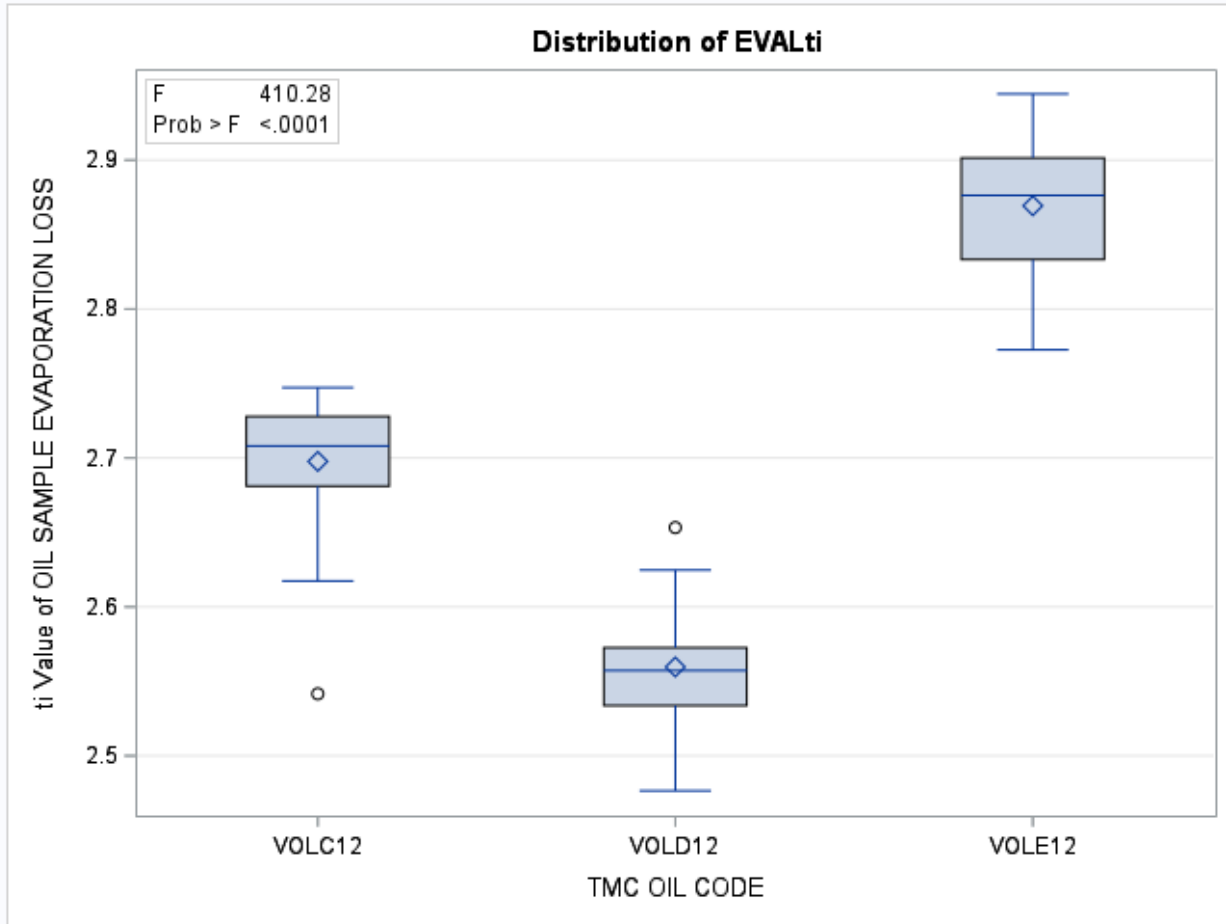
Number of Labs Reporting Data: 10
Fail Rate of Operationally Valid Tests: 4.55%

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MODEL NCK25G: OCT2023 - APR2024 Results



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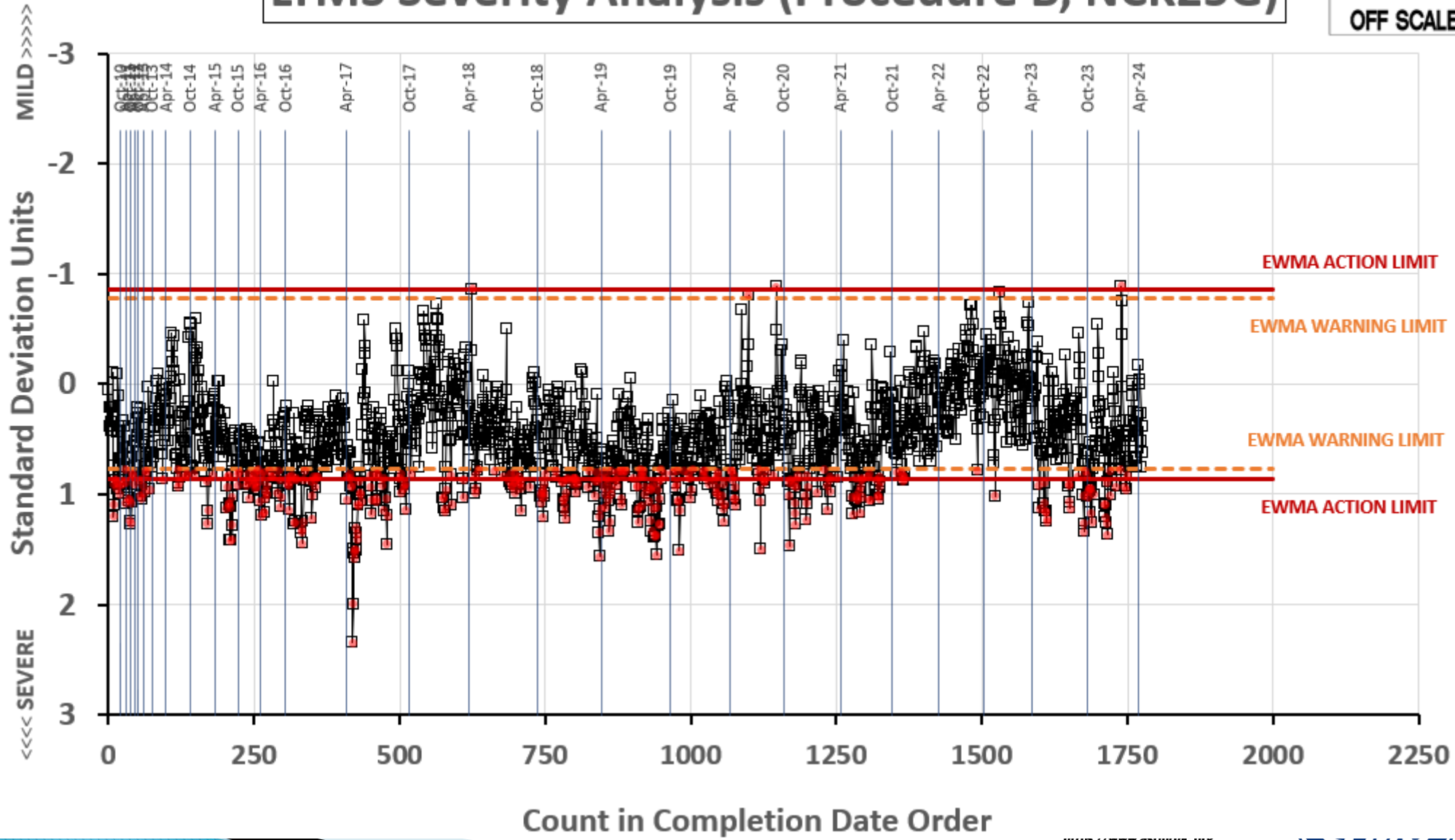
Test Monitoring Center
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NCK25G
only

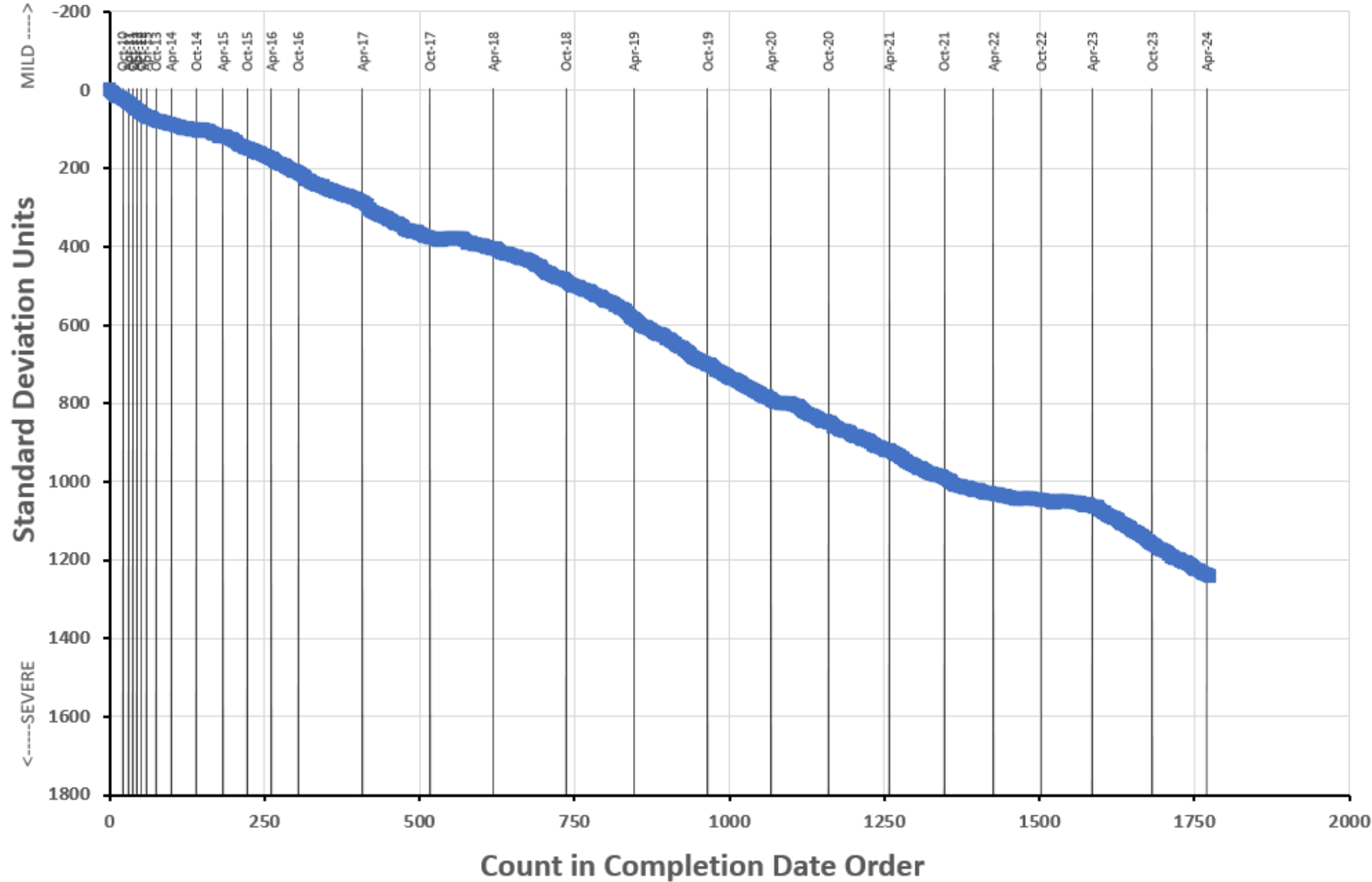
LTMS Severity Analysis (Procedure B, NCK25G)

EWMA 
OFF SCALE 



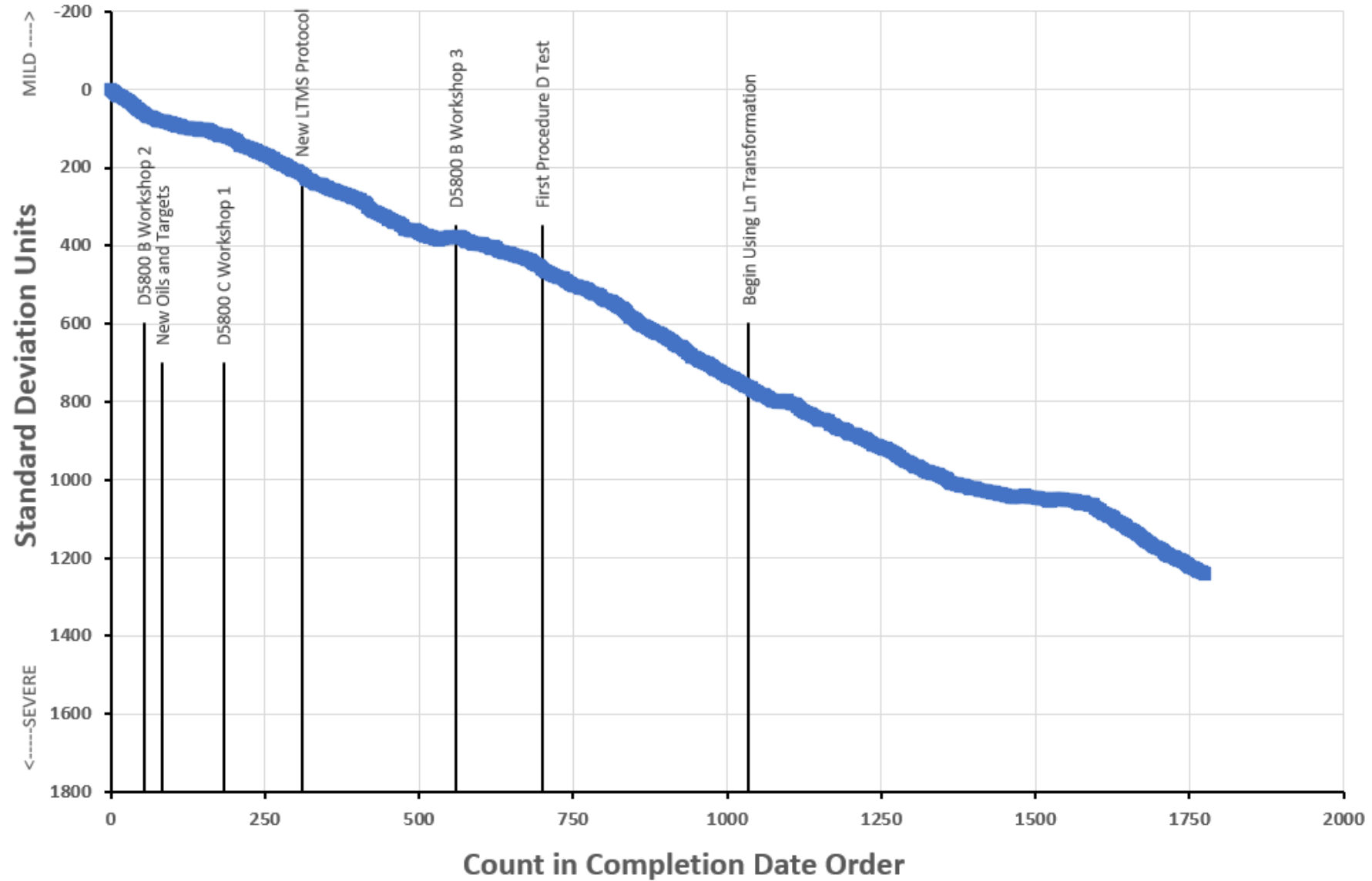
NCK25G
only

Procedure B (NCK25G) CUSUM Severity Analysis



NCK25G
only

Procedure B (NCK25G) CUSUM Severity Analysis



Reference Oil Inventory

D5800

Oil	Year Rec'd By TMC ⁴	Tests	TMC Inventory, gallons	Gallons Shipped last 6 months	Estimated Life
VOLC12	2013	D5800	20.2	1.7	5+ years
VOLD12	2013	D5800	18.2	1.7	5+ years
VOLE12	2013	D5800	16.0	1.8	5+ years
VOLD18	2018	D5800QC	614	8	5+ years

⁴ Integrity of TMC reference oils is confirmed annually by analytical QC testing of chemical and physical properties.

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D5800: Evaporation Loss of Lubricating Oil by Noack Method: Semester Summary

Precision (Pooled s) improved moving slightly towards target this semester.

Performance (Mean Δ/s) continues to be severe at +0.37 s .

- Procedure B rigs continue to trend severe (+0.86 s) while Procedure D rigs continue to trend mild (-0.20 s).

The industry EWMA Control Chart had several Severe Warning Alarms last semester, both Mild and Severe test results.

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D02.B0.07

TMC Monitored Tests



ASTM D 6082

High Temperature Foam

October 1, 2023 – March 31, 2024

Calibrated Labs and Stands*

(change since last Semi-Annual report)

Test	Labs	Stands
D6082	7 (+0)	11 (+3)

*Between 10/1/2023 and 3/31/2024

D6082: High Temperature Foam

Test Status	Validity Code	No. Tests
Acceptable Calibration Test	AC	18
Failed Calibration Test	OC	1
Acceptable Discrimination Test	AS	8
Operationally Invalid, Reported as Valid	RC, RS	0
Operationally Invalid, Reported by Lab	LC, LS	0
Informational Run (Valid)	NN	0
Aborted Tests	XC, XS	0
Total		27

Number of Labs Reporting Data: 7
Fail Rate of Operationally Valid Calibration Tests: 5.2%

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D6082: High Temperature Foam

Statistically Unacceptable Tests (OC, OS)	No. Of Tests
Foam Tendency Mild	1
Foam Tendency Severe	0
Total	1

- All severe oil discrimination runs (on TMC oil 66) reported this period demonstrated acceptable discrimination.
 - Discrimination runs are not evaluated for overall period precision or severity due to poor test precision above 100 ml foam tendency.
- There was ONE statistically unacceptable results this report period.

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D6082: High Temperature Foam

Operationally Unacceptable Tests (RS, LC, LS, XC, XS)	No. Of Tests
Total	0

- There were ZERO operationally invalid results this report period.

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D6082: High Temperature Foam

Informational Runs (MN, NN)	No. Of Tests
Non-blind Informational run on-target and valid (NN)	0
Non-blind Informational run invalid (MN)	0
Total	0

- There were no Informational results this report period.

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D6082: High Temperature Foam

Period Precision and Severity Estimates

Foam Tendency, ml	n	df	Pooled s	Mean Δ/s
Targets updated 20201001 ¹	18	17	9	-----
10/1/18 through 3/31/19	14	13	12	-0.07
4/1/19 through 9/30/19	14	12	12	-0.18
10/1/19 through 3/31/20	15	13	10	-0.23
4/1/20 through 9/30/20	13	11	8	-0.85
10/1/20 through 3/31/21	12	10	7	-0.48
4/1/21 through 9/30/21	14	13	7	-0.48
10/1/21 through 3/31/22	13	12	7	-0.57
4/1/22 through 9/30/22	15	14	4	-0.52
10/1/22 through 3/31/23	16	15	10	-0.69
4/1/23 through 9/30/23	14	13	4	-0.68
10/1/23 through 3/31/24	19	18	10	-0.62

¹Target precision updated to current reference oil FOAMB18

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D6082: High Temperature Foam

Period Precision and Severity Estimates

Foam Stability @ 1 min, ml	n	Mean	s
Current Targets	18	0.00	0.00
4/1/19 through 9/30/19	14	No non-zero occurrences	
10/1/19 through 3/31/20	15	No non-zero occurrences	
4/1/20 through 9/30/20	13	No non-zero occurrences	
10/1/20 through 3/31/21	12	No non-zero occurrences	
4/1/21 through 9/30/21	14	No non-zero occurrences	
10/1/21 through 3/31/22	13	No non-zero occurrences	
4/1/22 through 9/30/22	15	No non-zero occurrences	
10/1/22 through 3/31/23	16	No non-zero occurrences	
4/1/23 through 9/30/23	14	No non-zero occurrences	
10/1/23 through 3/31/24	19	No non-zero occurrences	

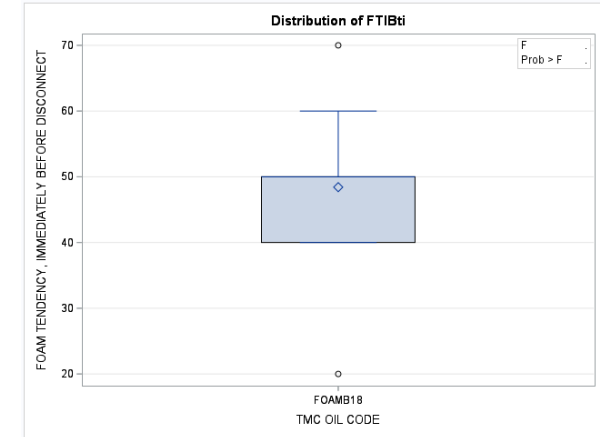
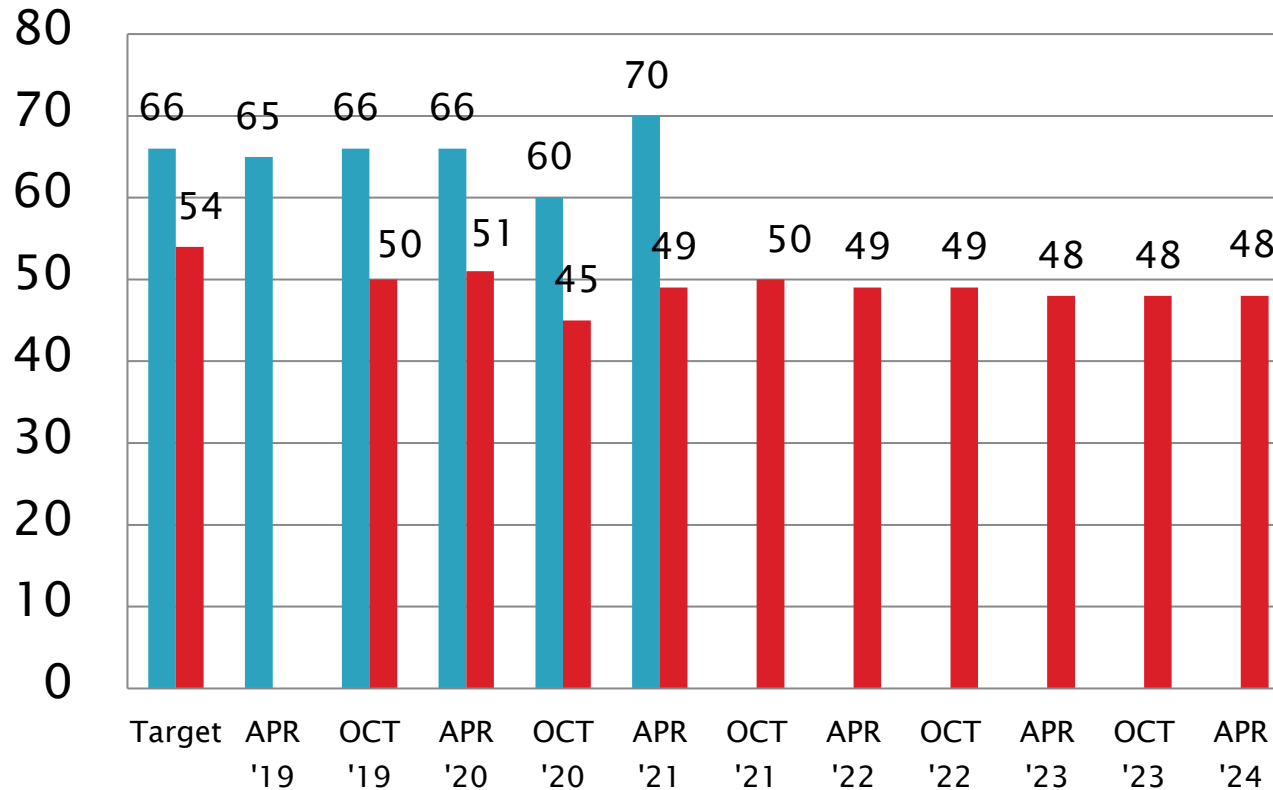
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D6082 Performance by Oil

Foam Tendency, ml
Mean



Oil 1007
Oil FOAMB18

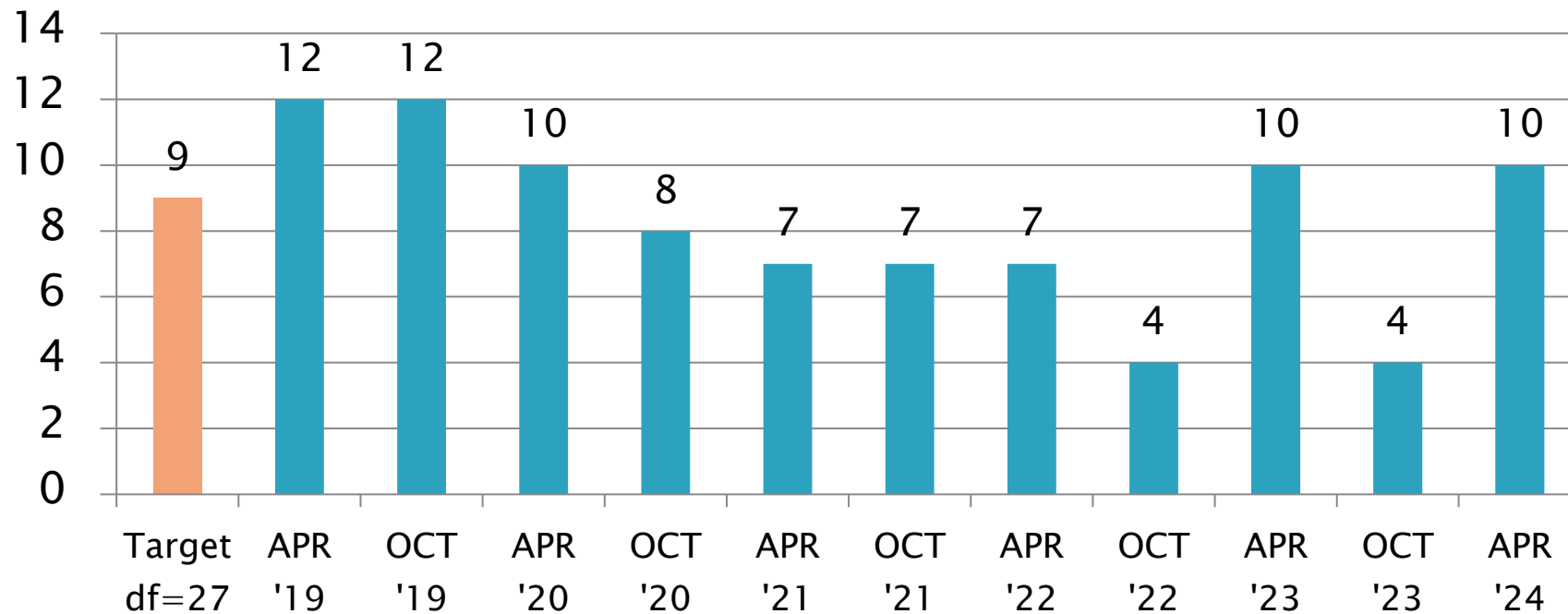
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D6082: High Temperature Foam

Foam Tendency, ml
Pooled s



October 1, 2023 - March 31, 2024

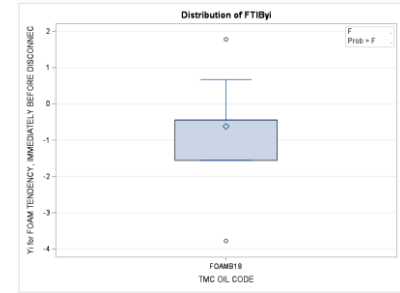
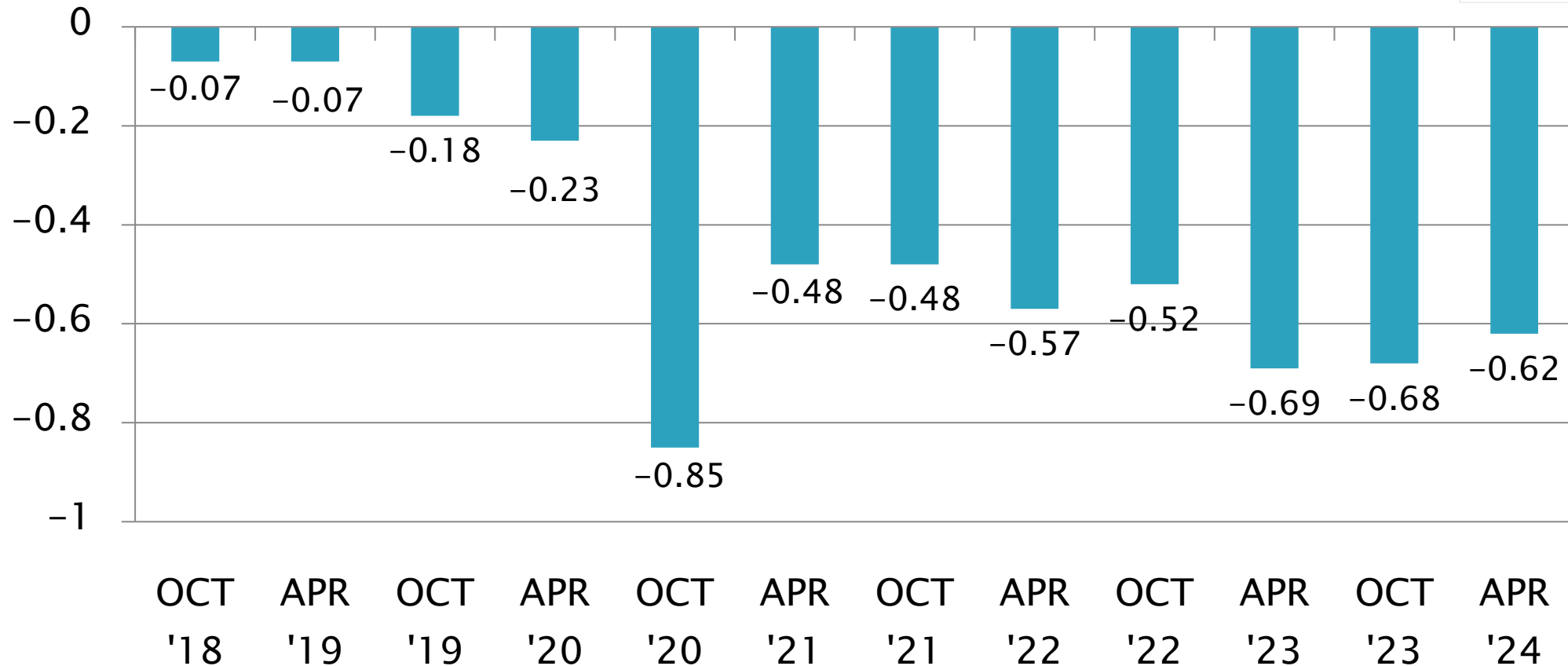
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D6082: High Temperature Foam

Foam Tendency, ml
Mean Δ/s



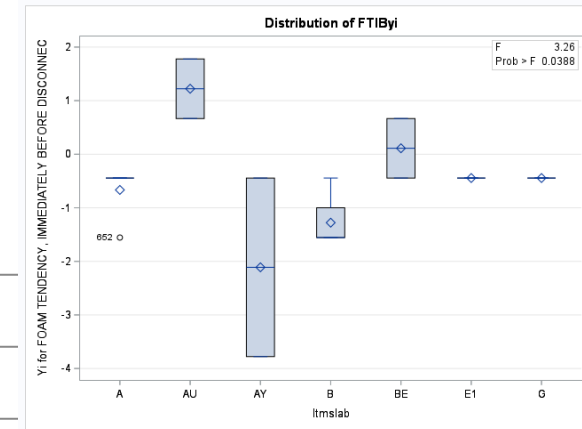
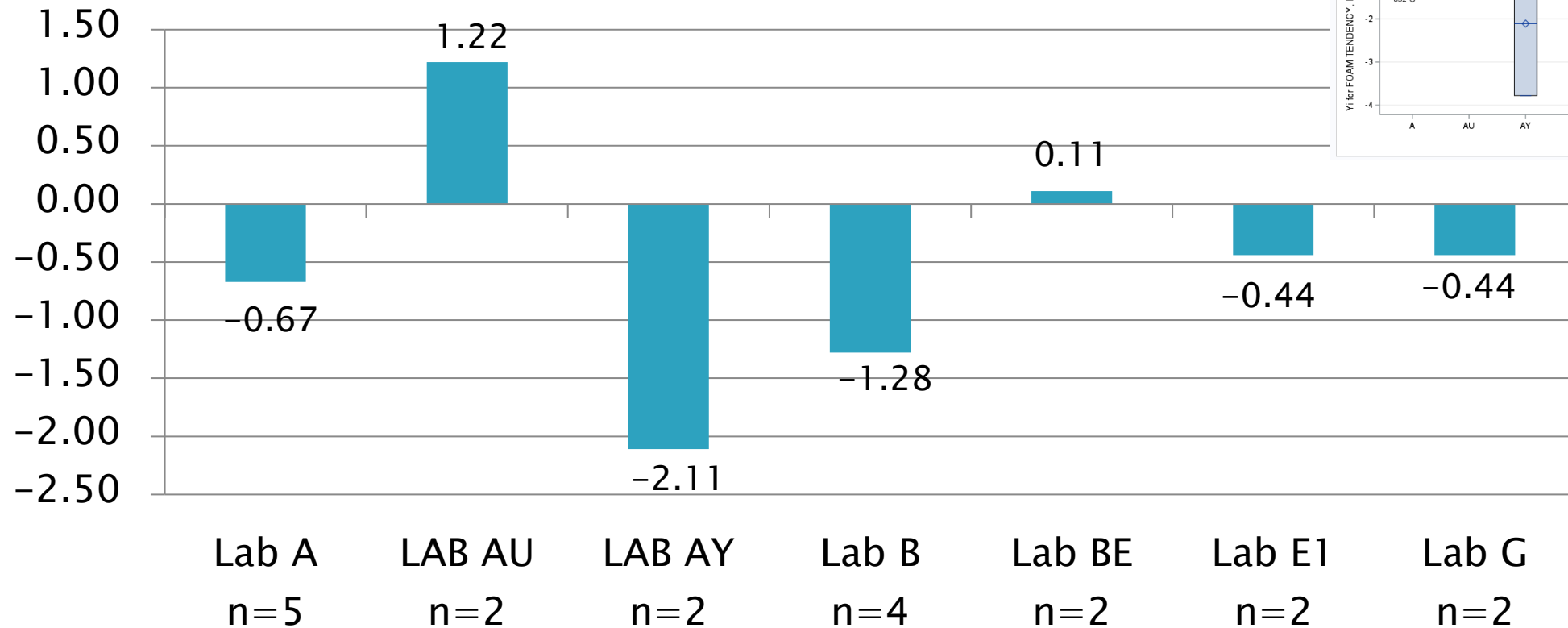
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D6082: High Temperature Foam

Current Period Severity Estimates by Lab
Foam Tendency, ml



October 1, 2023 - March 31, 2024

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D6082: High Temperature Foam

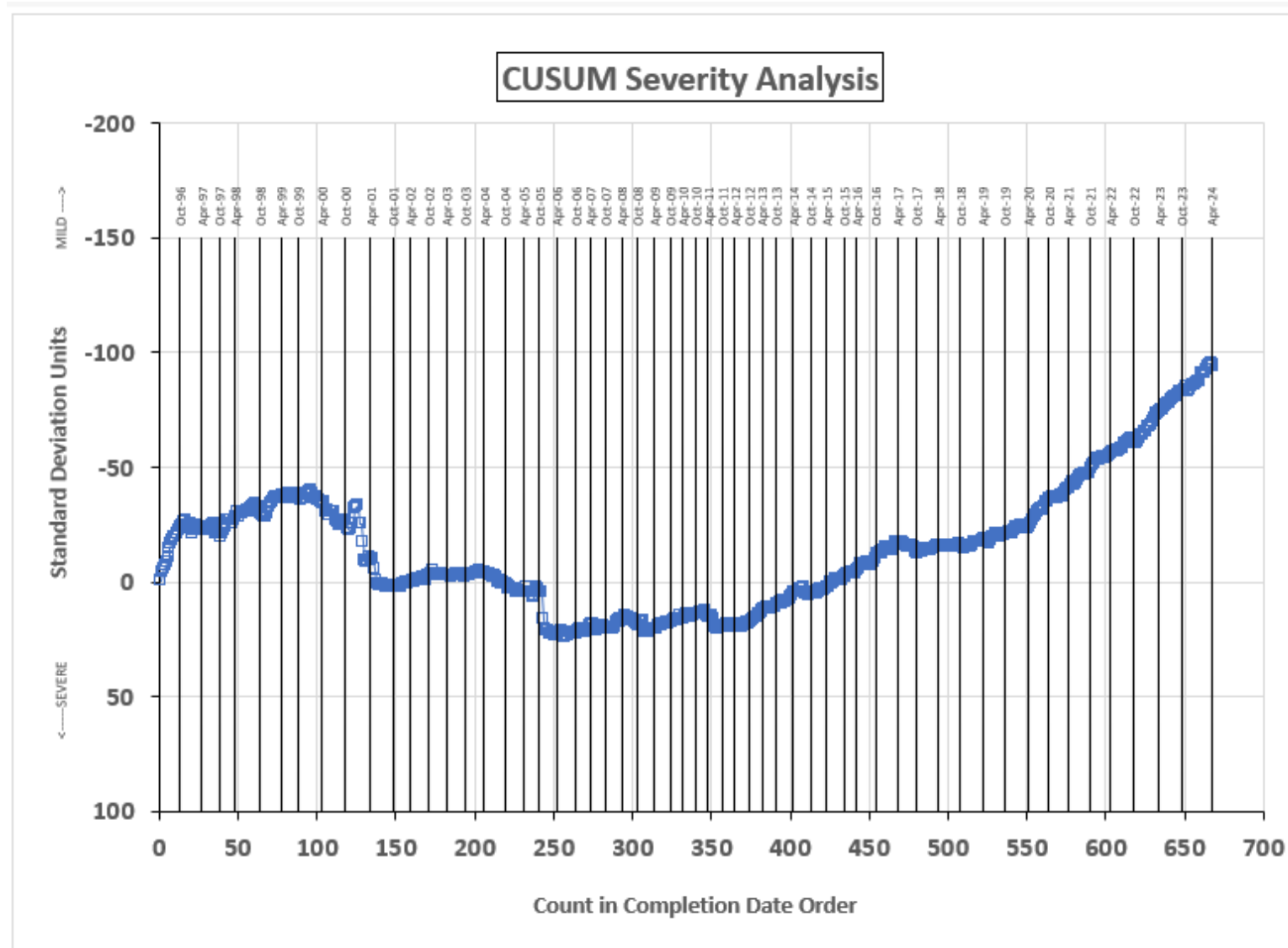
- ▶ Foam Tendency Precision (Pooled s) has fallen back to 10 this semester but remains close to target (9).
- ▶ Performance (Mean Δ/s) remains mild at -0.62 s and constant with last semester (-0.68 s)
 - Sixth consecutive period of $-0.5+$ s mild performance with FOAMB18.
 - Target performance, set on 18 runs in a RR, may need revisited.
- ▶ No non-zero occurrences of Foam Stability
- ▶ All EIGHT severe oil discrimination runs (on TMC oil 66) demonstrated acceptable discrimination on foam tendency (>100 ml).

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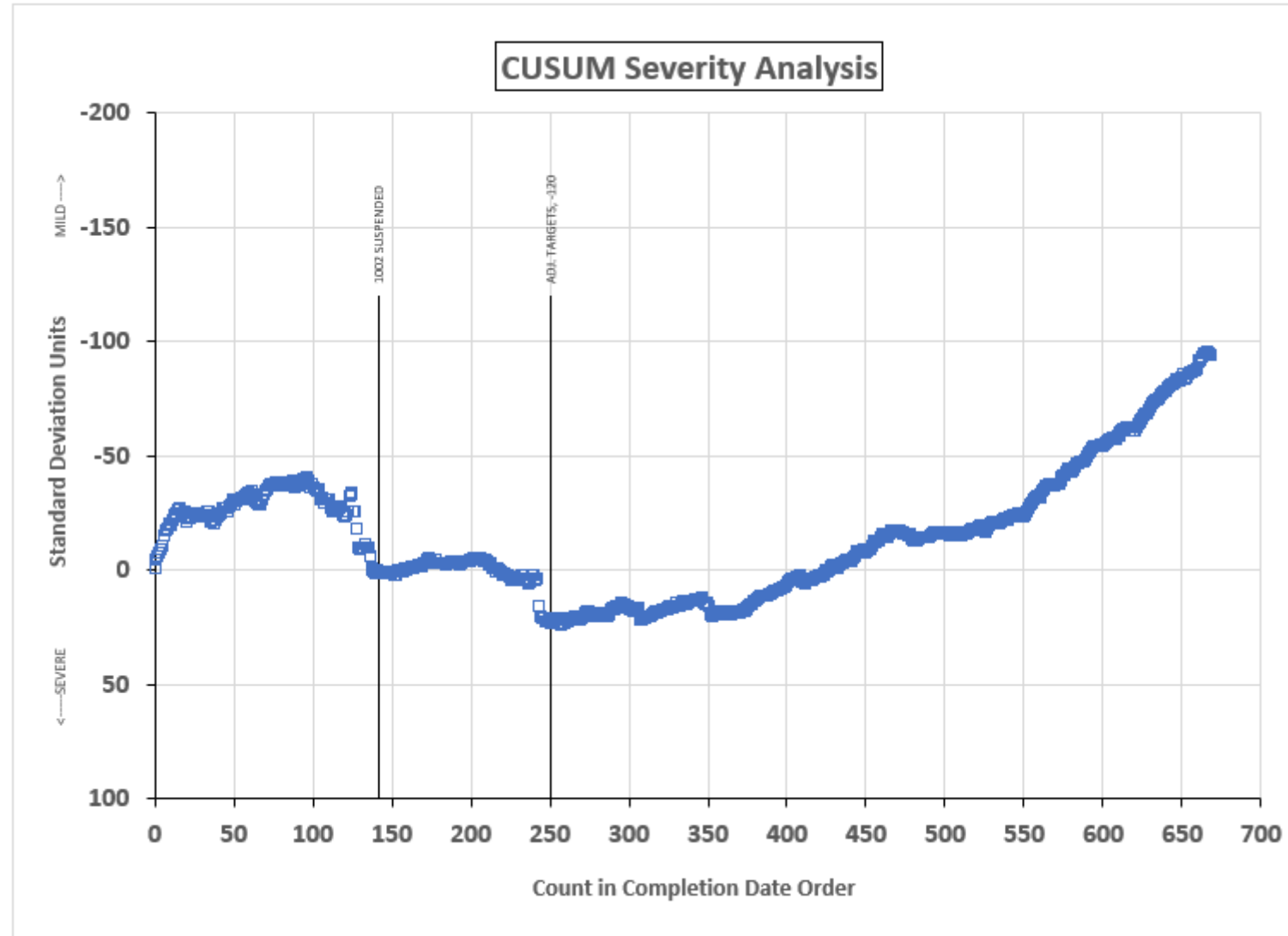
Test Monitoring Center
<https://www.astmtmc.org>



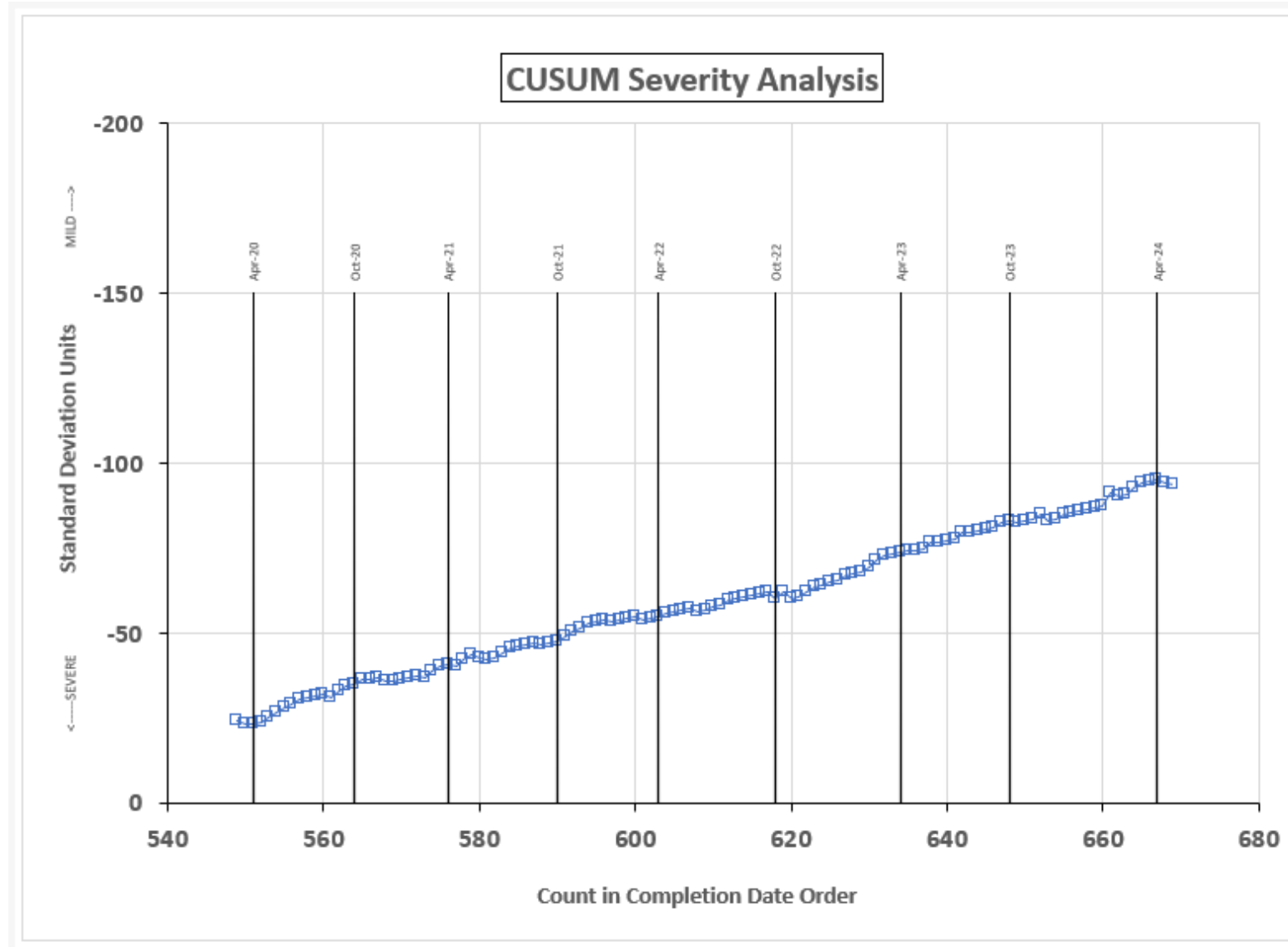
FOAM TENDENCY



FOAM TENDENCY



Last 120 Data Points
FOAM TENDENCY



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Reference Oil Inventory

D6082

Oil	Year Rec'd By TMC ^A	Tests	TMC Inventory, gallons	Gallons Shipped last 6 months	Estimated Life
FOAMB18	2018	D6082	71.06	1.2	5+ years
66	2002	D6082	67.70	0.55	5+ years

^A Integrity of TMC reference oils is confirmed annually by analytical QC testing of chemical and physical properties.

^B D874QC Samples (1L sizes) could quickly deplete Reference Oil 90 availability.

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D02.B0.07 TMC Monitored Tests



ASTM D 6335

TEOST

October 1, 2023 – March 31, 2024

Calibrated Labs and Stands*

(change since last Semi-Annual report)

Test	Labs	Stands
D6335	9 (+0)	14 (+1)

*As of 3/31/2024

D6335: Deposits by TEOST-33C

Test Status	Validity Code	No. Tests
Acceptable Calibration Tests	AC	26
Failed Calibration Tests	OC	8
Operationally Invalidated by Lab	LC	1
Total		35

Number of Labs Reporting Data: 9 (9 Labs Last Period)
Fail Rate of Operationally Valid Tests: 23.5% (13.3% Last Period)

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D6335: Deposits by TEOST-33C

Statistically Unacceptable Tests (OC)	No. Of Tests
Total Deposits Severe	7
Total Deposits Mild	1
Total	8
Operationally Invalid Tests (LC, RC, XC)	No. Of Tests
Thermocouple Issue	1
Total	1

- EIGHT statistically failing calibration runs this semester
 - ONE mild results, both on RO 75-1
 - SEVEN severe results; 6 with RO 435-2, 1 with RO 75-1 (three different labs)
- One operationally invalid test reported this period.
 - Discovered issue with Thermocouple after the test completed.
- No new Information Letters or Memos in the last semester.

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D6335: Deposits by TEOST-33C

Period Precision and Severity Estimates

Total Deposits, mg	n	df	Pooled s	Mean Δ/s
Updated Targets 20201001 ¹	46	44	4.85	-----
10/1/19 through 3/31/20	32	30	6.08	0.28
4/1/20 through 9/30/20 ²	33	30	11.44	0.02
4/1/20 through 9/30/20 ²	26	23	10.10	-0.02
10/1/20 through 3/31/21	26	23	8.39	0.42
4/1/21 through 9/30/21	31	28	8.27	-0.36
10/1/21 through 3/31/22	27	25	6.22	0.55
4/1/22 through 9/30/22	29	27	10.32	0.80
10/1/22 through 3/31/23	35	33	8.53	0.84
4/1/23 through 9/30/23	30	28	6.57	0.03
10/1/23 through 3/31/23	34	32	6.19	0.63

¹Target precision updated to include only current oils 75-1 and 435-2

²Rig with six OC results included and excluded.

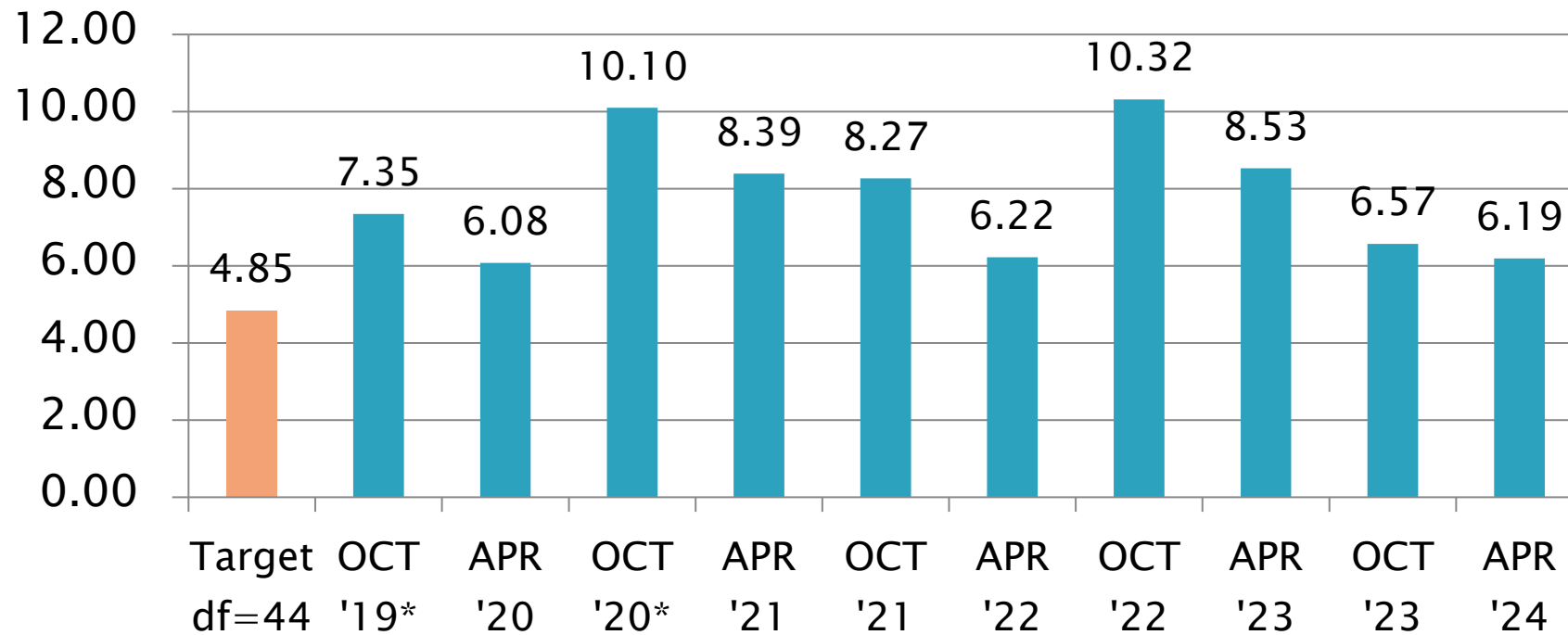
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D6335 Precision Estimates

Total Deposits, mg Pooled s



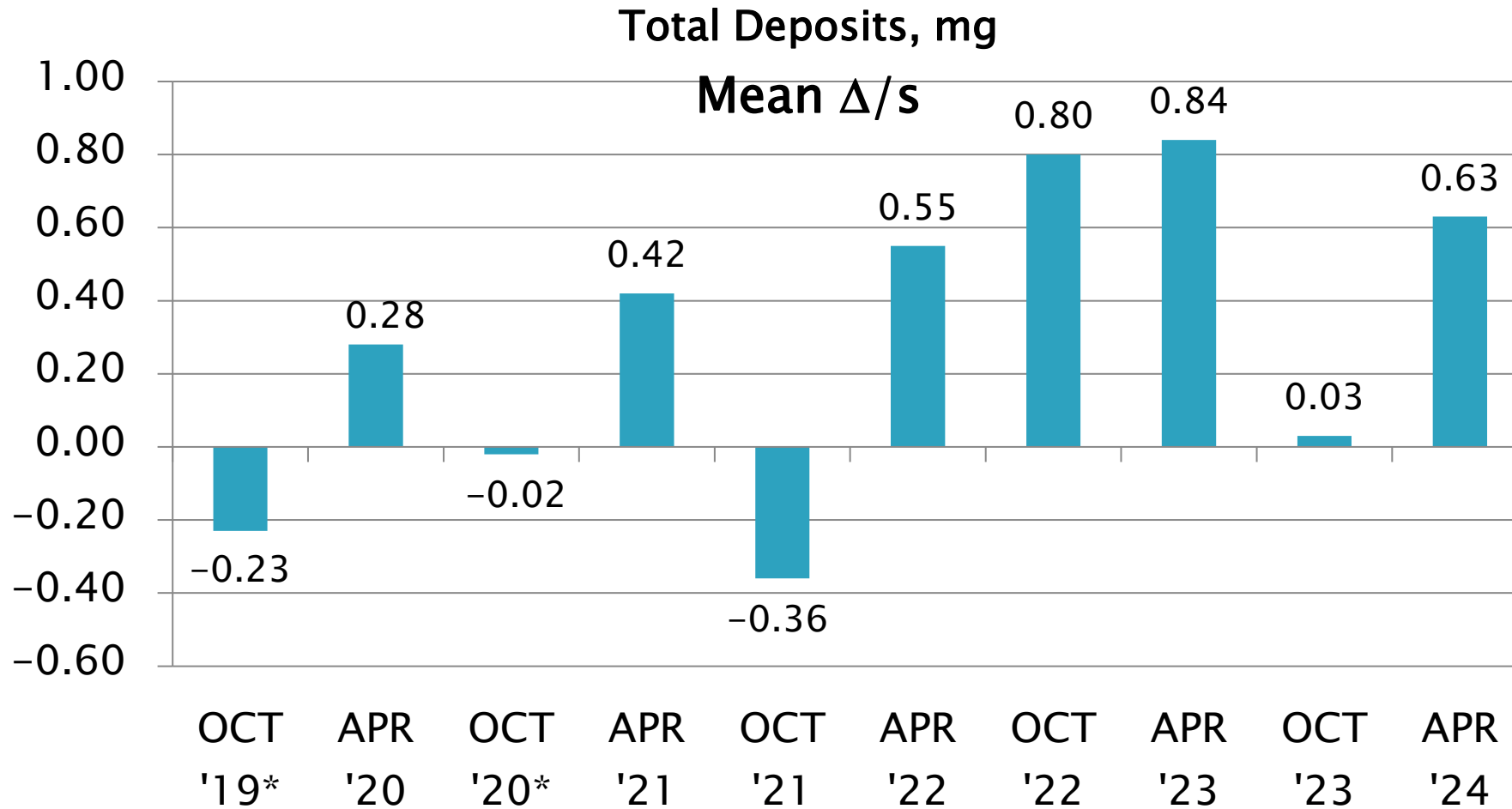
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D6335 Severity Estimates



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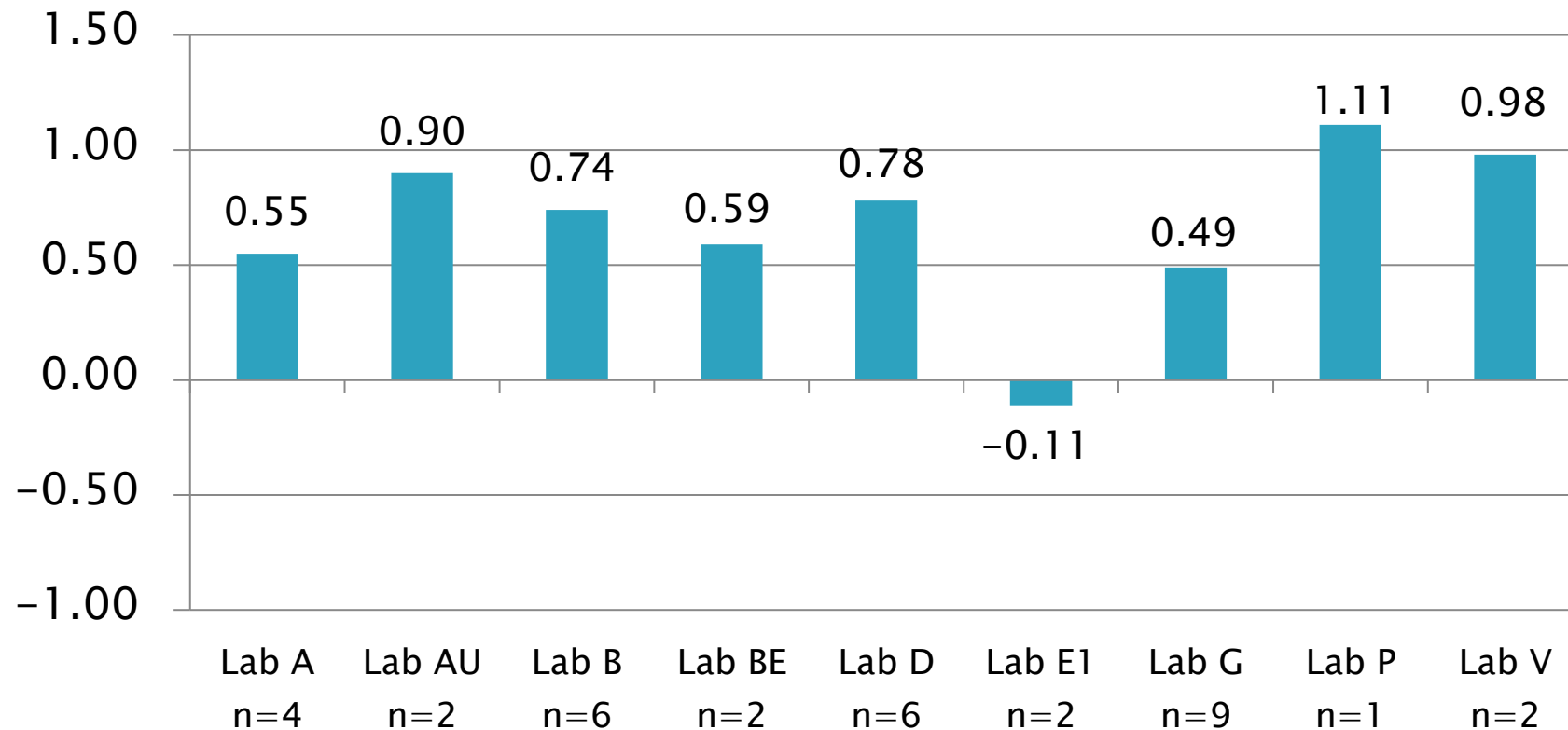
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D6335 Lab Severity Estimates

Total deposits, mg

Mean Δ/s



October 1, 2023 - March 31, 2024

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D6335: Deposits by TEOST-33C

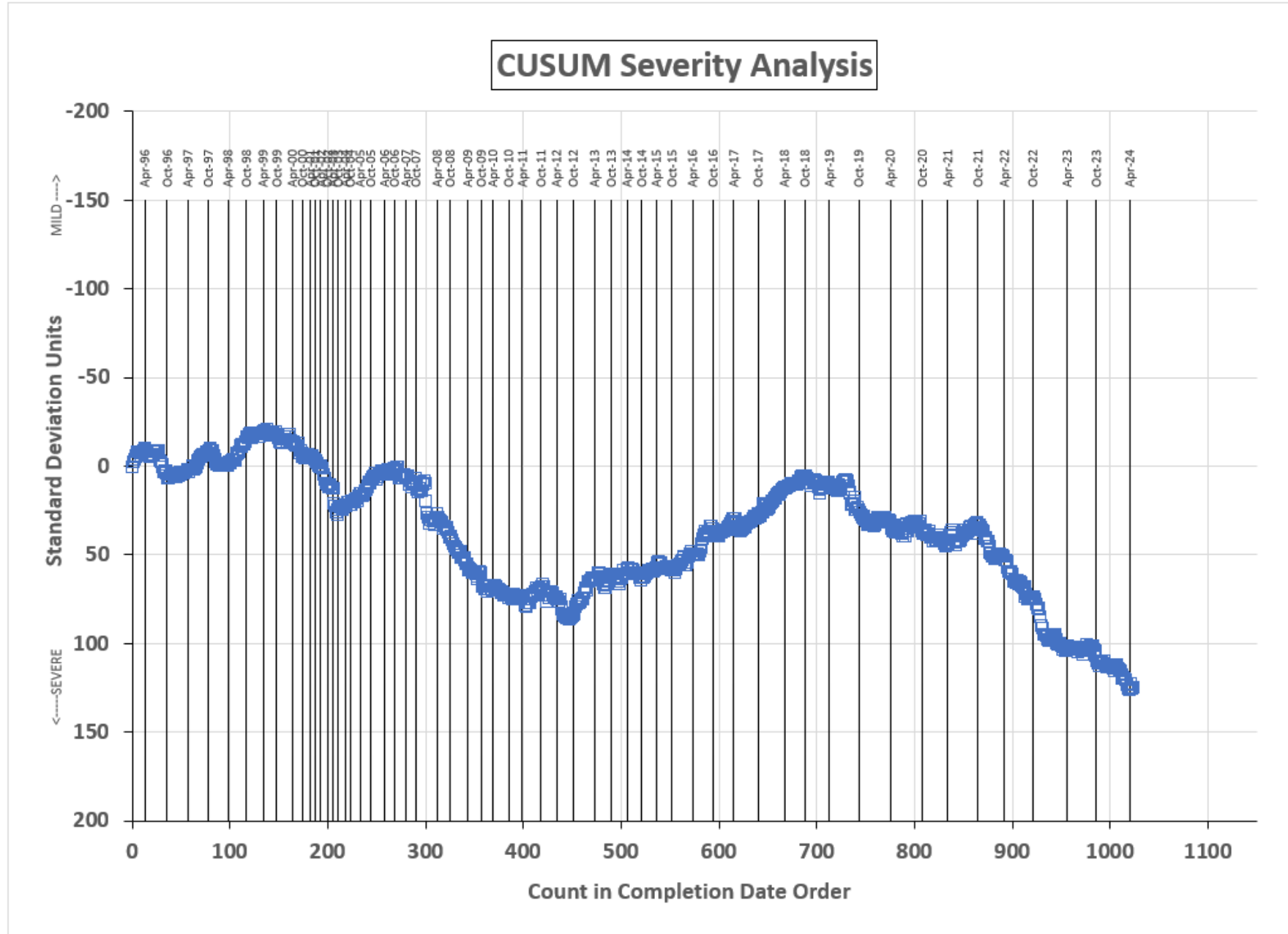
- Precision (Pooled s) continues to move back towards target for the fourth consecutive reporting semester
 - 6.19 APR '45; 6.57 OCT '23; 8.53 APR '23; 10.32 OCT '22
- Performance (Mean Δ/s) fell back to a severe 0.63 s this period (0.03 s last semester)
- Fail rate worsened to 23.5% after only being at 13.3% last semester.
- All tests this period report using Rod Batch M ($n=2$) or N ($n=32$).

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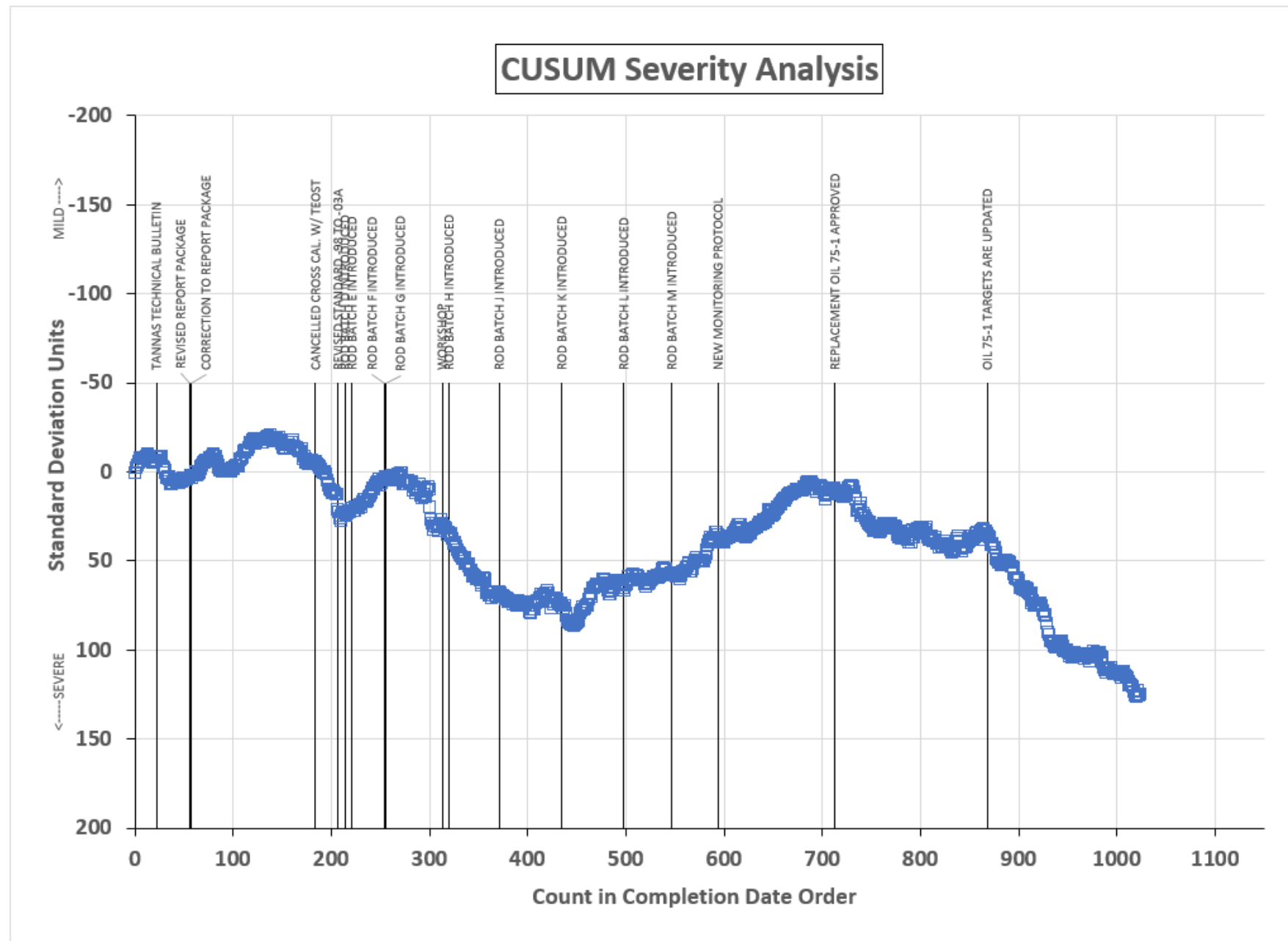
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TOTAL DEPOSITS MG

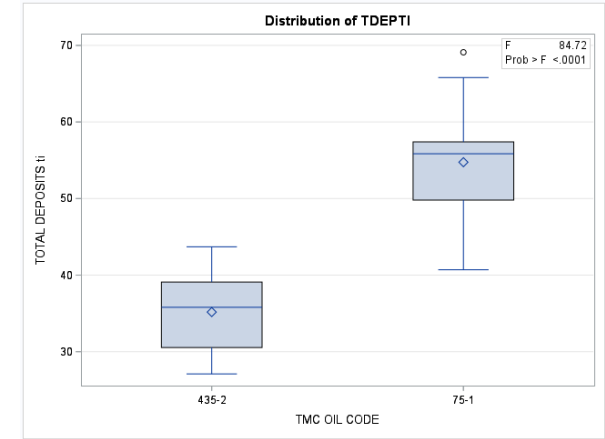
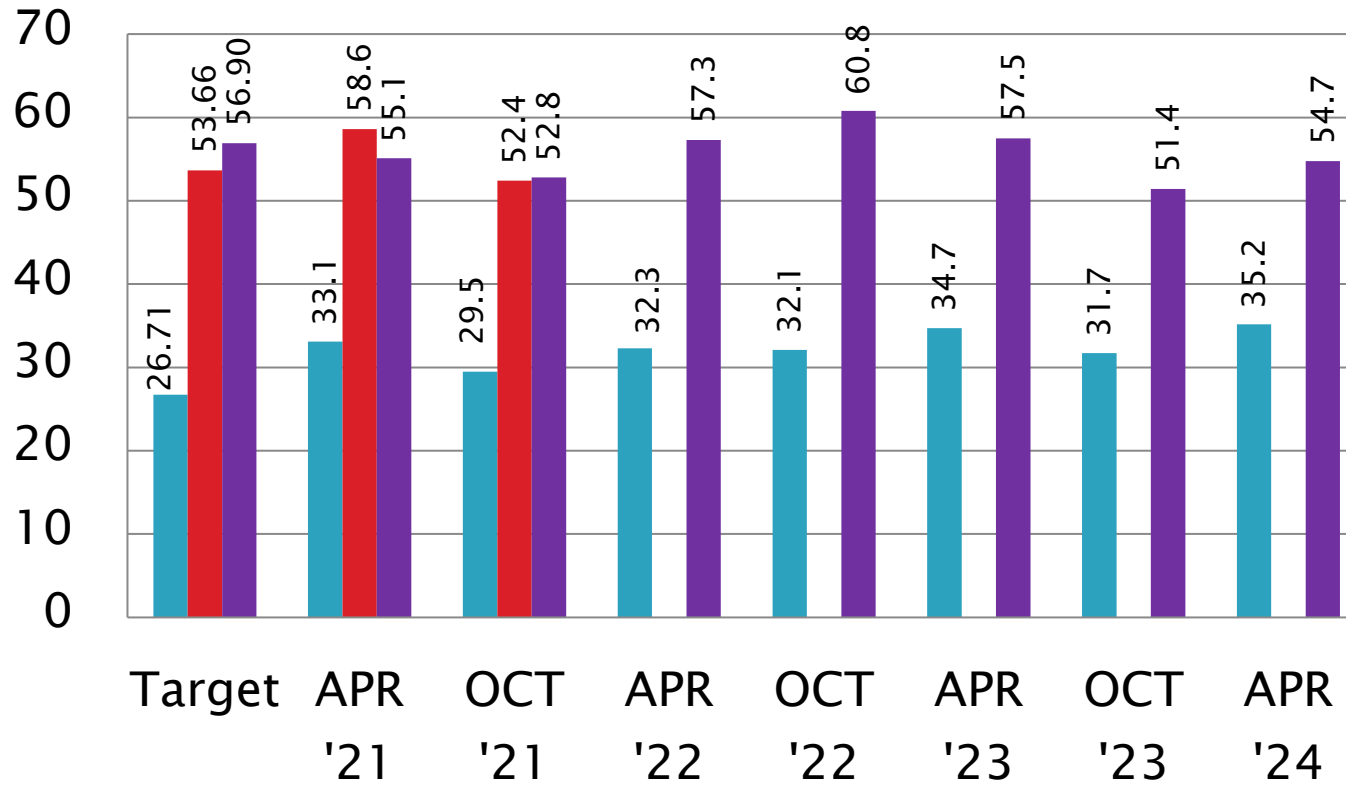


TOTAL DEPOSITS MG



D6335 Performance by Oil

Total Deposits, mg
Mean



- Oil 435-2
- Oil 75
- Oil 75-1

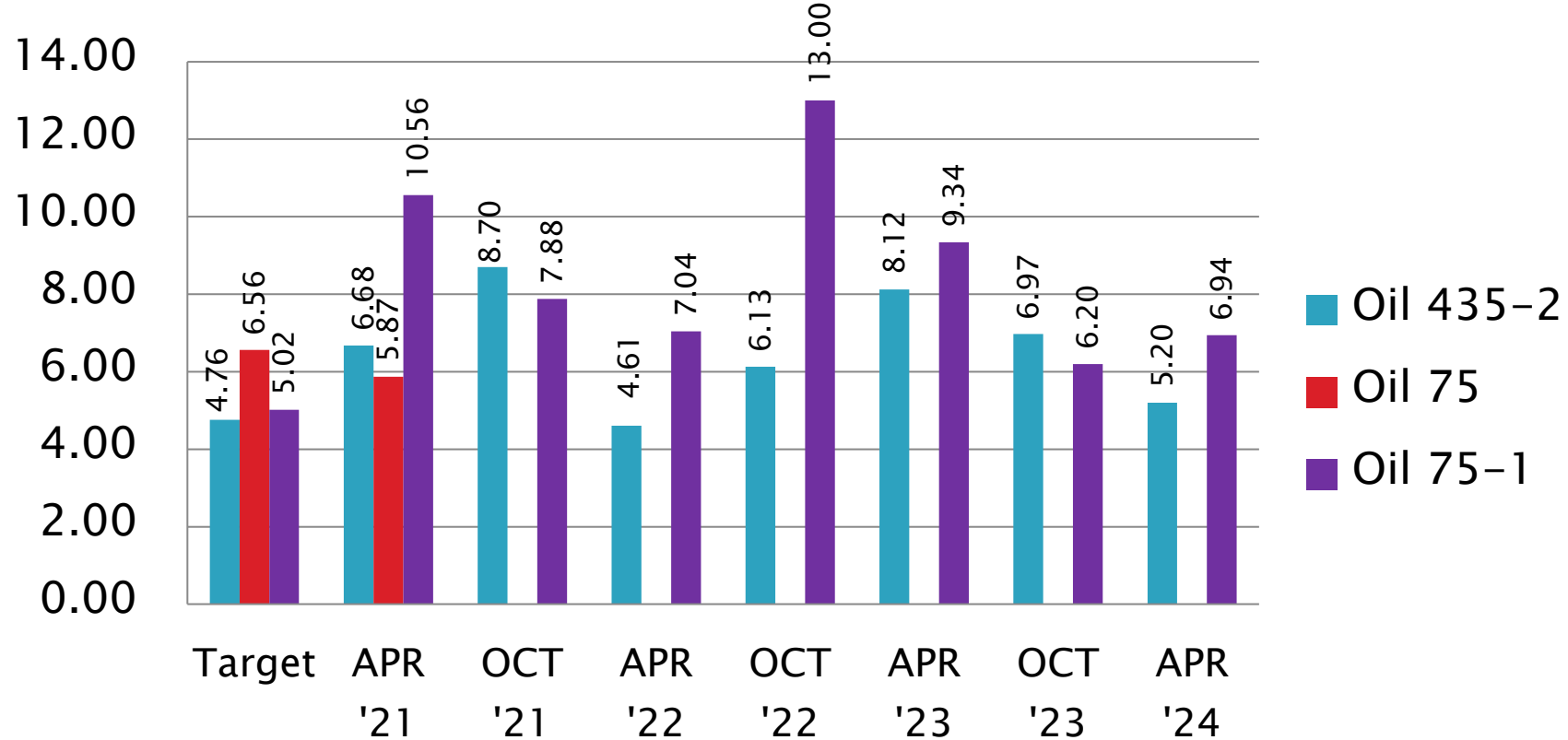
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D6335 Performance by Oil

Total Deposits, mg
Standard Deviation

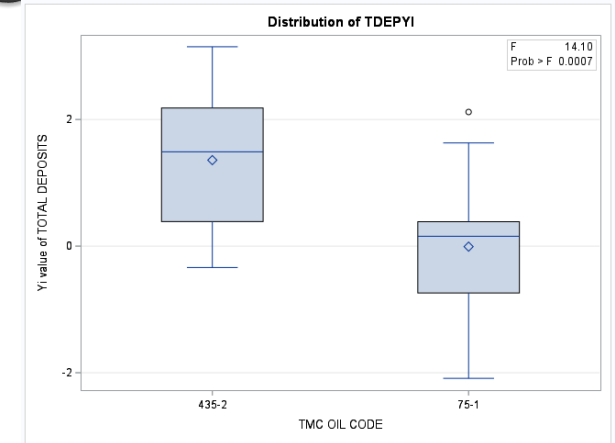
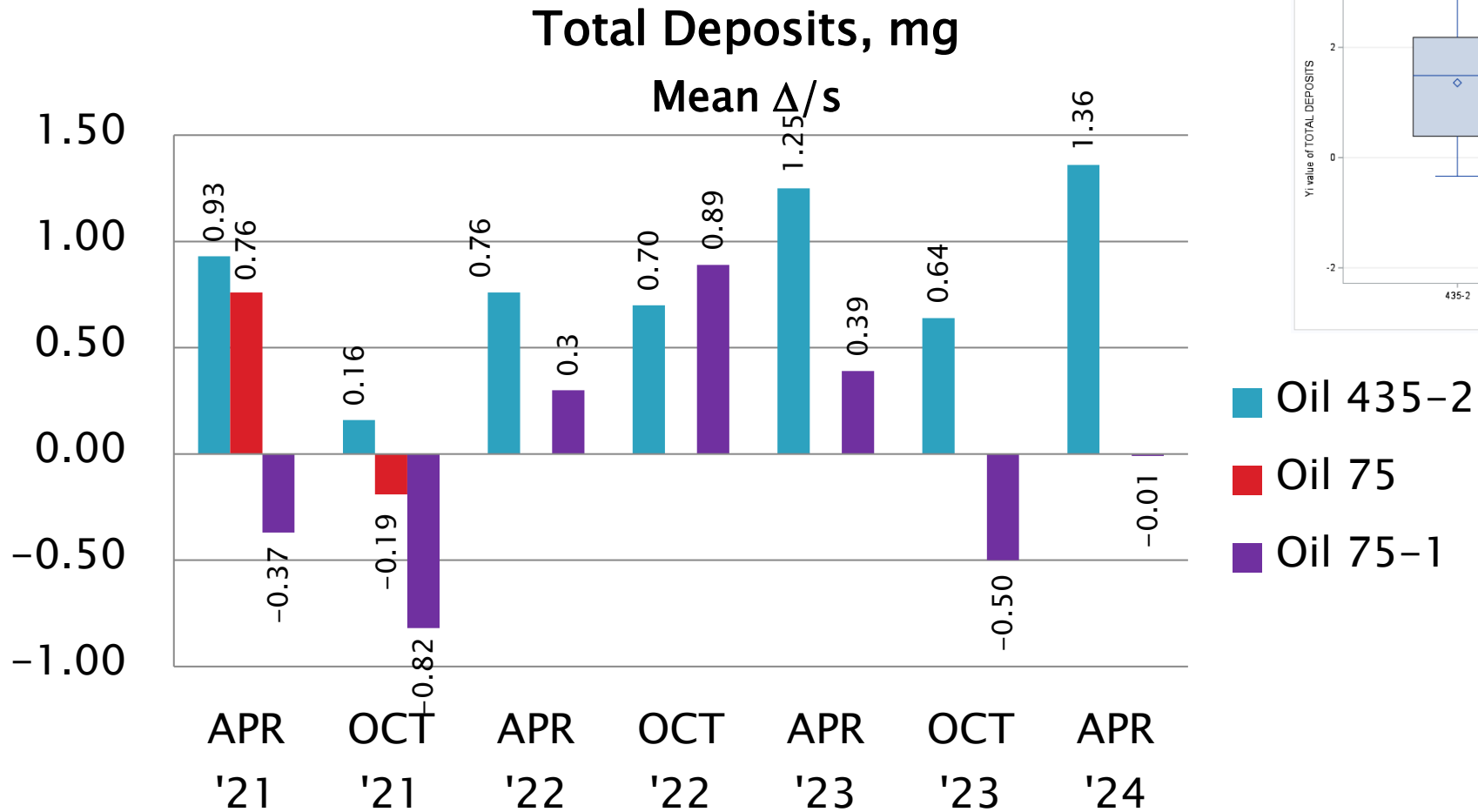


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D6335 Performance by Oil



- Oil 435-2
- Oil 75
- Oil 75-1

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Reference Oil Inventory

TEOST

Oil	Year Rec'd By TMC ^A	Tests	TMC Inventory, gallons	Gallons Shipped last 6 months	Estimated Life
75-1	2016	TEOST	1.22	0.86	1 year
435-2 ^B	2010	TEOST	33.39	0.60	5+ years
434-3 ^B	2017	TEOST	18.39	4.42	2 years

^A Integrity of TMC reference oils is confirmed annually by analytical QC testing of chemical and physical properties.

^B Multi-test oil; estimated aliquot reserved for bench testing.

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D02.B0.07 TMC Monitored Tests



ASTM D 6417

October 1, 2023 – March 31, 2024

Calibrated Labs and Stands*

(change since last Semi-Annual report)

Test	Labs	Stands
D6417	7 (+1)	10 (+2)

*Between 10/1/2023 and 3/31/2024

D6417: Estimation of Engine Oil Volatility by Capillary GC

Test Status	Validity Code	No. Tests
Acceptable Calibration Test	AC	18
Failed Calibration Test	OC	0
Acceptable Shakedown Runs	NN	4
Total		22

Number of Labs Reporting Data: 8

Fail Rate of Operationally Valid Tests: 0%

FOUR Shakedown Runs were conducted on two new heads

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D6417: Estimation of Engine Oil Volatility by Capillary GC

Statistically Unacceptable Tests (OC)	No. Of Tests
Volatility Loss Mild	0
Volatility Loss Severe	0

Operationally Invalid Tests (LC)	No. Of Tests
Daily QC was out of range (Severe)	0

- There were no statistically invalid tests reported this period.
- There were no operationally invalid tests reported this period.
- No D6417 TMC technical updates were issued this report period.

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D6417: Estimation of Engine Oil Volatility by Capillary GC

Period Precision and Severity Estimates

Area % Volatized @ 371°C	n	df	Pooled s	Mean Δ/s
Initial Selected Oils from RR	54	51	0.39	-----
4/1/20 through 9/30/20*	16	13	0.41	-0.34
4/1/20 through 9/30/20*	14	11	0.31	0.01
10/1/20 through 3/31/21*	21	18	0.47	-0.81
10/1/20 through 3/31/21*	19	16	0.37	-0.43
4/1/21 through 9/30/21	17	14	0.39	-0.28
10/1/21 through 3/31/22	20	17	0.51	0.13
4/1/22 through 9/30/22	19	16	0.48	-0.67
10/1/22 through 3/31/23	18	15	0.43	0.41
4/1/23 through 9/30/23	16	13	0.34	-0.02
10/1/23 through 3/31/24	18	15	0.27	0.25

*Period statistics with two mild results from rigs D5/D6 included and excluded (operational problem suspected but lab never confirmed)

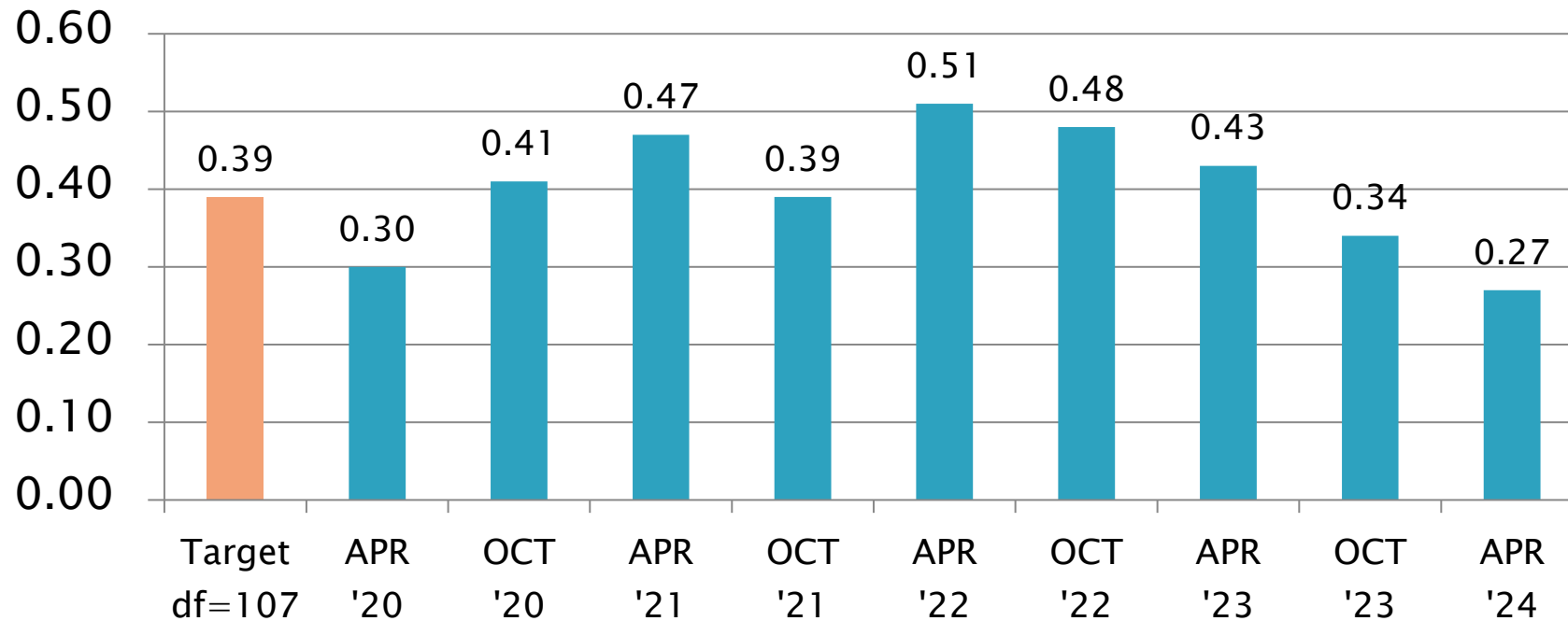
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D6417 Precision Estimates

Area % Volatized @ 371°C
Pooled s



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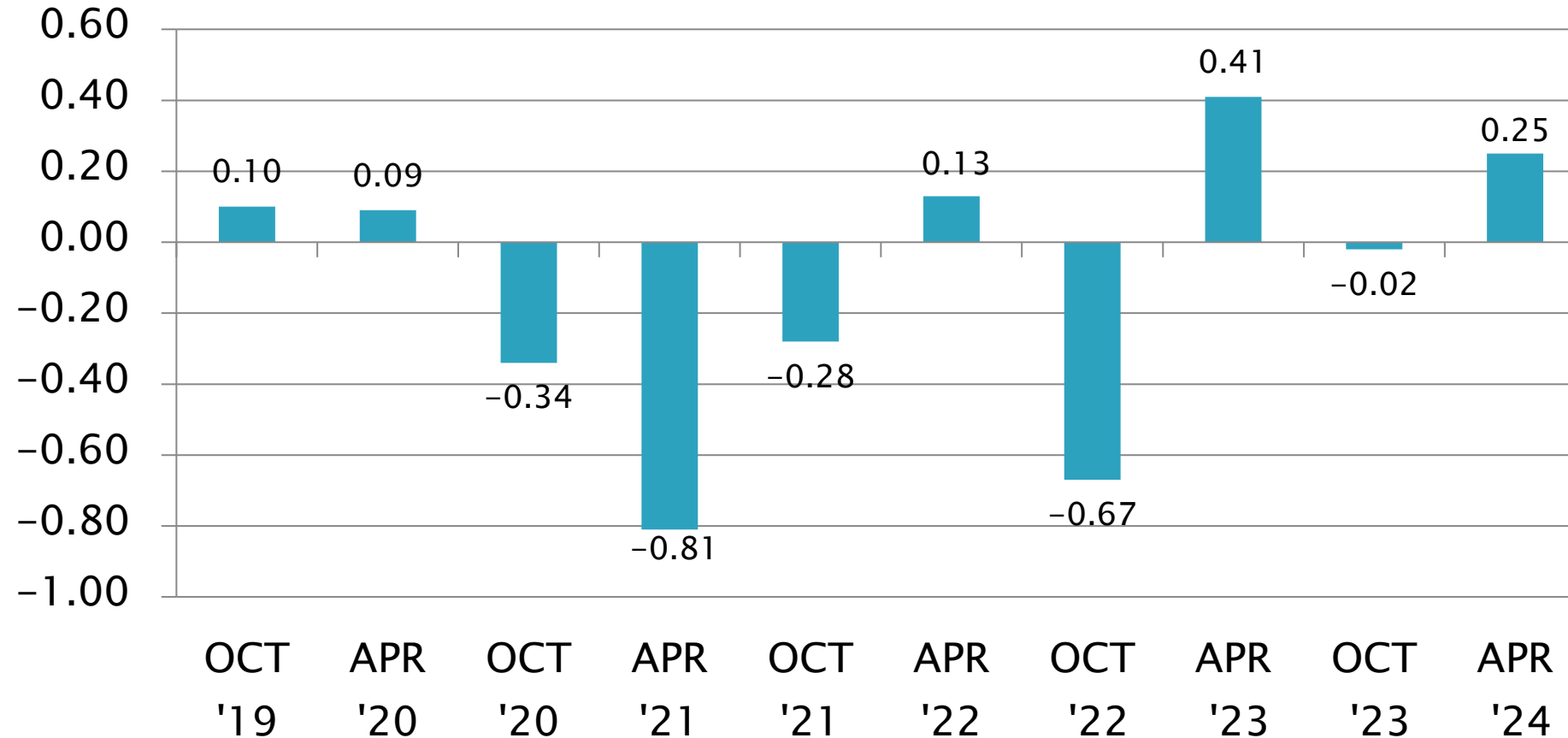
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D6417 Severity Estimates

Area % Volatized @ 371°C
Mean Δ/s

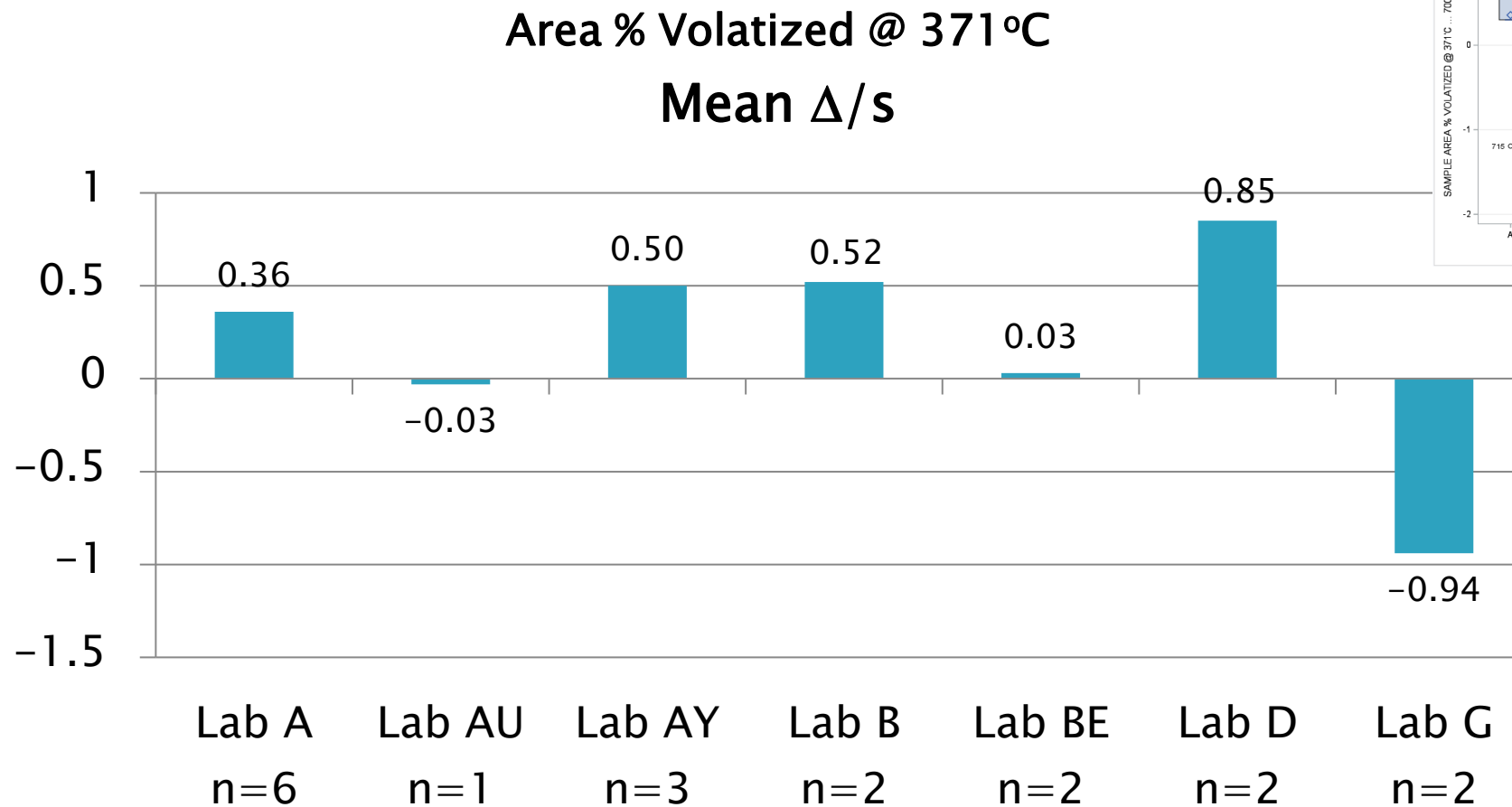


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D6417 Lab Severity Estimates



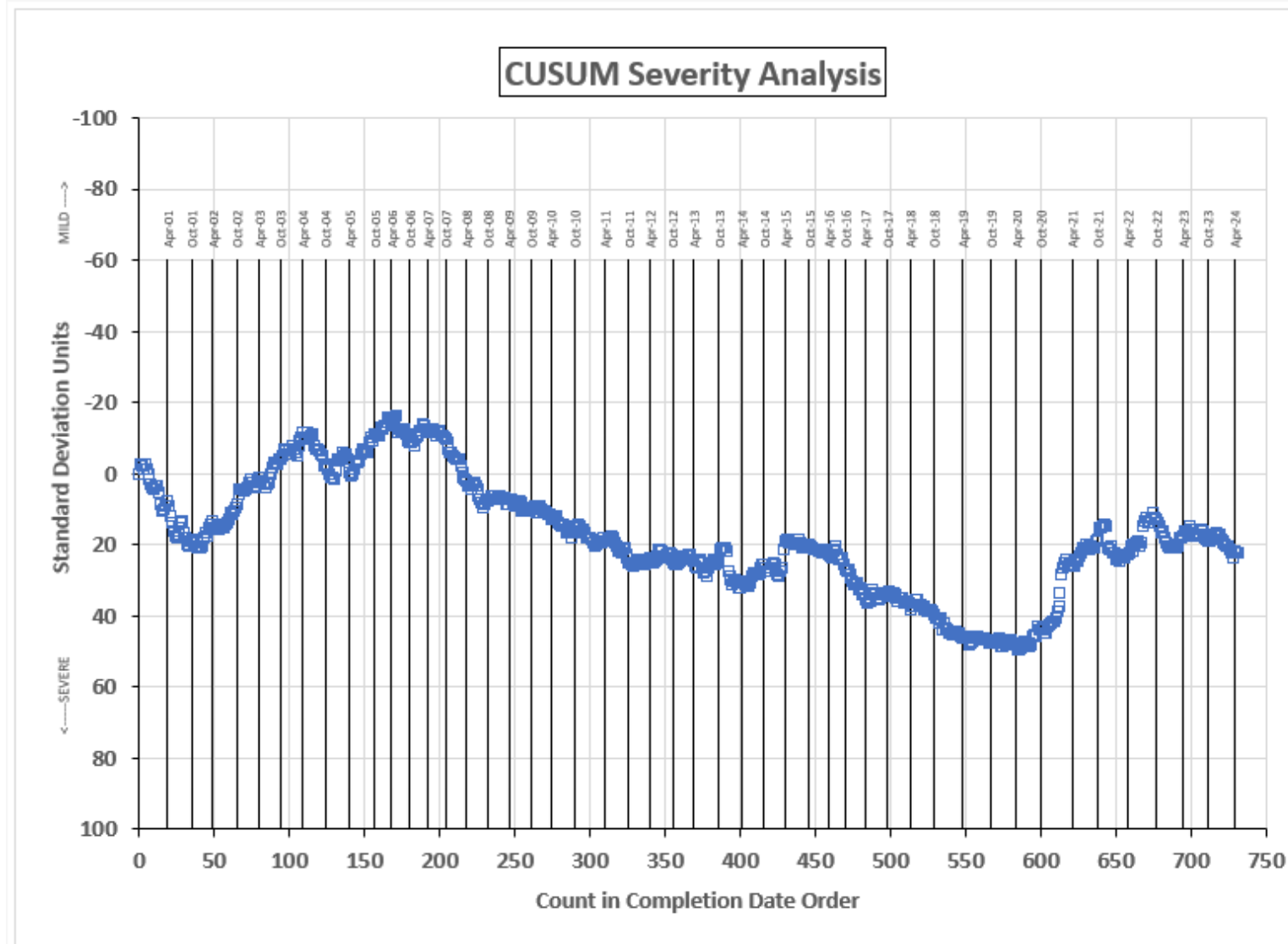
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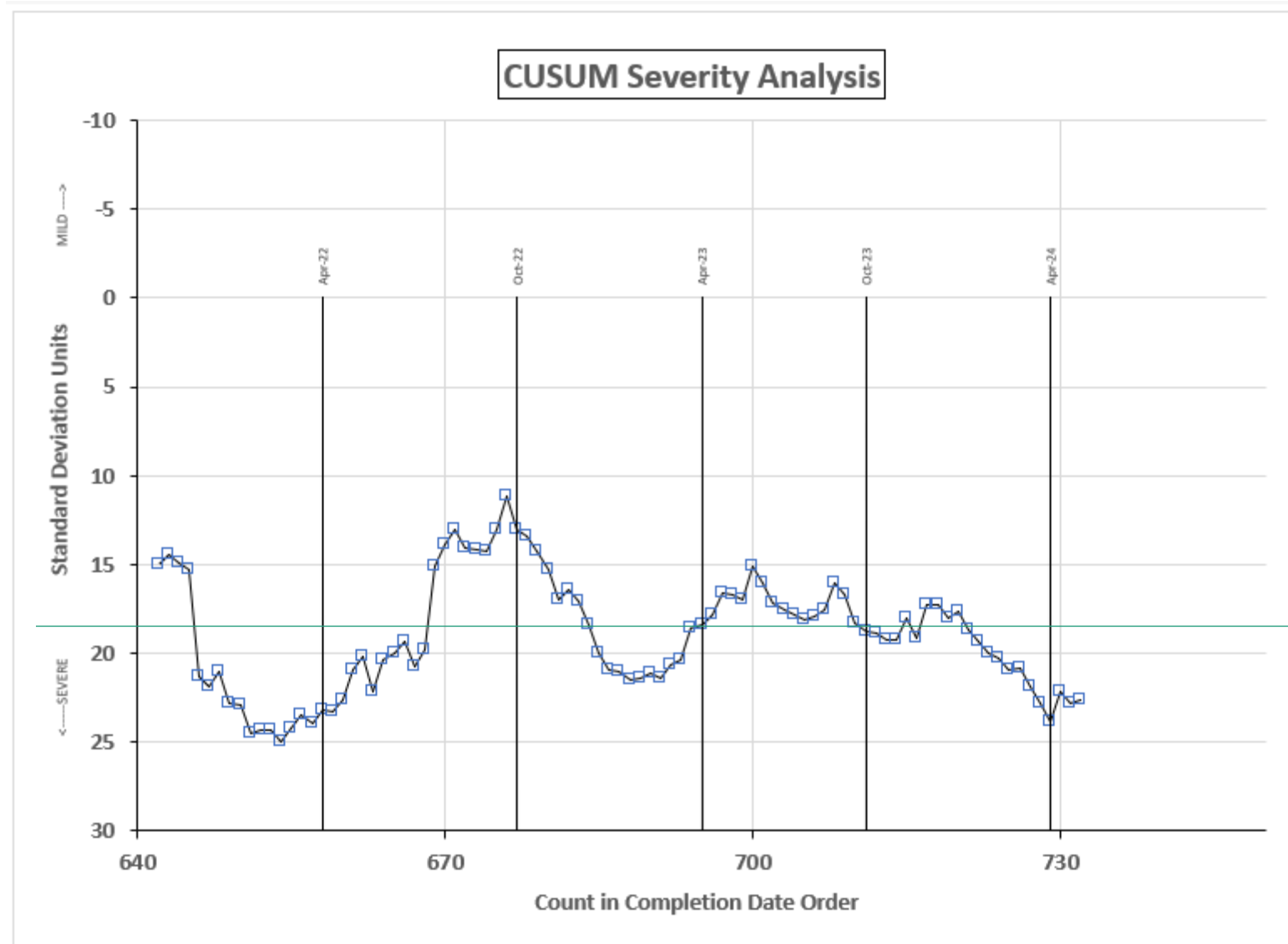


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SAMPLE AREA % VOLATIZED

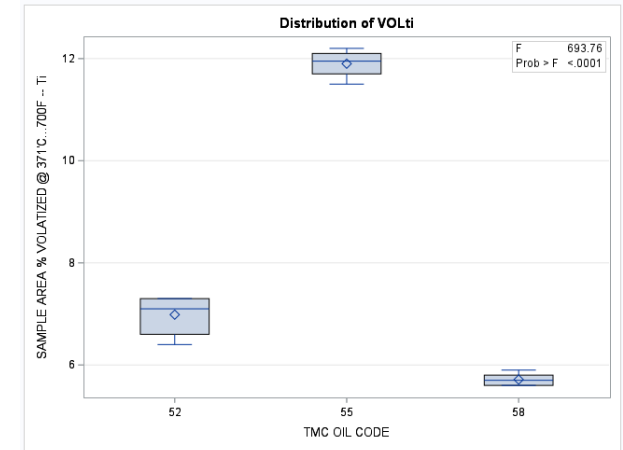
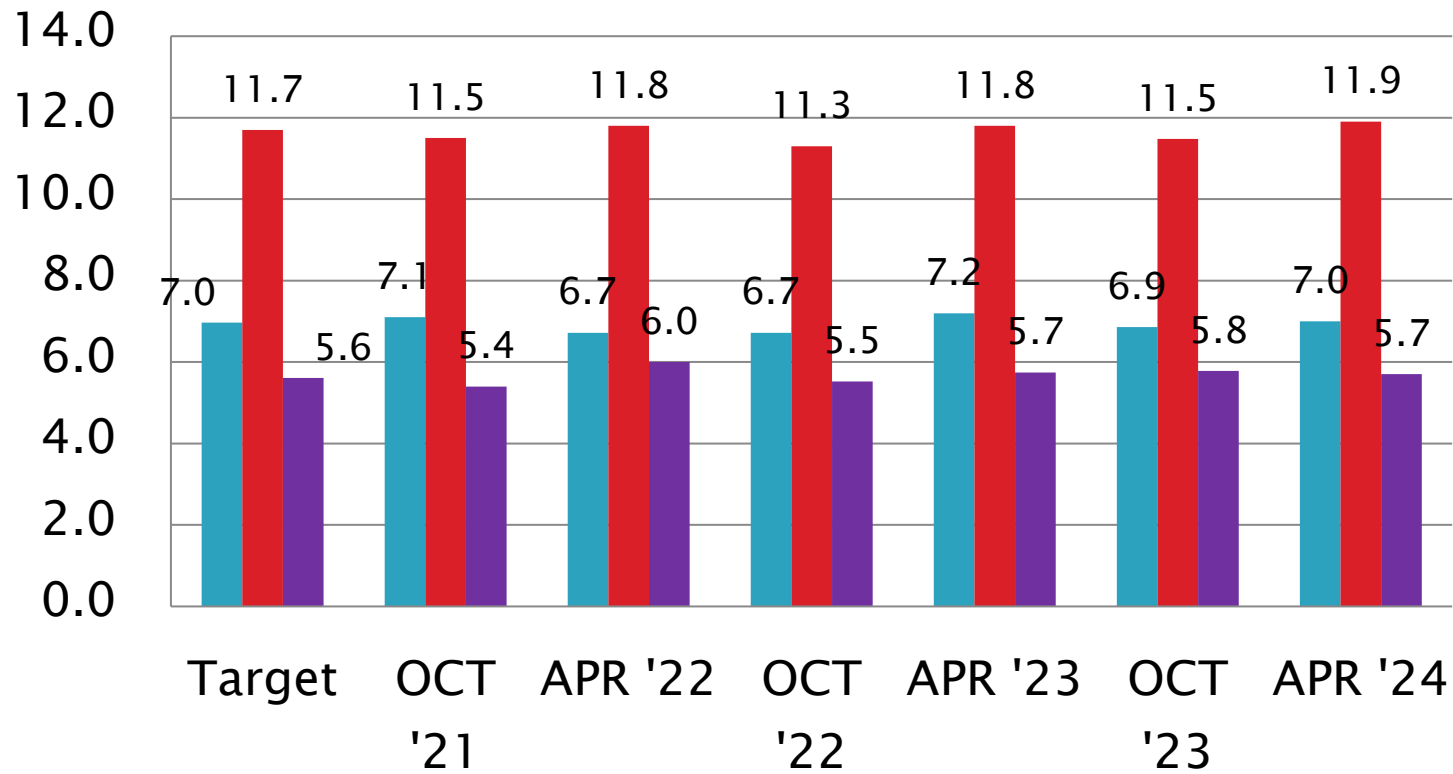


**D6417 VOLATILITY BY GC INDUSTRY OPERATIONALLY VALID DATA
LAST 90 Points
SAMPLE AREA % VOLATIZED**



D6417 Performance by Oil

Area % Volatized @ 371°C
Mean



- Oil 52
- Oil 55
- Oil 58

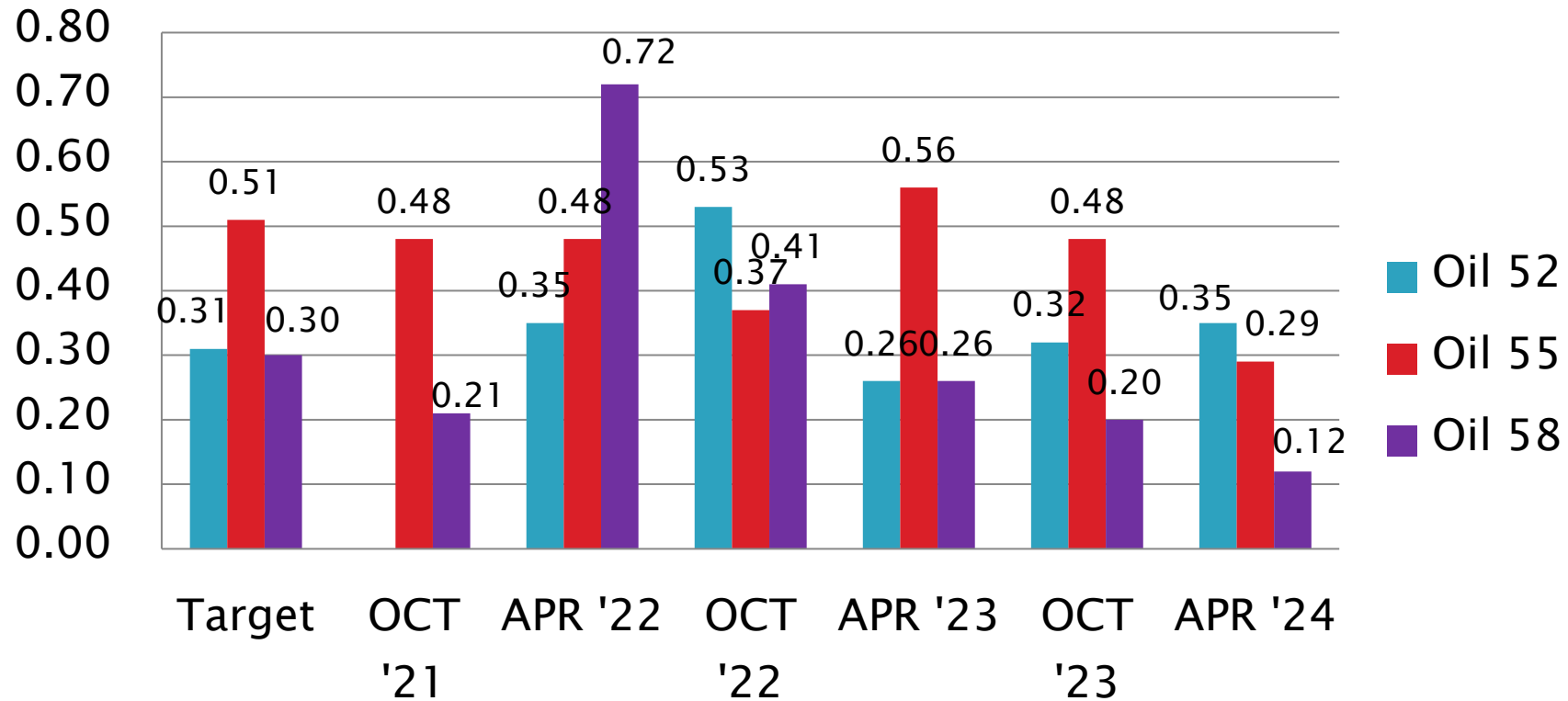
October 1, 2023 - March 31, 2024

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D6417 Performance by Oil

Area % Volatized @ 371°C
Standard Deviation



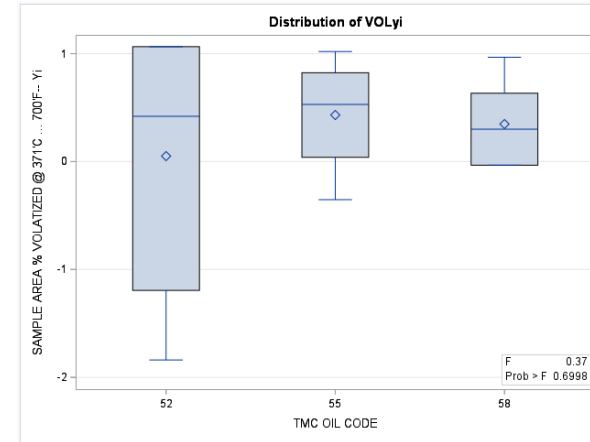
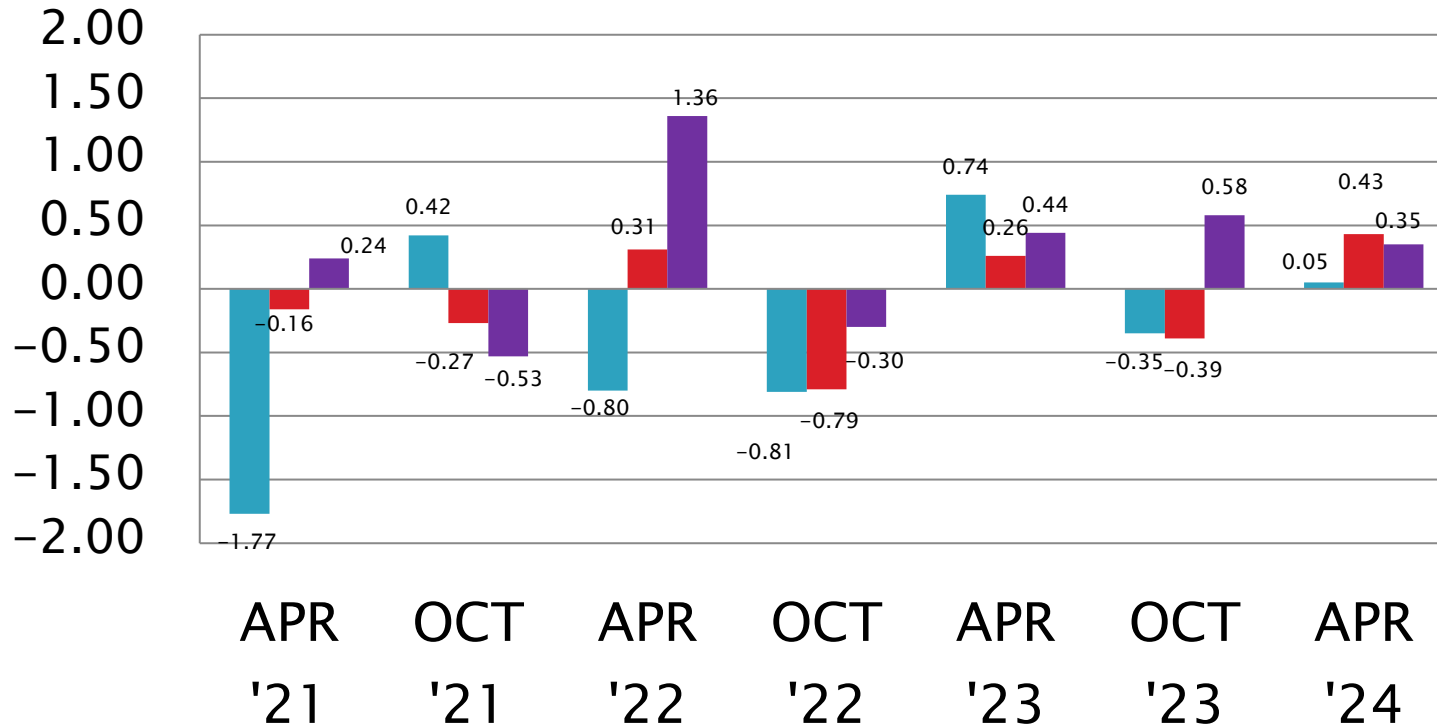
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D6417 Performance by Oil

Area % Volatized @ 371°C
Mean Δ/s



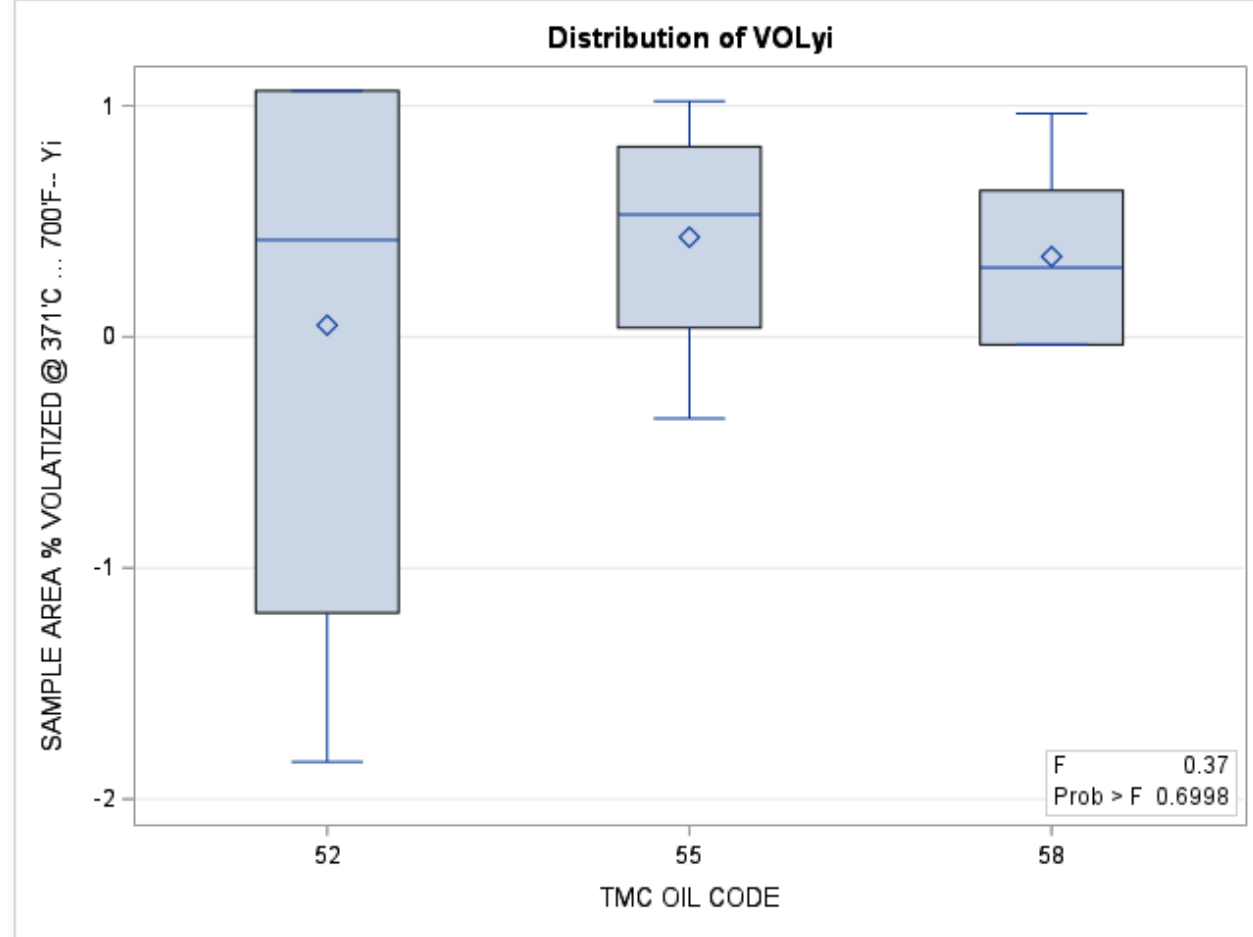
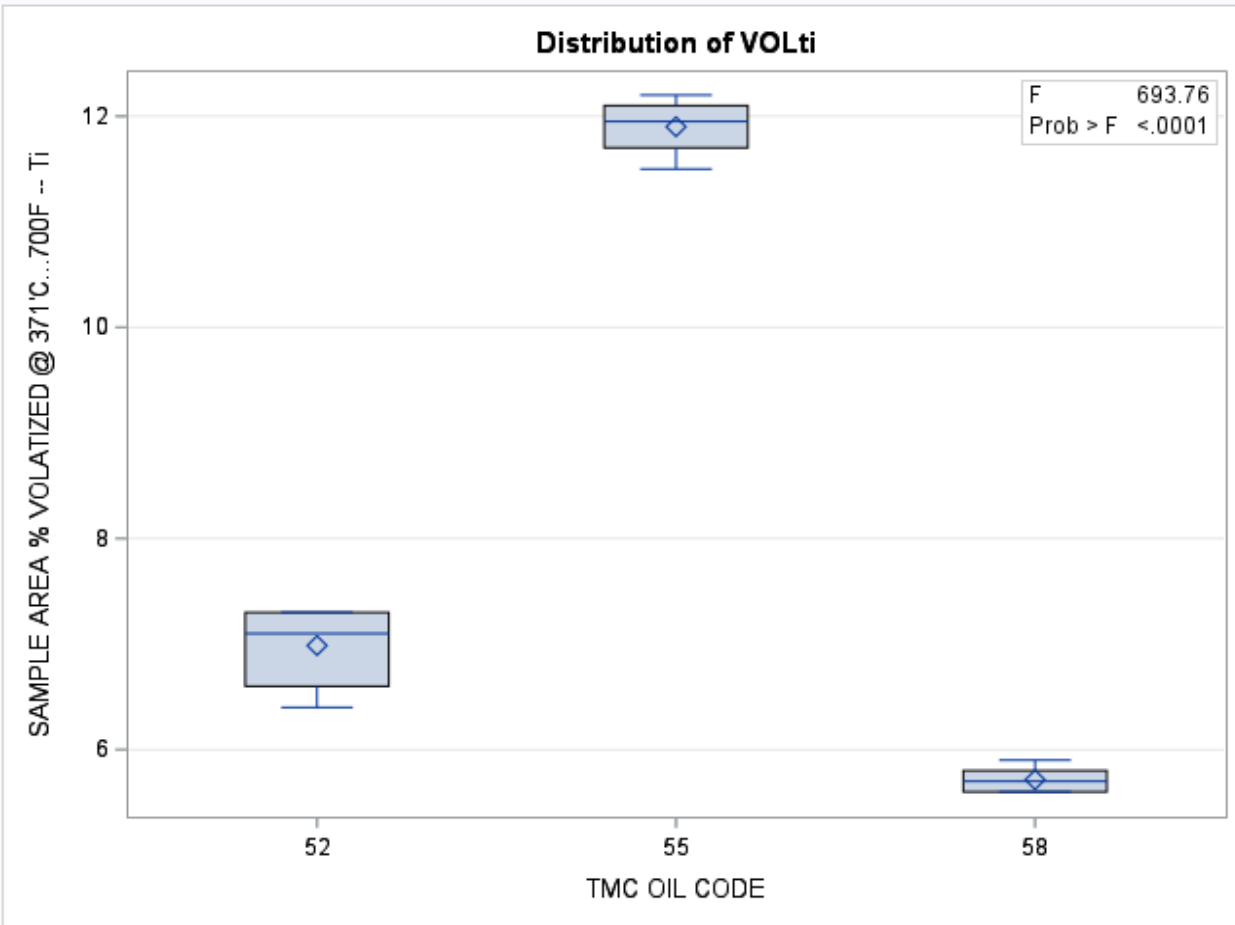
- Oil 52
- Oil 55
- Oil 58

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D6417 Performance by Oil



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Reference Oil Inventory

D6417

Oil	Year Rec'd By TMC ^A	Tests	TMC Inventory, gallons	Gallons Shipped last 6 months	Estimated Life
52	1995	D6417	59.38	<0.01	5+ years
55	1995	D6417	65.90	<0.01	5+ years
58	1998	D6417, D6417QC	110.19	0.47	5+ years

^A Integrity of TMC reference oils is confirmed annually by analytical QC testing of chemical and physical properties.

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D6417: Estimation of Engine Oil Volatility by Capillary GC

- ▶ Precision (Pooled s) continues to be remarkably consistent and close to target.
- ▶ Performance (Mean Δ/s) returned to being slightly severe after being “on target” in prior reporting period.
- ▶ CUSUM severity plot trending a bit severe this semester moving away from the 19.7 value where it had circled for previous four semesters.

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D02.B0.07 TMC Monitored Tests



ASTM D 6557

Ball Rust Test (BRT)

October 1, 2023 – March 31, 2024

Calibrated Labs and Stands*

(change since last Semi-Annual report)

Test	Labs	Stands
D6557	5 (+0)	5 (+0)

*As of 3/31/2024

BRT Test Activity*

Test Status	Validity Code	Number of Tests
Acceptable Calibration Test	AC	175
Failed Calibration Test	OC	8
Operationally Invalid	LC, RC, LS, RS	0
Aborted Run	XC, XS	0
Shakedown Run	NN, MN	0
Total		183

- 5 labs reported data

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BRT Failed Tests

Failed Parameter (OC)	Number of Tests
Severe (low) Average Gray Value	6
Mild (high) Average Gray Value	2
Total	8

RO 82-1 TWO Mild Tests
RO 86 THREE Severe Tests
RO 87 THREE Severe Tests

October 1, 2023 – March 31, 2024

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BRT Failed Tests (OC) by Lab

Failed Parameter	LTMS Lab					#
	A	B	D	G	L	
Severe Average Gray Value	2	0	2	2	0	6
Mild Average Gray Value	0	0	0	2	0	2
Total	2	0	2	4	0	8

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BRT Lost Tests*

Failed Parameter (LC, RC, XC)	Number of Tests
Total	0

*Invalid (LC, RC) and Aborted (XC) calibration tests

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BRT Lost Tests by Lab

Cause	LTMS Lab					#
	A	B	D	G	L	
Air Flow Rate	0	0	0	0	0	0
Acid Injector Malfunction	0	0	0	0	0	0
Total	0	0	0	0	0	0

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BRT Test Severity

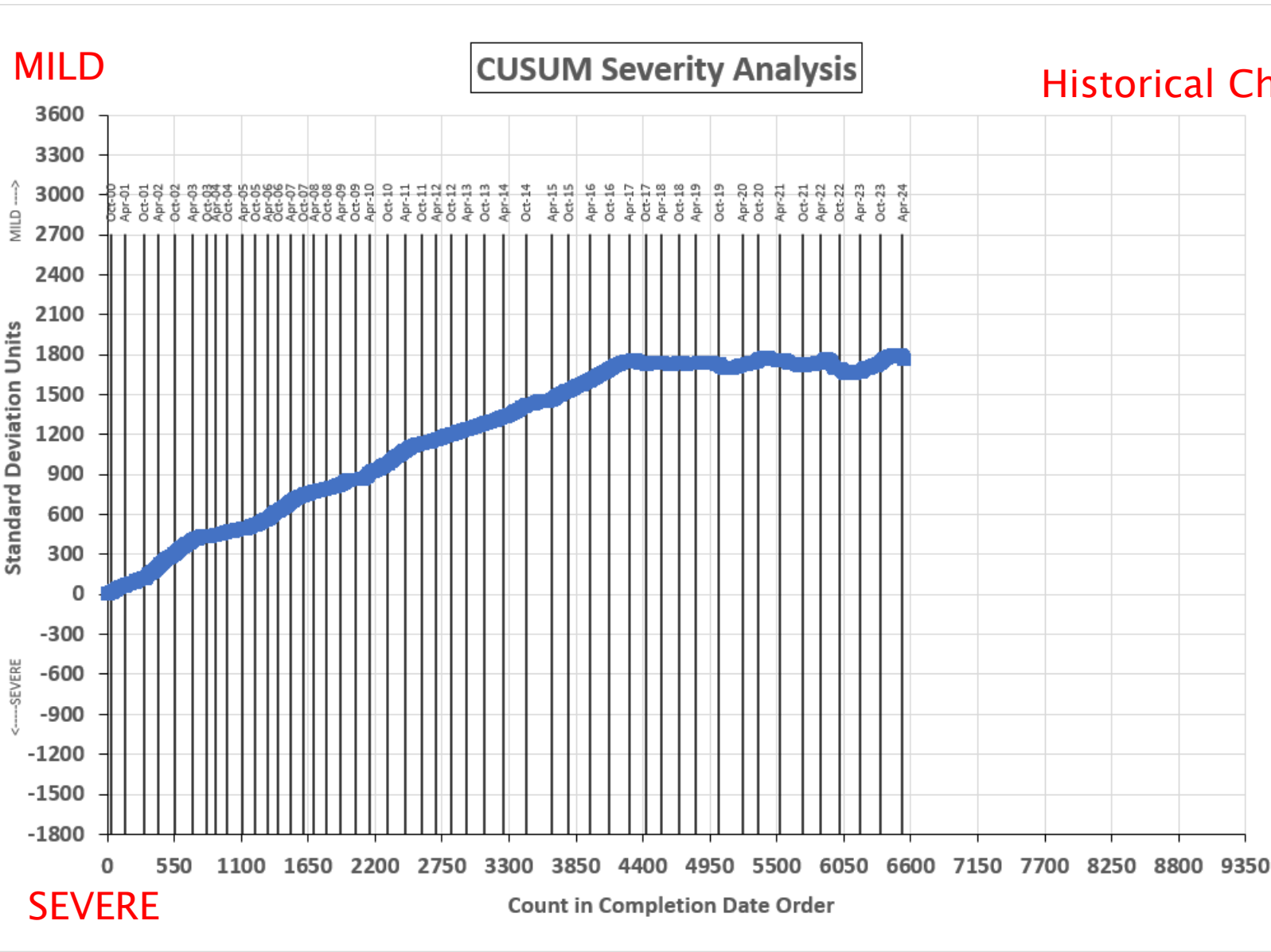
- ▶ Average Gray Value (AGV) has returned to a slightly severe trend this semester after a mild run the last semester. Reference Oils 86 and 87 have been failing severe at the end of last semester and the beginning of the new semester and were removed from assignment rotation in a recent Surveillance Panel meeting.

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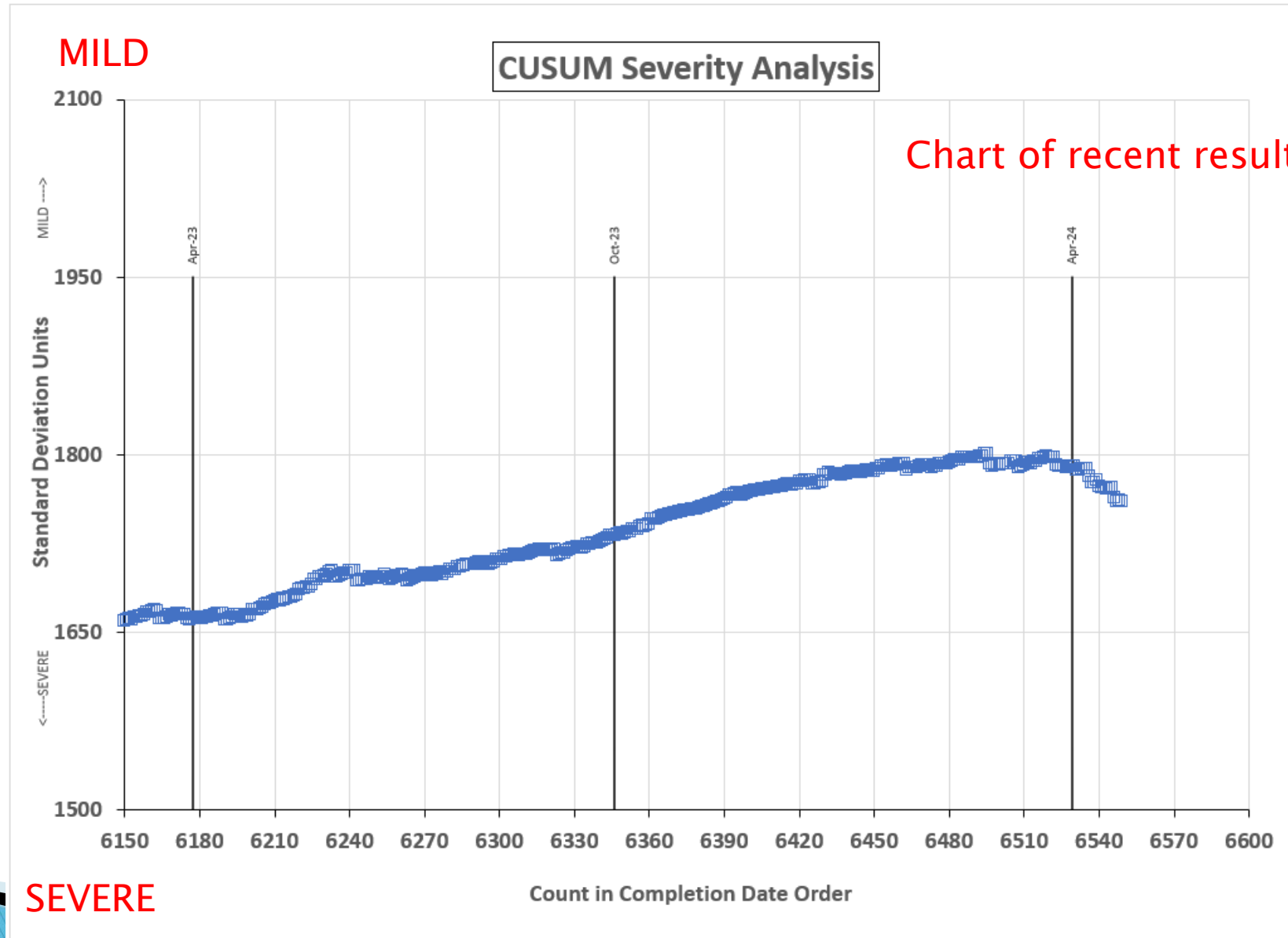
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REFERENCE AVERAGE GRAY VALUE



BALL RUST TEST INDUSTRY OPERATIONALLY VALID DATA
Last 500 Points
REFERENCE AVERAGE GRAY VALUE



SEVERE

BRT (D6557) Rust Protection Test

Period Precision and Severity Estimates

Average Gray Value	n	df	Pooled s	Mean Δ/s
10/1/20 through 3/31/21	171	168	13.58	-0.01
4/1/21 through 9/30/21	191	188	11.27	-0.20
10/1/21 through 3/31/22	141	138	16.28	0.12
4/1/22 through 9/30/22	154	151	21.10	-0.29
10/1/22 through 3/31/23	165	162	15.56	-0.17
4/1/23 through 9/30/23	171	168	17.56	0.34
10/1/23 through 3/31/24	183	1	13.75	0.32

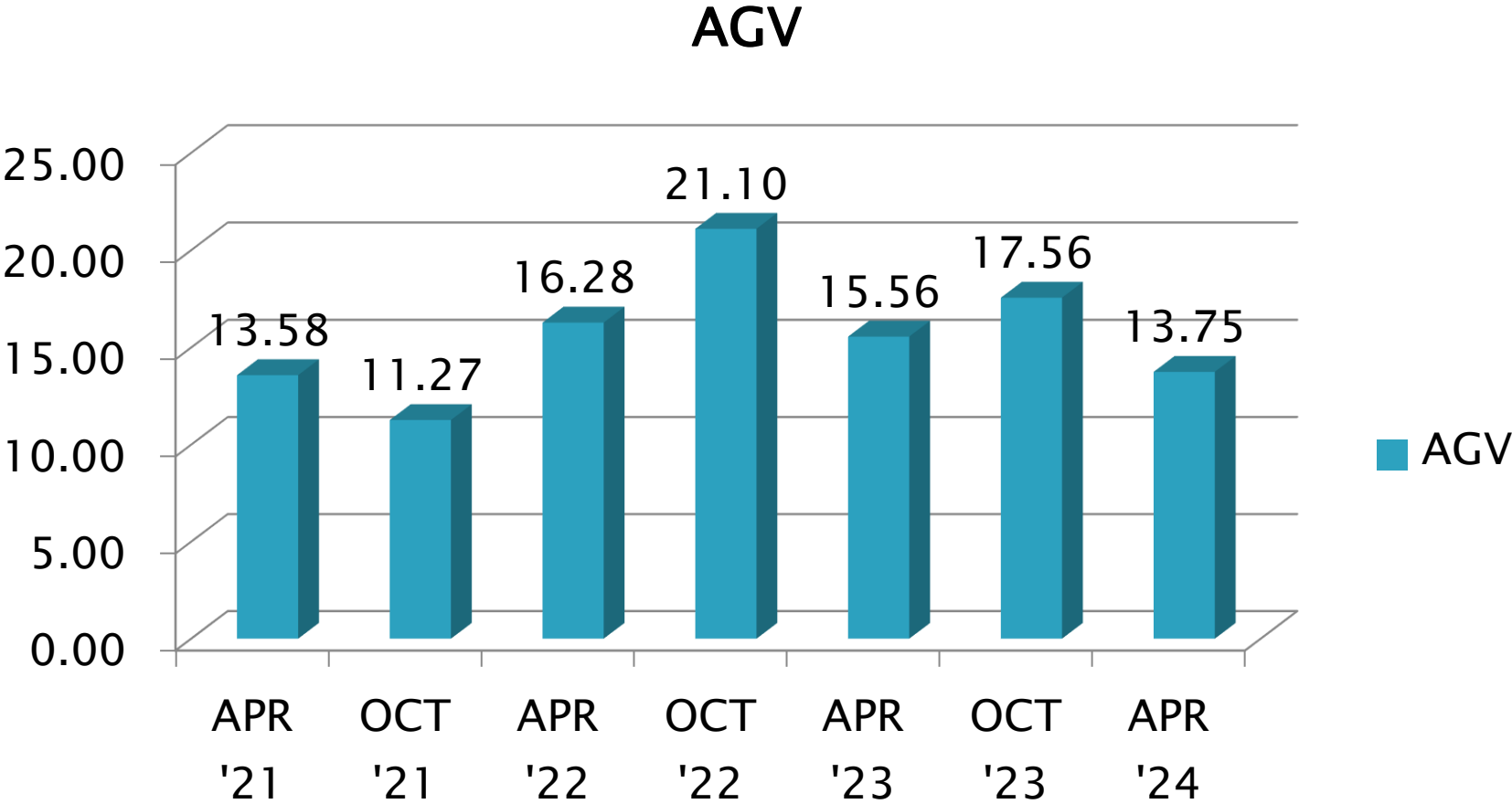
*Period statistics for all Valid Reference Oil Results (pooled)

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BRT Precision (Pooled s) Estimates

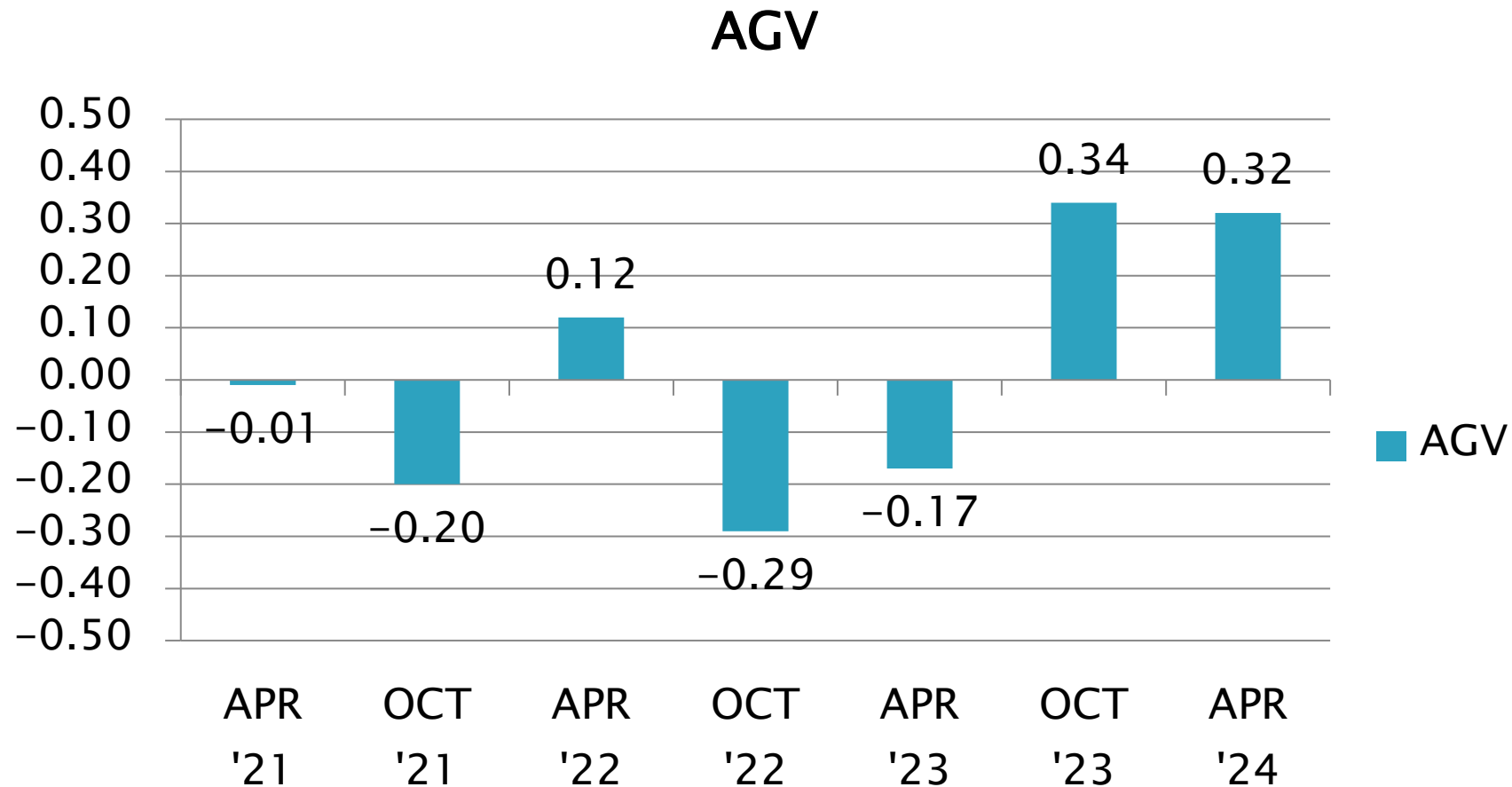


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BRT Performance (Mean Δ/s) Estimates



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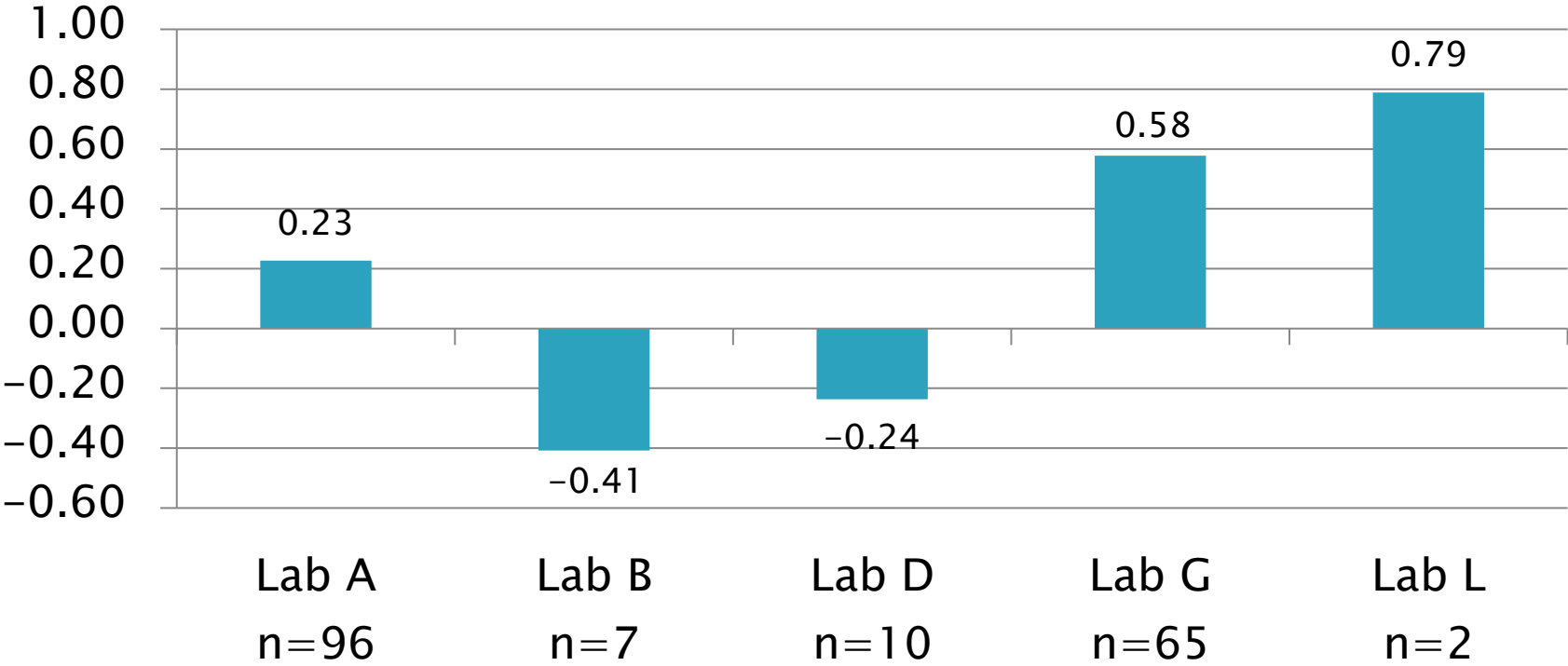
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BRT Lab Severity Estimates

AGV
Mean Δ/s



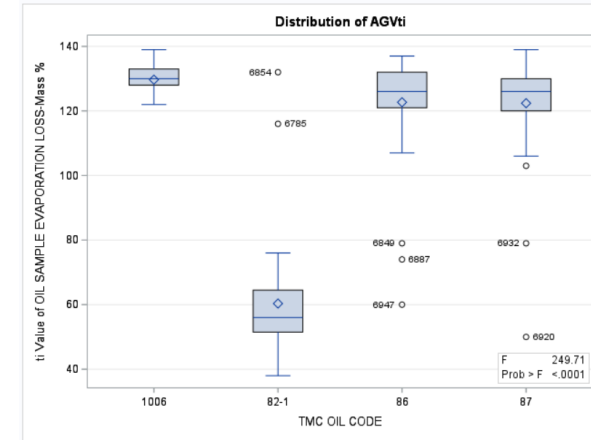
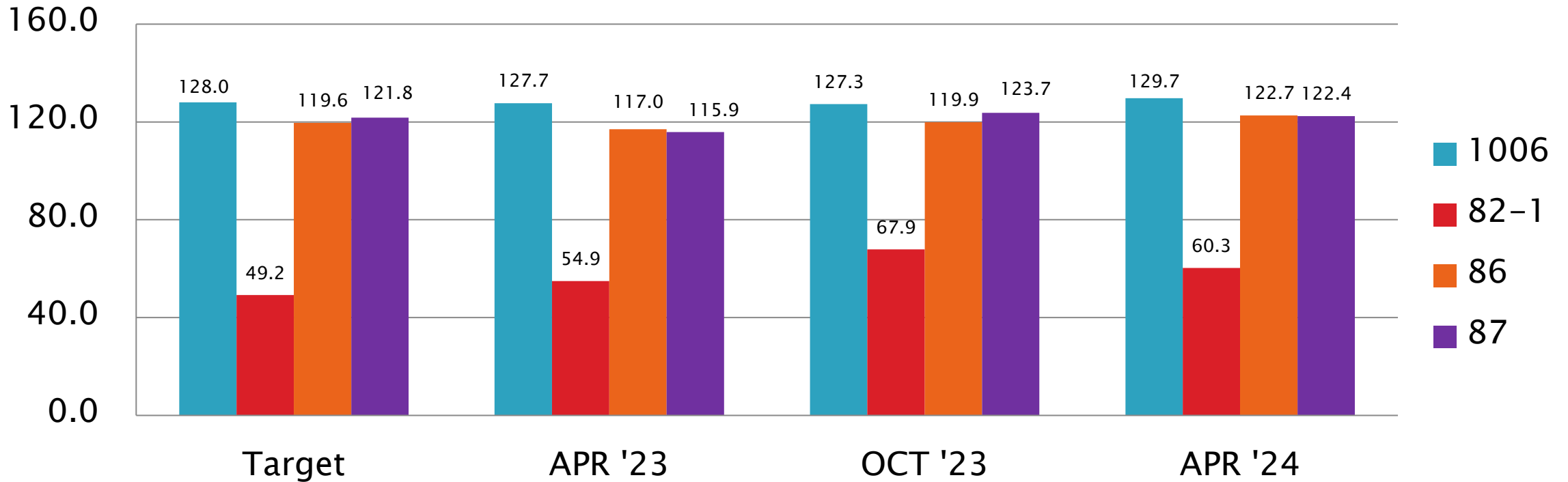
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BRT Performance by OIL

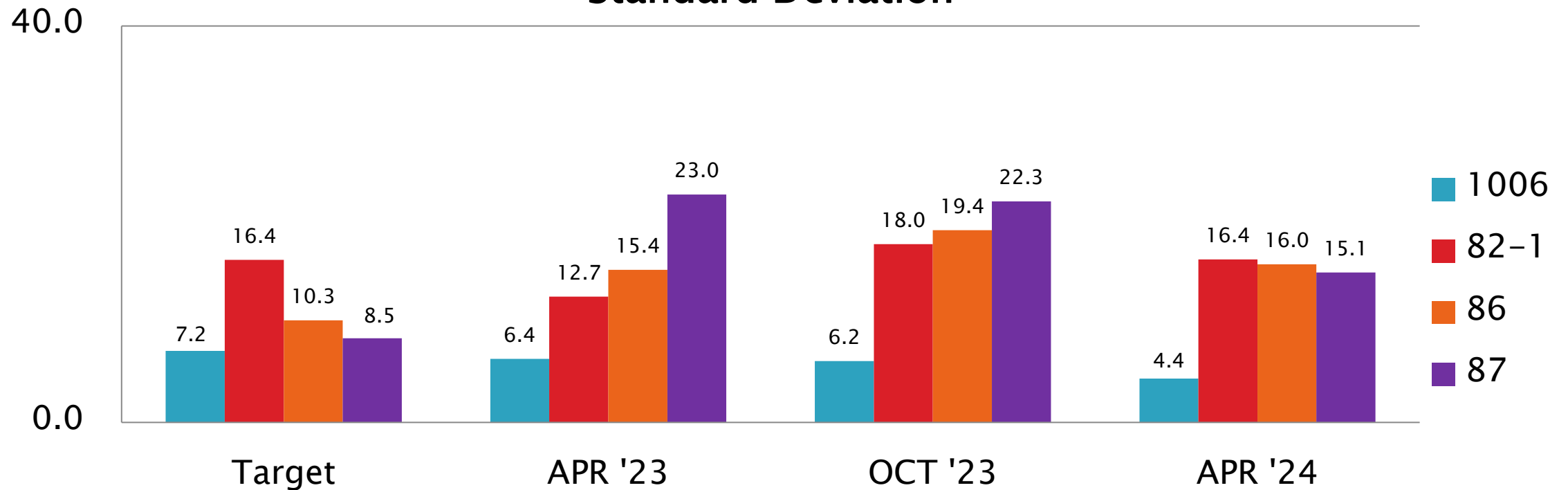
Average Gray Value Mean



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BRT Performance by OIL

Average Gray Value Standard Deviation



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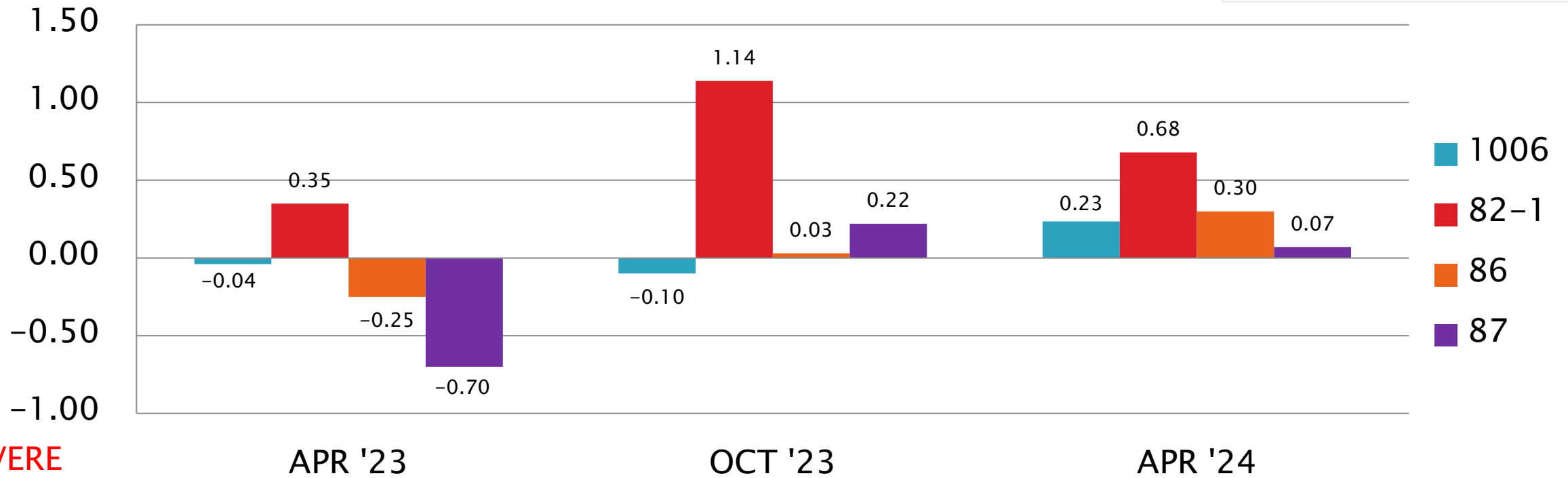
Test Monitoring Center
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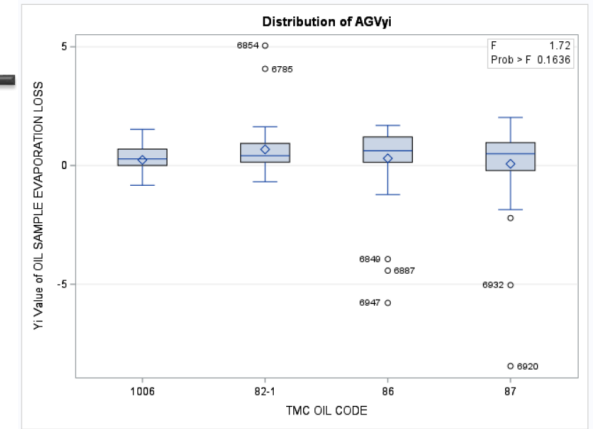
BRT Performance by OIL

Average Gray Value
MEAN Δ/s

MILD



SEVERE



October 1, 2023 - March 31, 2024

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Information Letters & Memos*

Test	Date	IL / Memo	Topic
			No new information letters or memos published this period.

*Available from TMC Website

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Reference Oil Inventory Estimated Life

Oil	TMC Inventory (gallons)	Quantity Shipped in last 6 months (gallons)	Total Assignments made over Semester	Estimated Life
1006	28.9	0.5	49	5+ years
82-1	1.5	0.4	45	2 years
86	49.1	0.5	47	5+ years
87	93.0	0.4	47	5+ years

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D02.B0.07 TMC Monitored Tests



ASTM D 6594

High Temperature Corrosion Bench Test (HTCBT)

October 1, 2023 – March 31, 2024

Calibrated Labs and Stands*

(change since last Semi-Annual report in parentheses)

Test	Labs	Stands
D6594	8 (-2)	23 (-7)

*As of 3/31/2024

HTCBT Test Activity*

Test Status	Validity Code	Number of Tests
Acceptable Calibration Test	AC	267
Failed Calibration Test	OC	20 ¹
Operationally Invalid, by lab	LC	3
Aborted Calibration Test	XC	3
Information Run in Range	NN	25 ²
Information Run out of Range	MN	6 ²
Total		324

8 labs reported data (2 less from previous semester)

¹ An increase of 3 from previous semester

² Informational Runs donated by labs for Batch P coupon approval

October 1, 2023 – March 31, 2024

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HTCBT Failed Tests

Failed Parameter	Number of Tests
Lead Concentration Severe	5
Lead Concentration Mild	1
Copper Concentration Severe	7
Copper Concentration Mild	4
Lead and Copper Concentrations (both) Severe	1
Lead and Copper Concentrations (both) Mild	1
Lead Mild and Copper Severe	1
Total	20

NOTE: Of the 20 failing tests
12 (60%) were on runs with 1005-5 Reference Oil
4 (20%) were on runs with 44-4 Reference Oil
4 (20%) were on runs with 44-5 Reference Oil

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HTCBT Failed Tests by Lab

Failed Parameter	LTMS Lab										#
	A	L	G	I	V	BB	BC	B	P	BE	
Lead Concentration Severe	0	0	1	3	0	0	0	0	1	0	5
Lead Concentration Mild	0	0	1	0	0	0	0	0	0	0	1
Copper Concentration Severe	0	0	3	3	0	0	0	0	0	1	7
Copper Concentration Mild	0	0	4	0	0	0	0	0	0	0	4
Lead & Copper Concentrations Severe	0	0	1	0	0	0	0	0	0	0	1
Lead & Copper Concentrations Mild	1	0	0	0	0	0	0	0	0	0	1
Lead Severe & Copper Mild	0	0	1	0	0	0	0	0	0	0	1
Total	1	0	11	6	0	0	0	0	1	1	20

October 1, 2023 – March 31, 2024

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HTCBT Lost Tests*

Status (LC, XC)	Cause	#
Invalid	Test contaminated with water from condenser	2
Invalid	Air not turned on	1
Aborted	Air supply issues	2
Aborted	Temperature Bath / Heater Malfunction	1
Total		6

*Invalid or Aborted calibration tests

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Test Monitoring Center
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HTCBT Lost Tests by Lab

Failed Parameter (LC, XC)	LTMS Lab										#
	A	L	G	I	V	BB	BC	B	P	BE	
Temperature Bath / Heater Malfunction	1	0	0	0	0	0	0	0	0	0	1
Contamination	0	0	0	0	2	0	0	0	0	0	2
Air Flow Issue	0	0	2	1	0	0	0	0	0	0	3
Total	1	0	2	1	2	0	0	0	0	0	6

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HTCBT Test Status

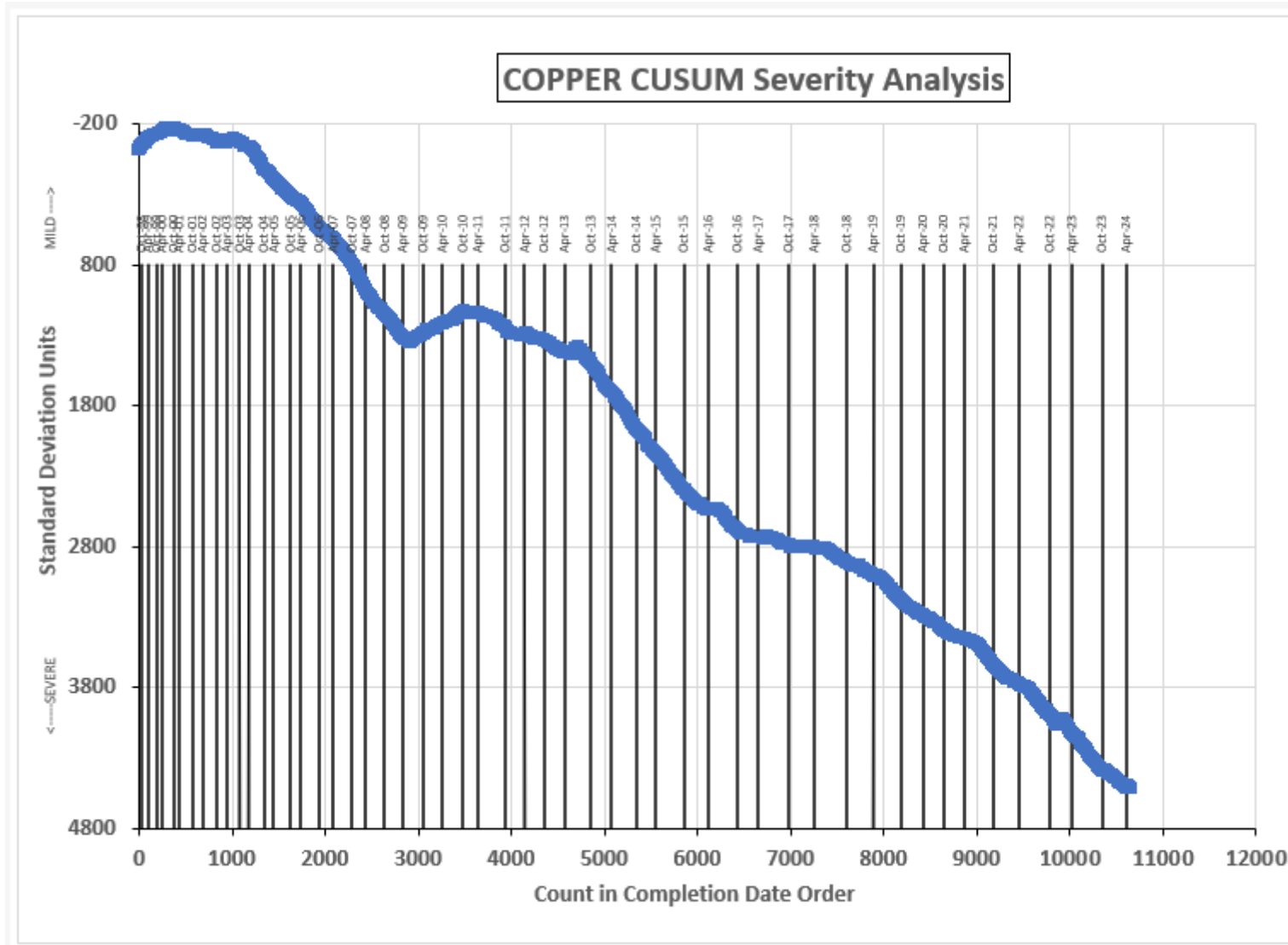
- ▶ New Reference Oil 44-5 has been assigned Acceptance Limits
- ▶ Final samples of Reference Oil 44-4 inventory is being consumed
- ▶ Two fewer labs and seven less stands were calibrated this semester

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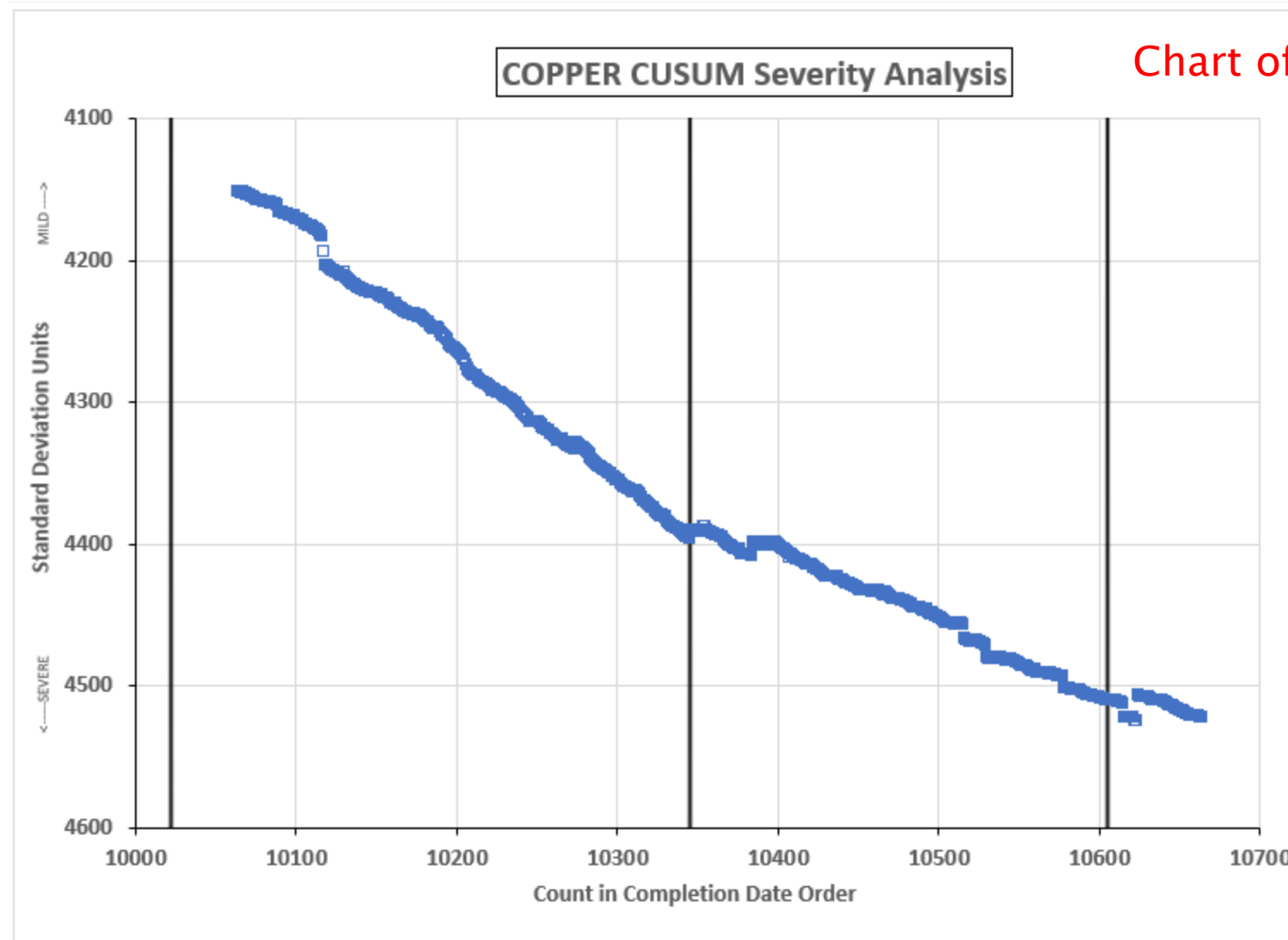
Test Monitoring Center
<https://www.astmtmc.org>



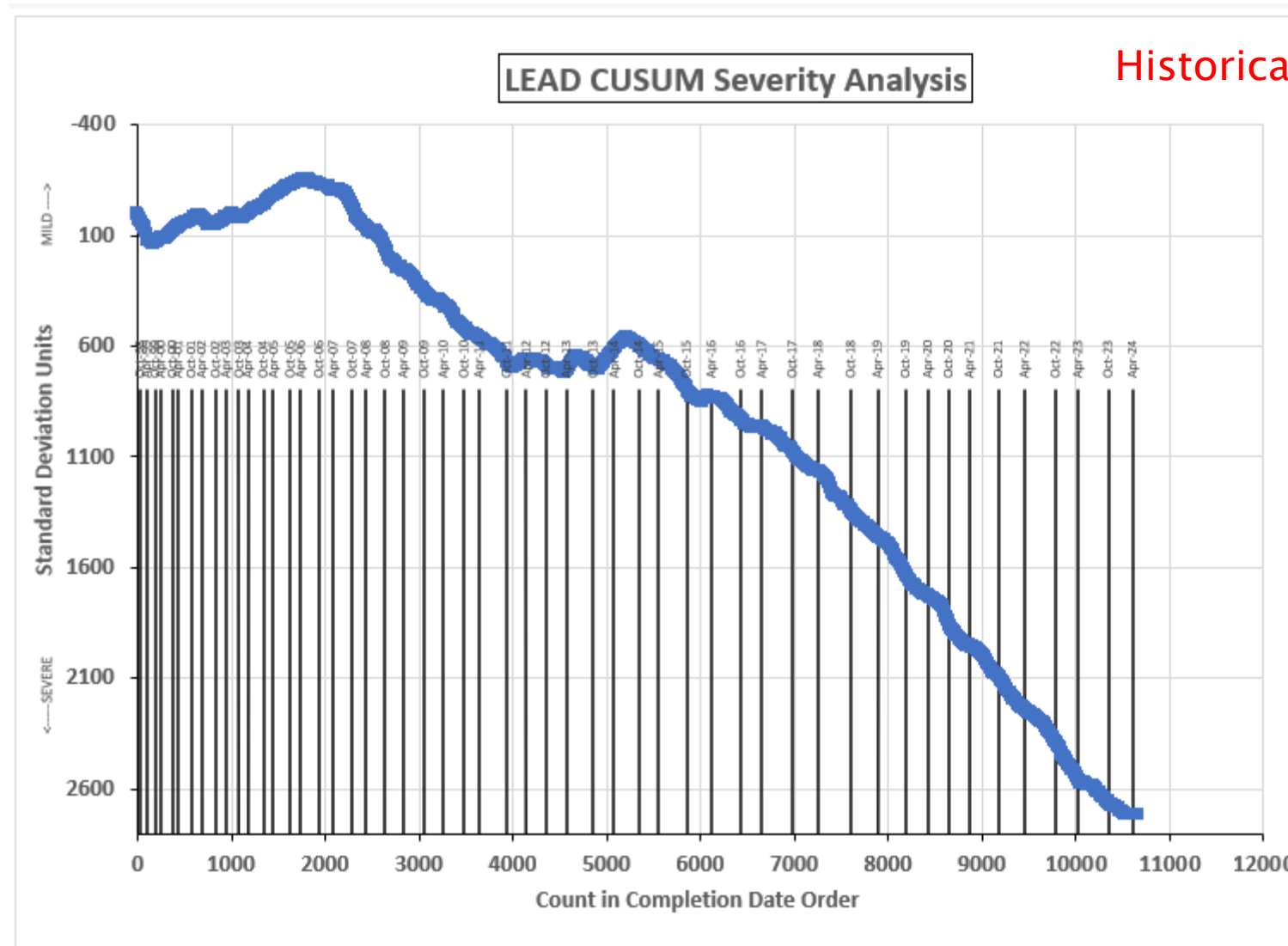
COPPER CHANGE (ppm)



HIGH TEMP CBT INDUSTRY OPERATIONALLY VALID DATA
LAST 600 DATA POINTS
COPPER CHANGE (ppm)



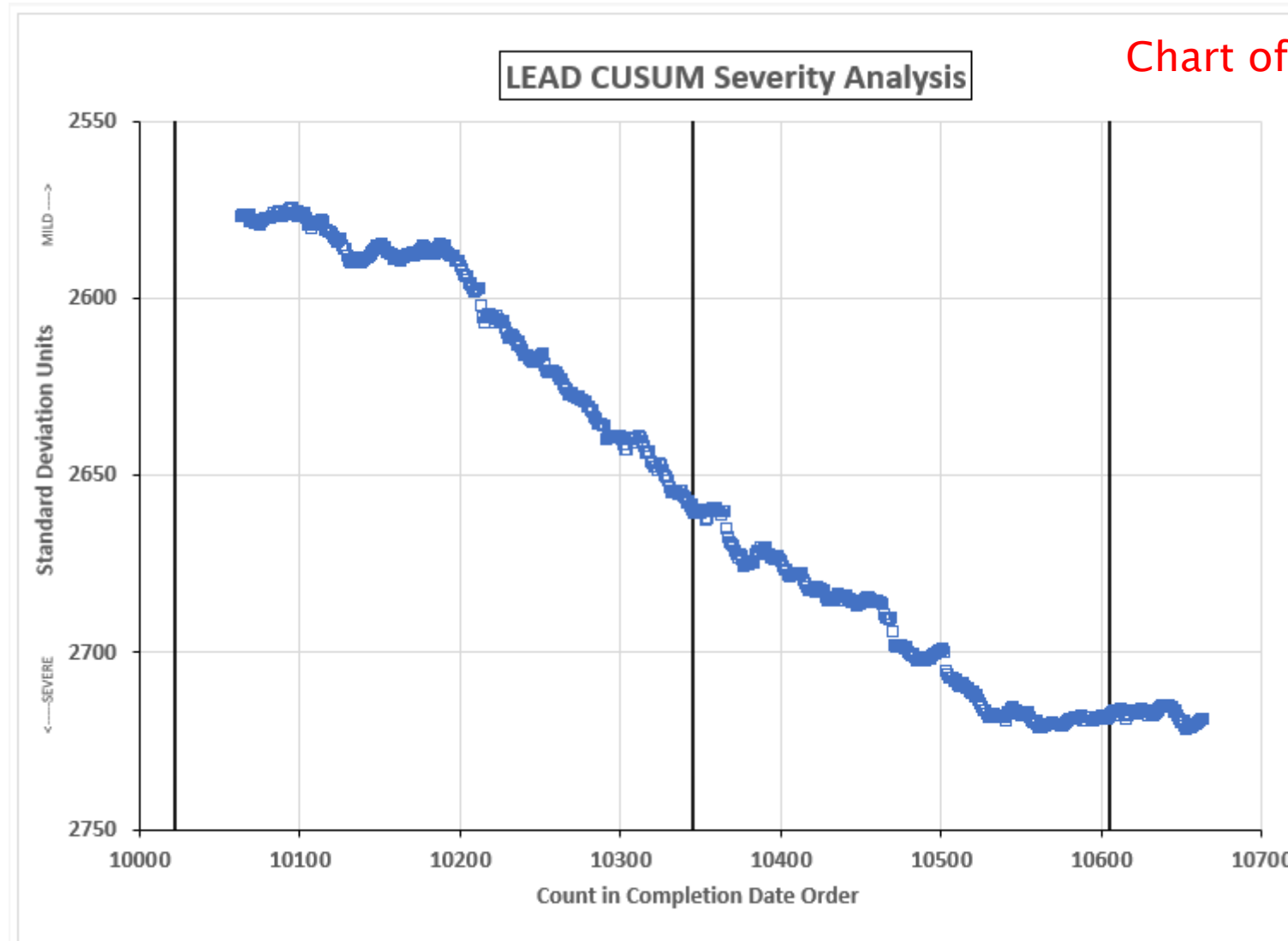
LEAD CHANGE (ppm)



HIGH TEMP CBT INDUSTRY OPERATIONALLY VALID DATA
LAST 600 DATA POINTS
LEAD CHANGE (ppm)



Chart of recent results



HTCBT (D6594): High Temperature Corrosion Bench Test

Period Precision and Severity Estimates: Copper Change

Average Gray Value	n	df	Pooled s	Mean Δ/s
10/1/21 through 3/31/22	305	302	0.31	0.53
4/1/22 through 9/30/22	306	303	0.33	0.63
10/1/22 through 3/31/23	263	260	0.66	0.57
4/1/23 through 9/30/23	296	293	0.34	0.87
10/1/23 through 3/31/24	287	284	0.44	0.39

*Period statistics for all Valid Reference Oil Results (pooled)

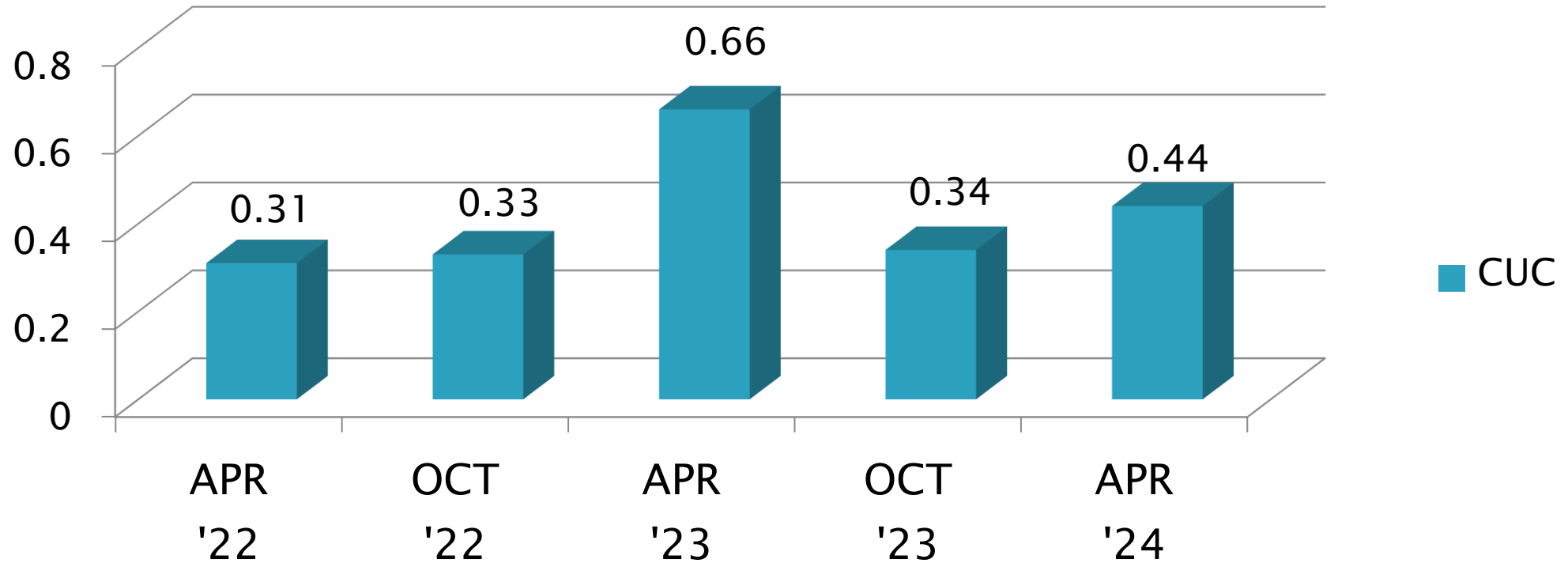
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HTCBT Precision (Pooled s) Estimates

COPPER CHANGE



October 1, 2023 – March 31, 2024

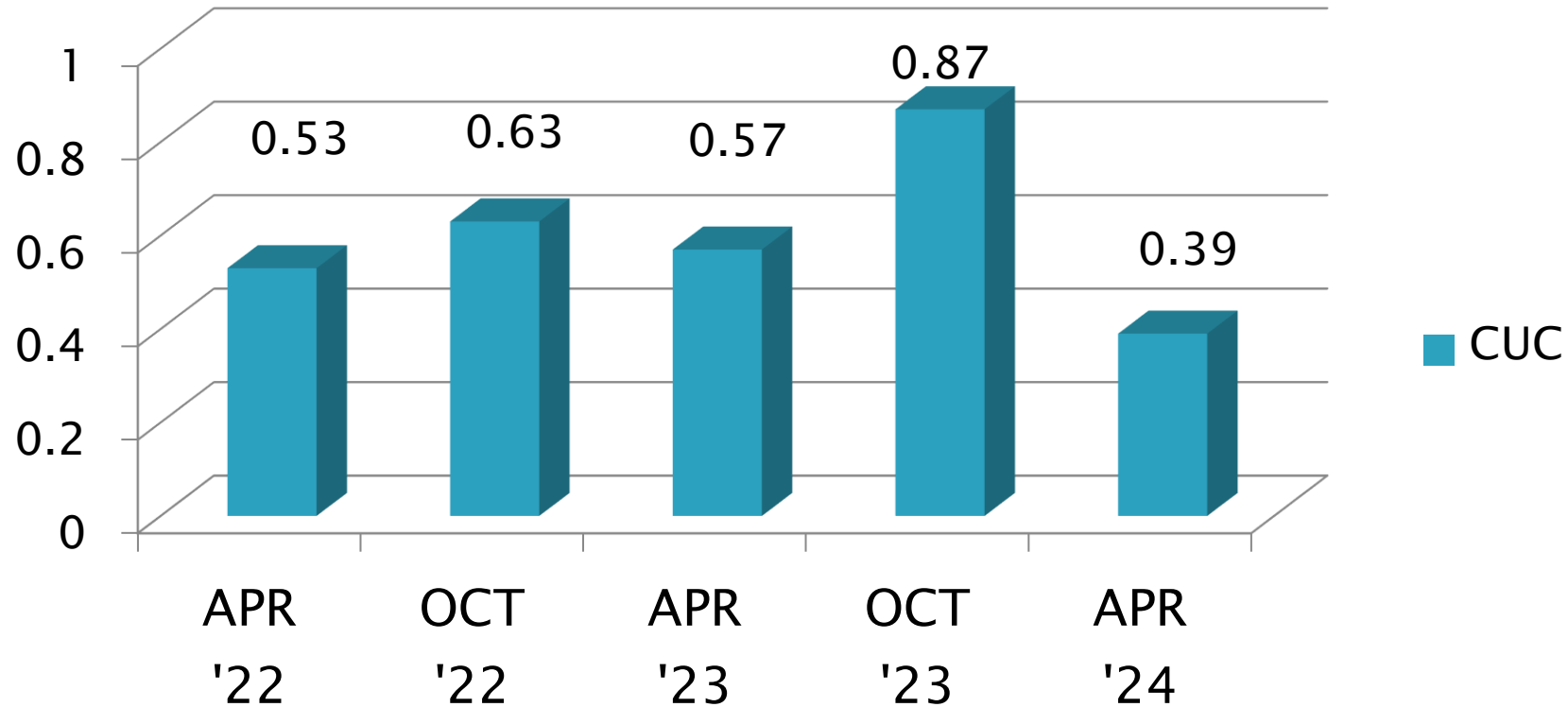
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HTCBT Performance (mean Δ/s) Estimates

COPPER CHANGE



October 1, 2023 – March 31, 2024

Test Monitoring Center
<https://www.astmtmc.org>



HTCBT (D6594): High Temperature Corrosion Bench Test

Period Precision and Severity Estimates: Lead Change

Average Gray Value	n	df	Pooled s	Mean Δ/s
10/1/21 through 3/31/22	305	302	8.20	0.55
4/1/22 through 9/30/22	306	303	5.72	0.43
10/1/22 through 3/31/23	263	260	11.6	0.69
4/1/23 through 9/30/23	296	293	6.91	0.31
10/1/23 through 3/31/24	287	284	6.89	0.20

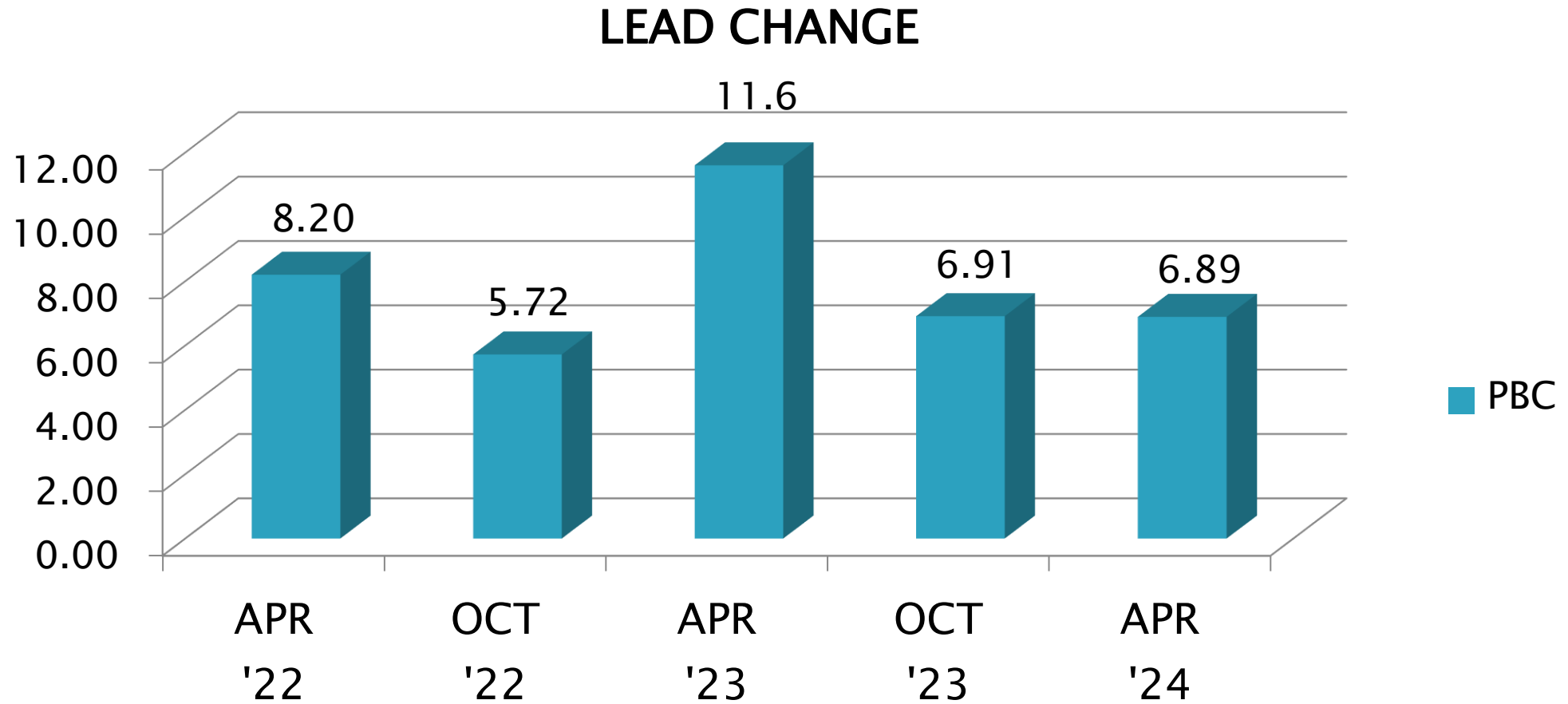
*Period statistics for all Valid Reference Oil Results (pooled)

October 1, 2023 – March 31, 2024

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HTCBT Precision (Pooled s) Estimates



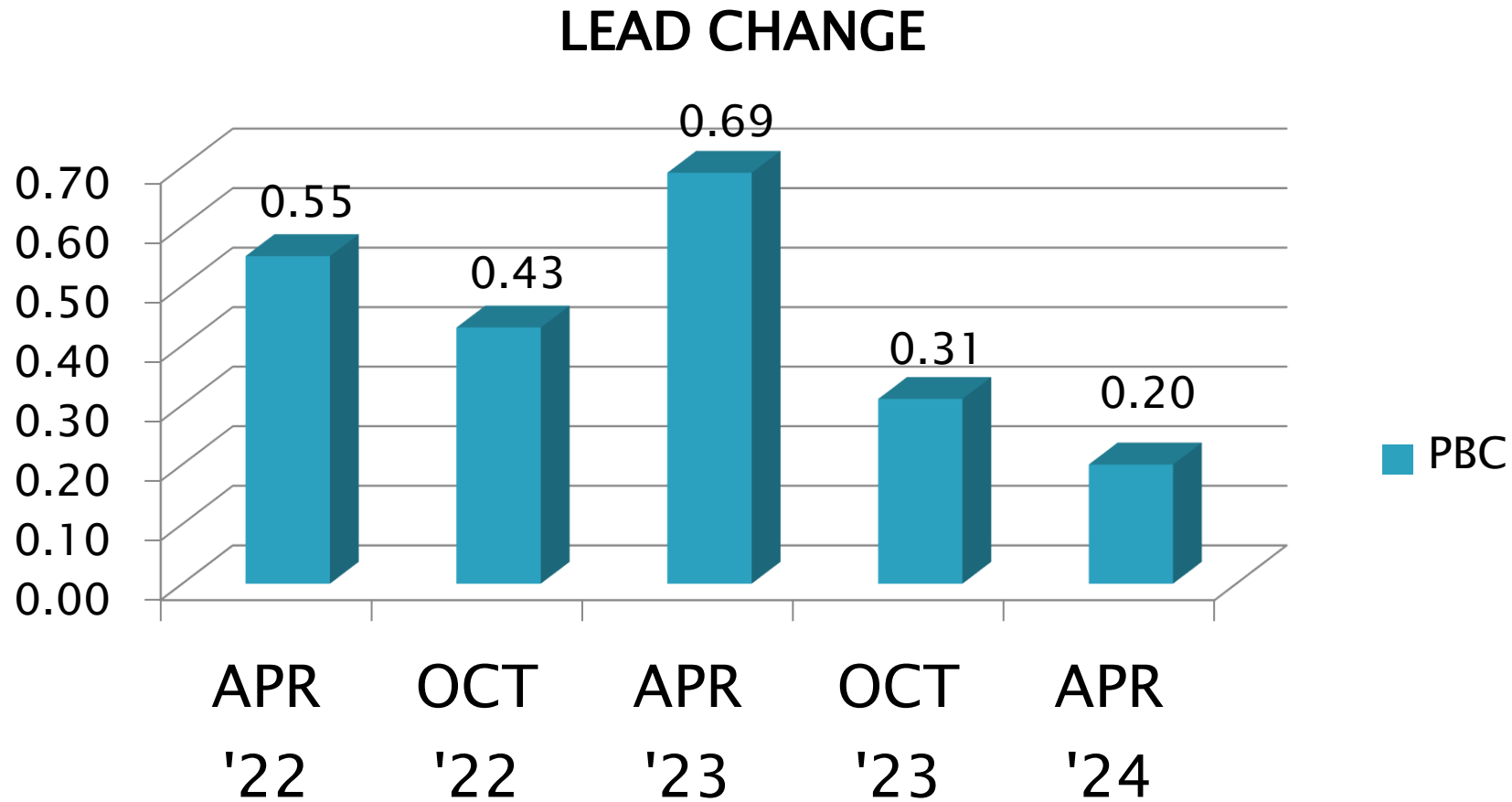
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HTCBT Performance (mean Δ/s) Estimates

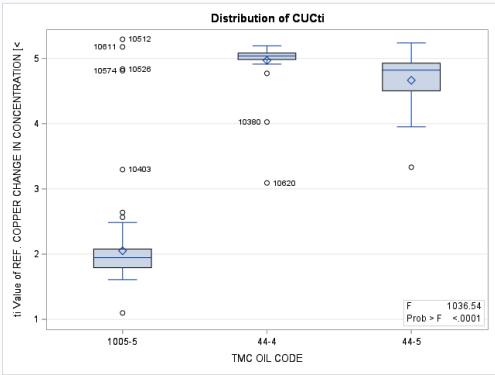


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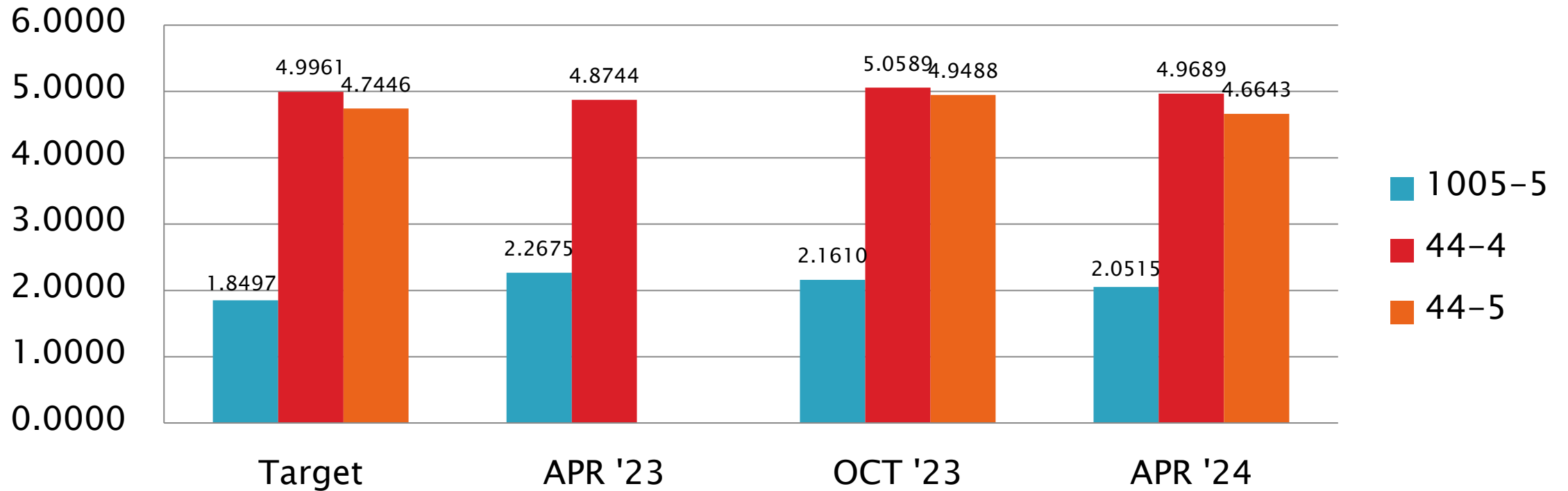


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HTCBT Performance by OIL

Copper Concentration* Mean

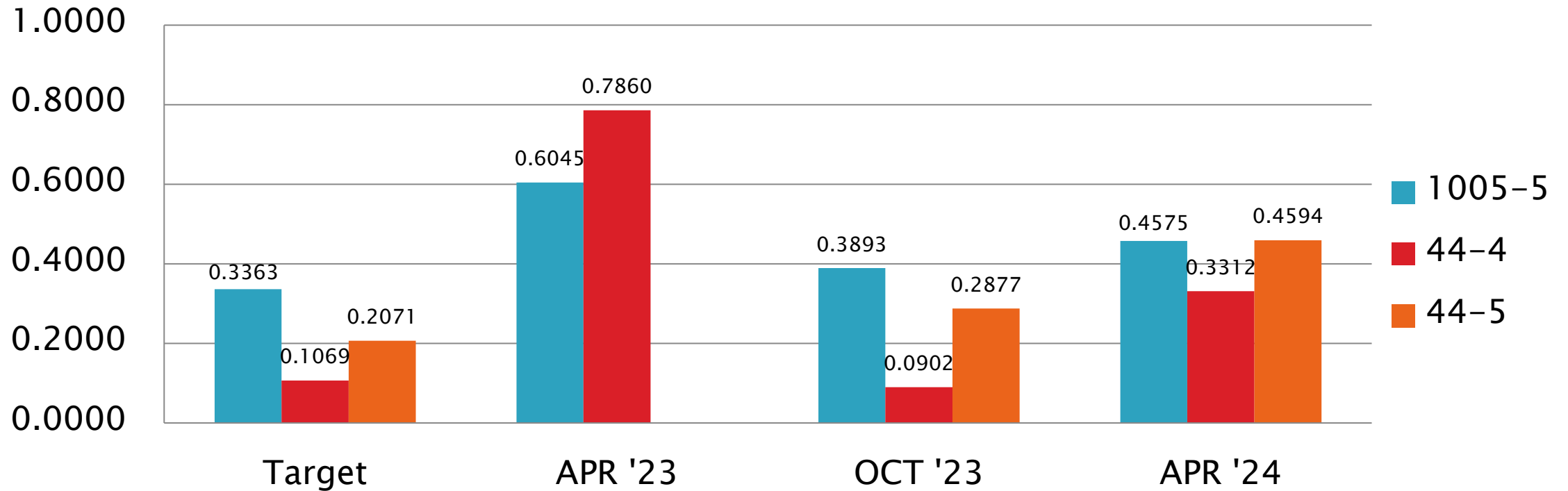


*Transformed Units

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HTCBT Performance by OIL

Copper Concentration Standard Deviation



October 1, 2023 - March 31, 2024

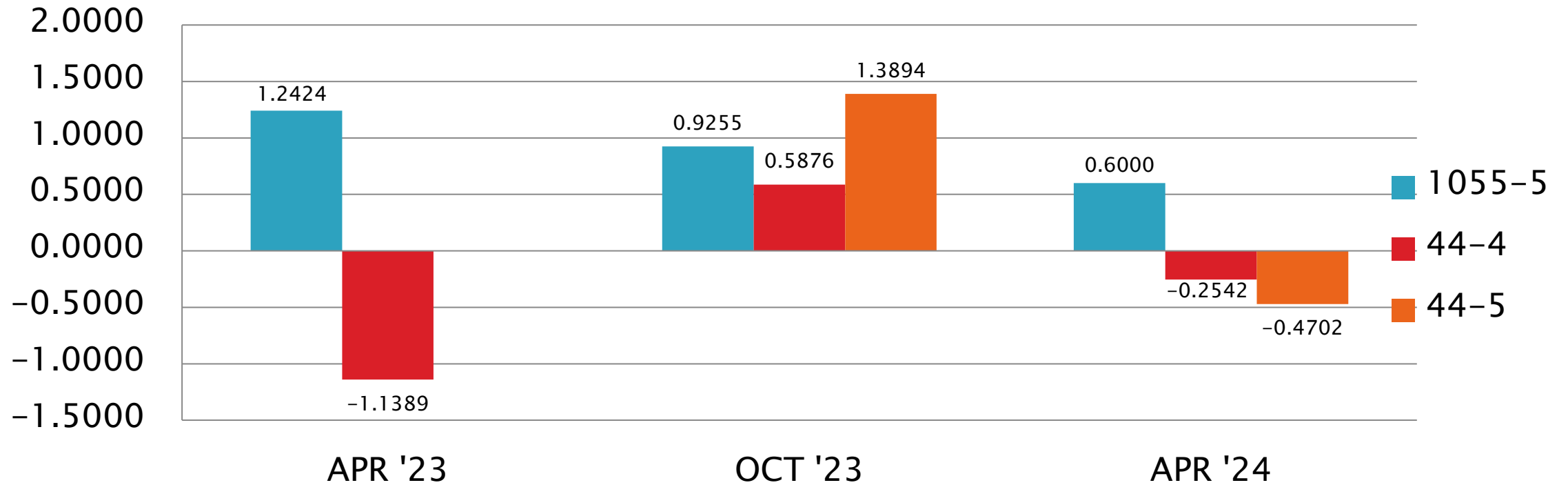
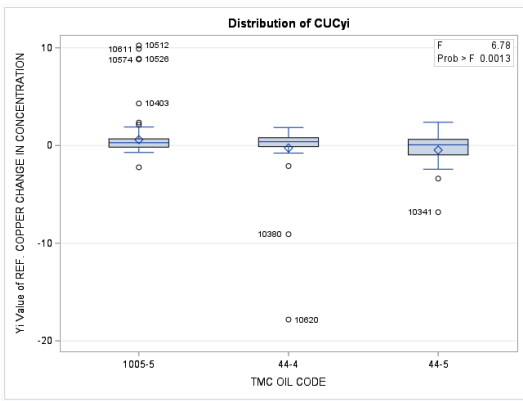
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HTCBT Performance by OIL

Copper Concentration MEAN Δ/s



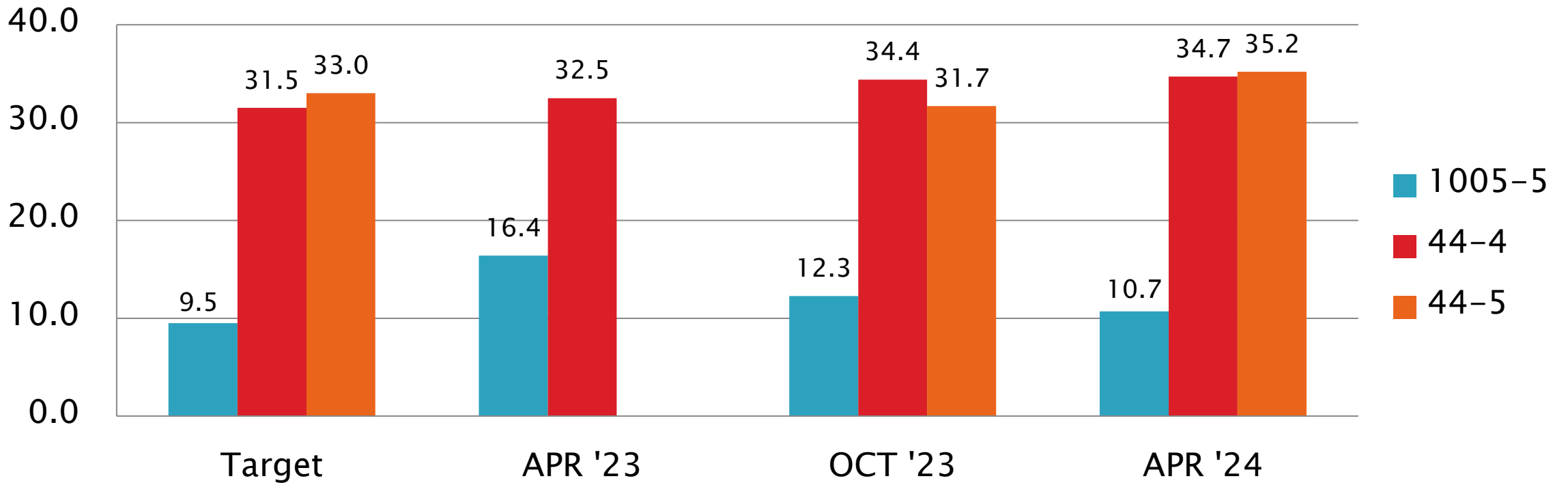
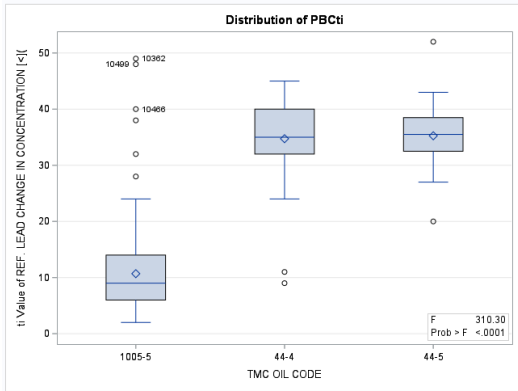
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HTCBT Performance by OIL

Lead Concentration Mean



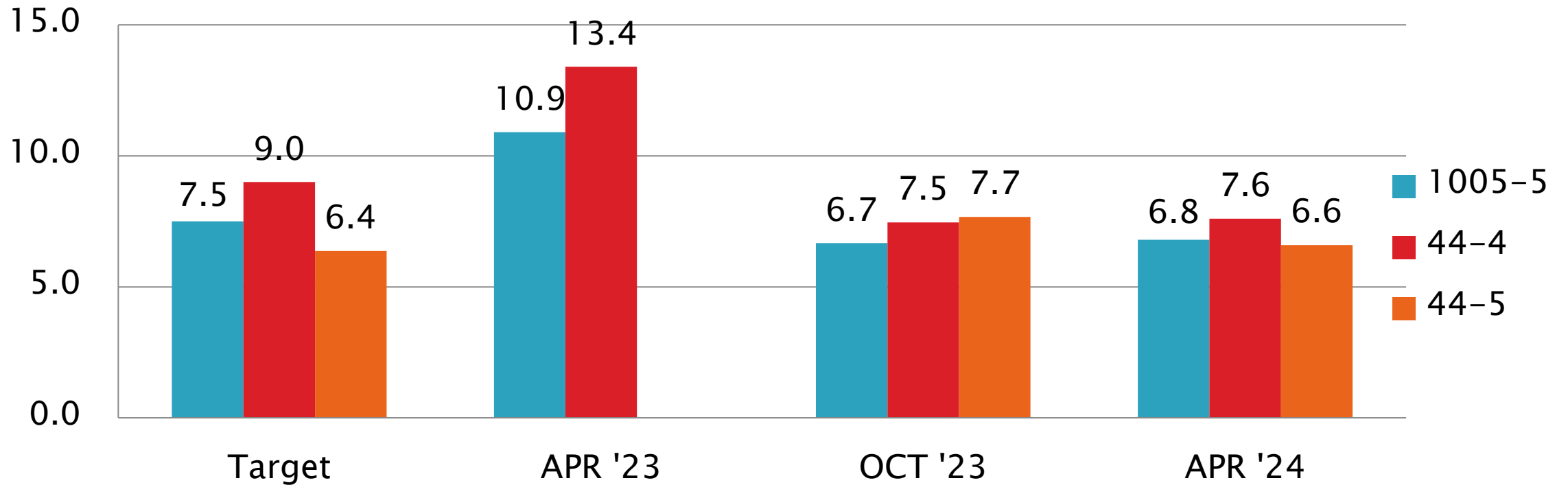
October 1, 2023 - March 31, 2024

Test Monitoring Center
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HTCBT Performance by OIL

Lead Concentration Standard Deviation

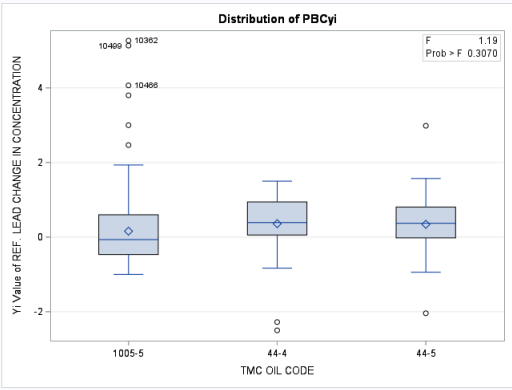


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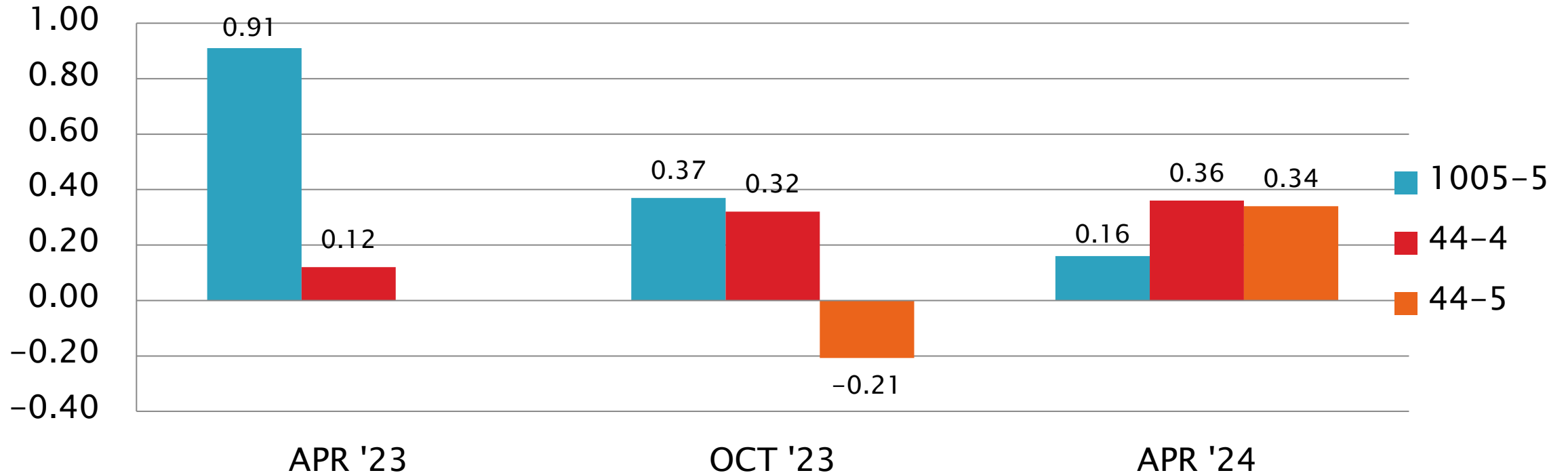


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HTCBT Performance by OIL

Lead Concentration
MEAN Δ/s



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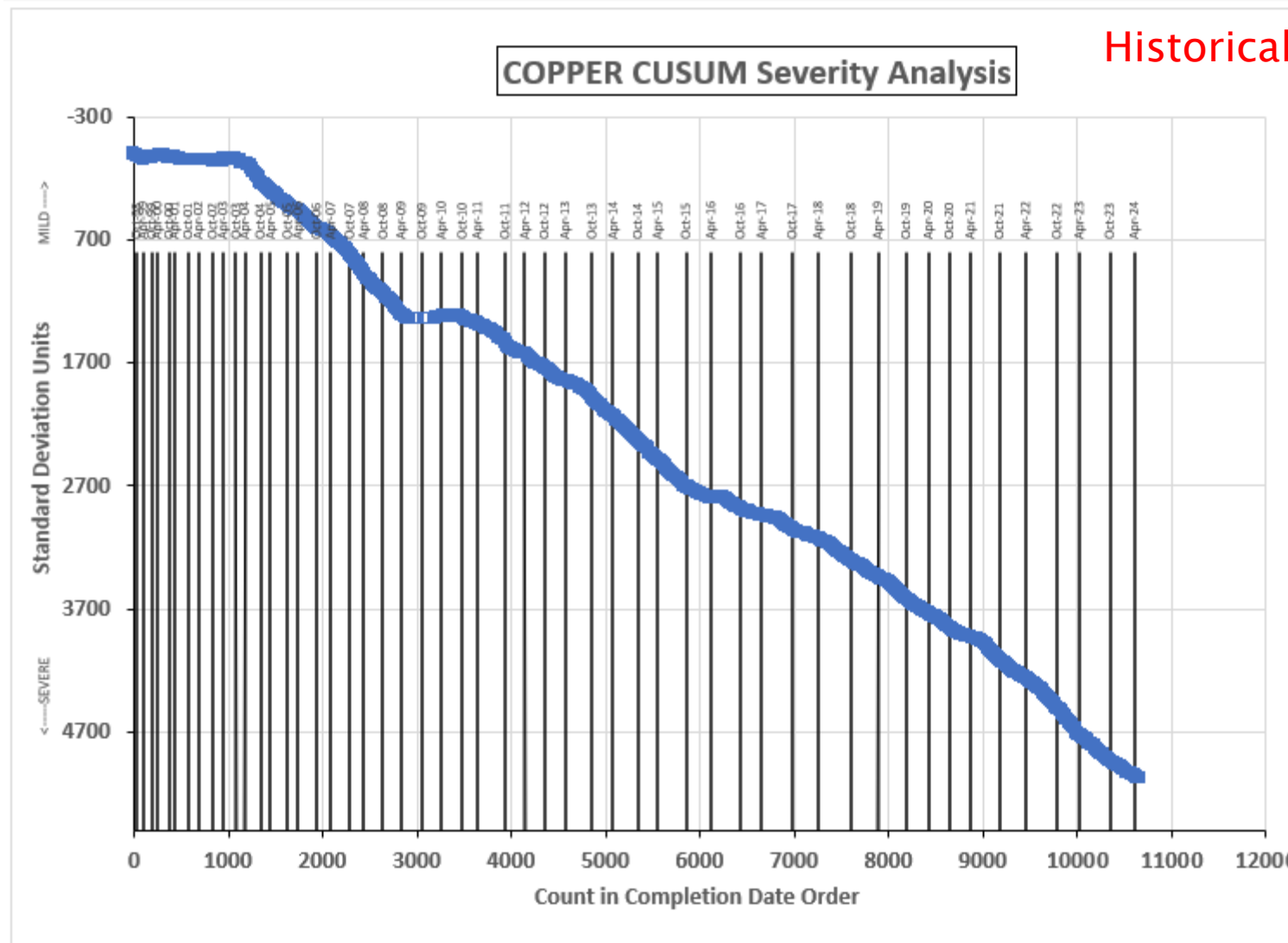


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HIGH TEMP CBT INDUSTRY OPERATIONALLY VALID DATA
Oil 1005 → Only
COPPER CHANGE (ppm)



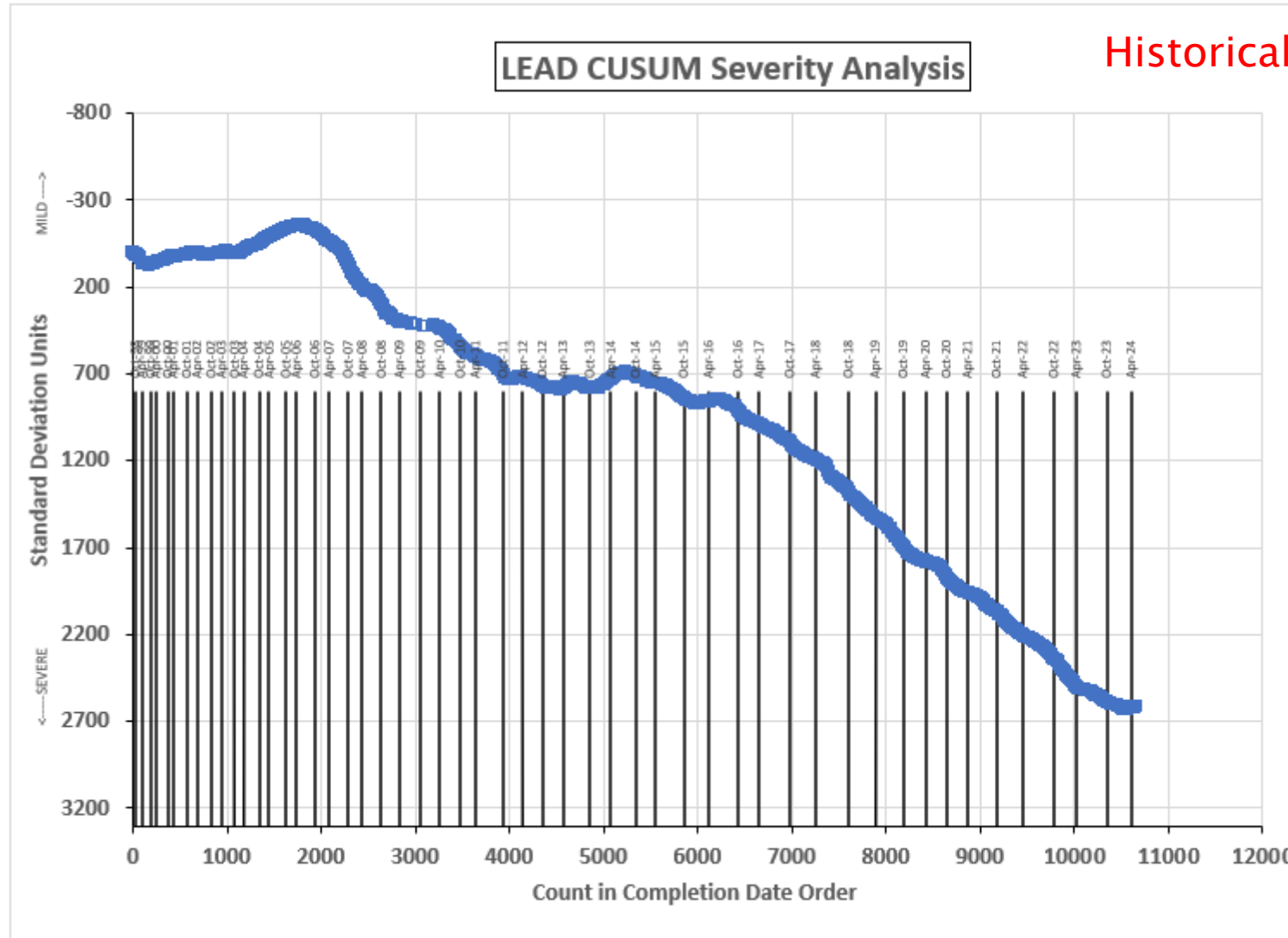
Historical 1005-x Chart



HIGH TEMP CBT INDUSTRY OPERATIONALLY VALID DATA
Oil 1005 → Only
LEAD CHANGE (ppm)



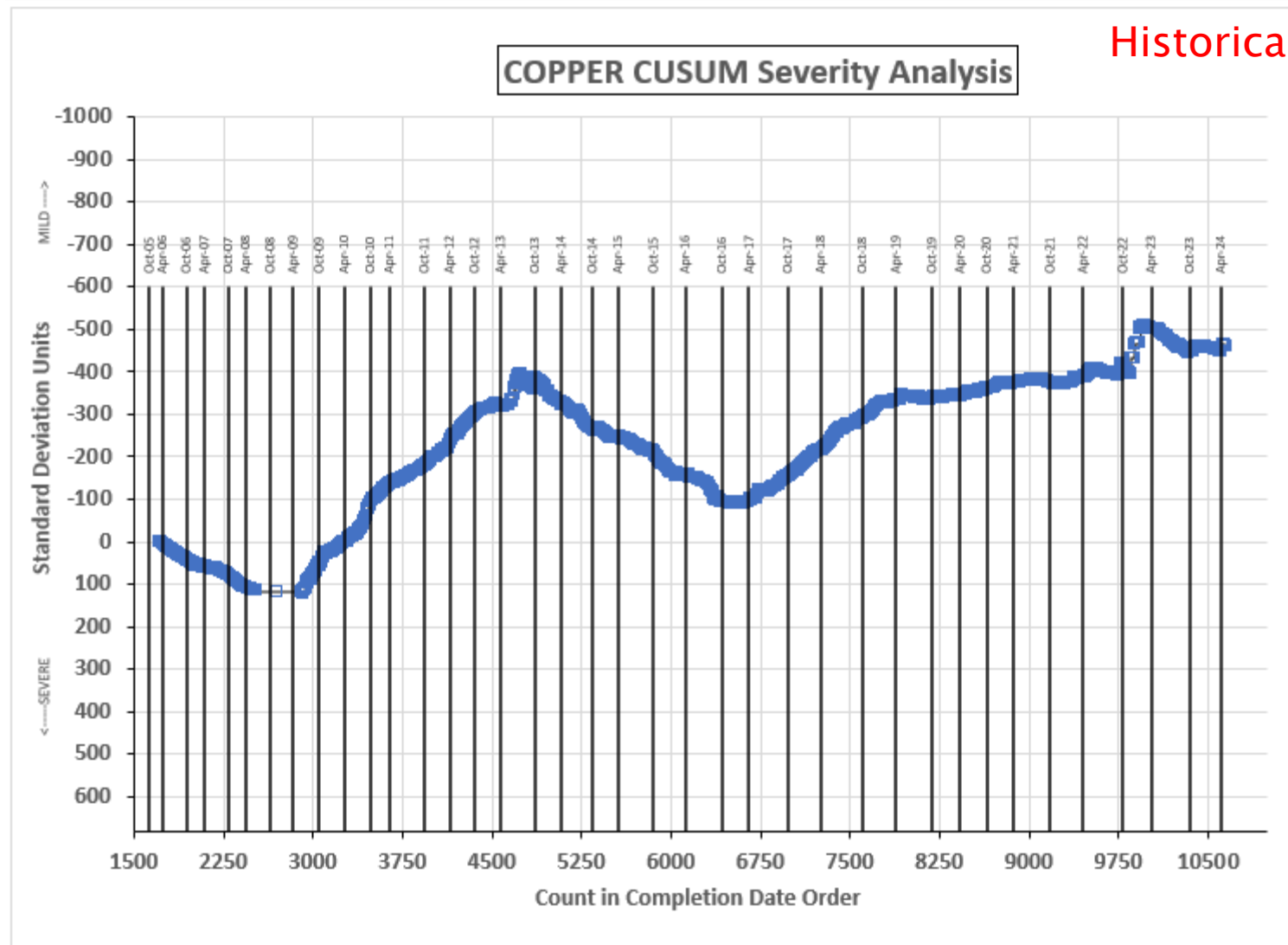
Historical 1005-x Chart



HIGH TEMP CBT INDUSTRY OPERATIONALLY VALID DATA
Oil 44 → Only
COPPER CHANGE (ppm)



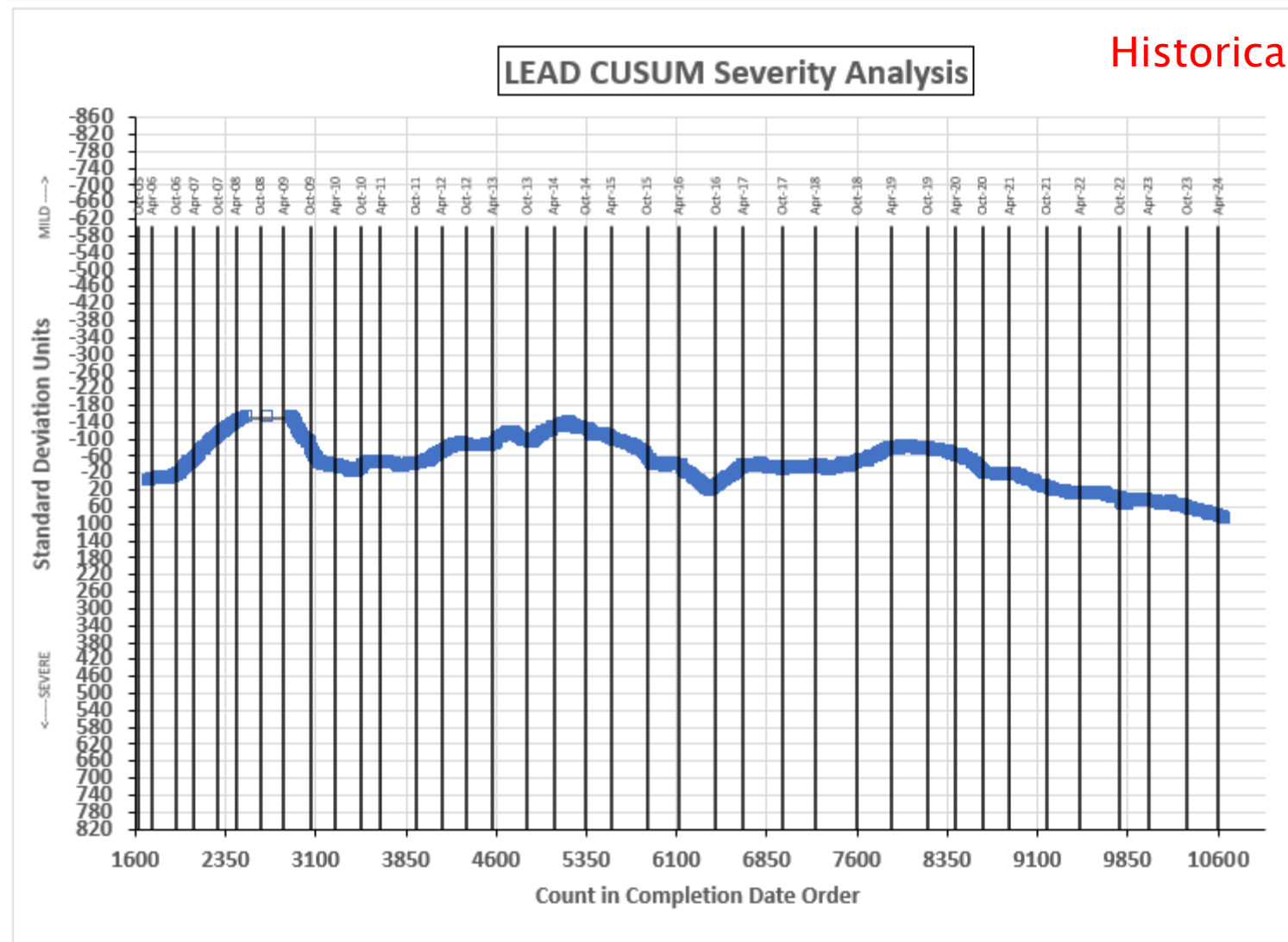
Historical 44-x Chart



HIGH TEMP CBT INDUSTRY OPERATIONALLY VALID DATA
Oil 44 →x Only
LEAD CHANGE (ppm)



Historical 44-x Chart



Information Letters and Memos*

Test	Date	IL/Memo	Topic
HTCBT	20241229	M23-041	RO 44-5 Acceptance Bands Updated

*Available from TMC Website

October 1, 2023 – March 31, 2024

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Reference Oil 44-5 Acceptance Bands Update

- ▶ Reference Oil 44-5 completed 49 HTCBT Tests
 - 49 Valid HTCBT Results (16 Round Robin + 33 Calibration Tests)

Parameter	Target (Mean)	STDEV	Maximum	Minimum
Copper Change	4.8268*	0.3608*	253 ppm	62 ppm
Lead Change	32.67 ppm	7.652	47 ppm	18 ppm

* Natural Log Transformed Parameter

Memo 23-041. December 29, 2023

Surveillance Panel approved these Acceptance Ranges for RO 44-5

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Reference Oil Inventory Estimated Life

D6594

Oil	TMC Inventory (gallons)	Quantity Shipped in last 6 months (gallons)	Lab Assignments Made	Estimated Life
44-4	1.9	0.7	50	<1 year
44-5	52	1.0	30	>5 year
1005-5	34.91 (Reserved drum - Additional oil available at the TMC)	8.34	240	>5 years

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D02.B0.07 TMC Monitored Tests



ASTM D 6794

Engine Oil Water Tolerance (EOWT)

October 1, 2023 – March 31, 2024

Calibrated Labs and Stands*

(change since last Semi-Annual report)

Test	Labs	Stands
D6794	6 (+0)	N/A

*As of 3/31/2024

EOWT Test Activity by Treat Rate

Test Status	Validity Code	Number of Tests by Water Treat Rate				Total
		0.6%	1.0%	2.0%	3.0%	
Acceptable Calibration Test	AC	185	184	184	187	740
Failed Calibration Test	OC	2	2	3	0	7
Acceptable Information Run	NN	0	0	0	0	0
Unacceptable Information Run	MN	0	0	0	0	0
Invalid Calibration Test	LC, RC	0	0	1	0	1
Aborted Calibration Test	XC	0	0	0	0	0
Total		187	186	188	187	748

- 6 labs reported data

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EOWT Test Activity by Reference Oil*

Test Status	Validity Code	Number of Tests by Reference Oil		Total
		77-3	79	
Acceptable Calibration Test	AC	365	375	740
Failed Calibration Test	OC	4	3	7
Acceptable Informational Test	NN	0	0	0
Unacceptable Informational Test	MN	0	0	0
Invalid Calibration Test	LC, RC	1	0	1
Aborted Calibration Test	XC	0	0	0
Total		370	378	748

- No Informational runs requested this semester

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EOWT Failed Tests

Failed Parameter (OC)	Number of Tests				Total
	0.6%	1.0%	2.0%	3.0%	
Severe Change in Flowrate	1	1	2	0	4
Mild Change in Flowrate	1	1	1	0	3
Total	2	2	3	0	7

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EOWT Failed Tests by Lab

Failed Parameter (OC)	LTMS Lab						#
	A	B	BE	G	I	L	
Severe Change in Flowrate	3	0	0	0	1	0	4
Mild Change in Flowrate	2	0	0	0	1	0	3
Total	5	0	0	2	0	0	7

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EOWT Lost Calibration Tests*

Cause	Number of Tests				#
	0.6%	1.0%	2.0%	3.0%	
Wide Difference in measured CFA's	0	0	1	0	1
Total	0	0	1	0	1

*Invalid (LC,RC) and Aborted (XC) calibration tests

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EOWT Test Severity

- ▶ Change in Flowrate Average (CIFA) continues to trend severe for all water treat rates except for 0.6% which went mild this semester.

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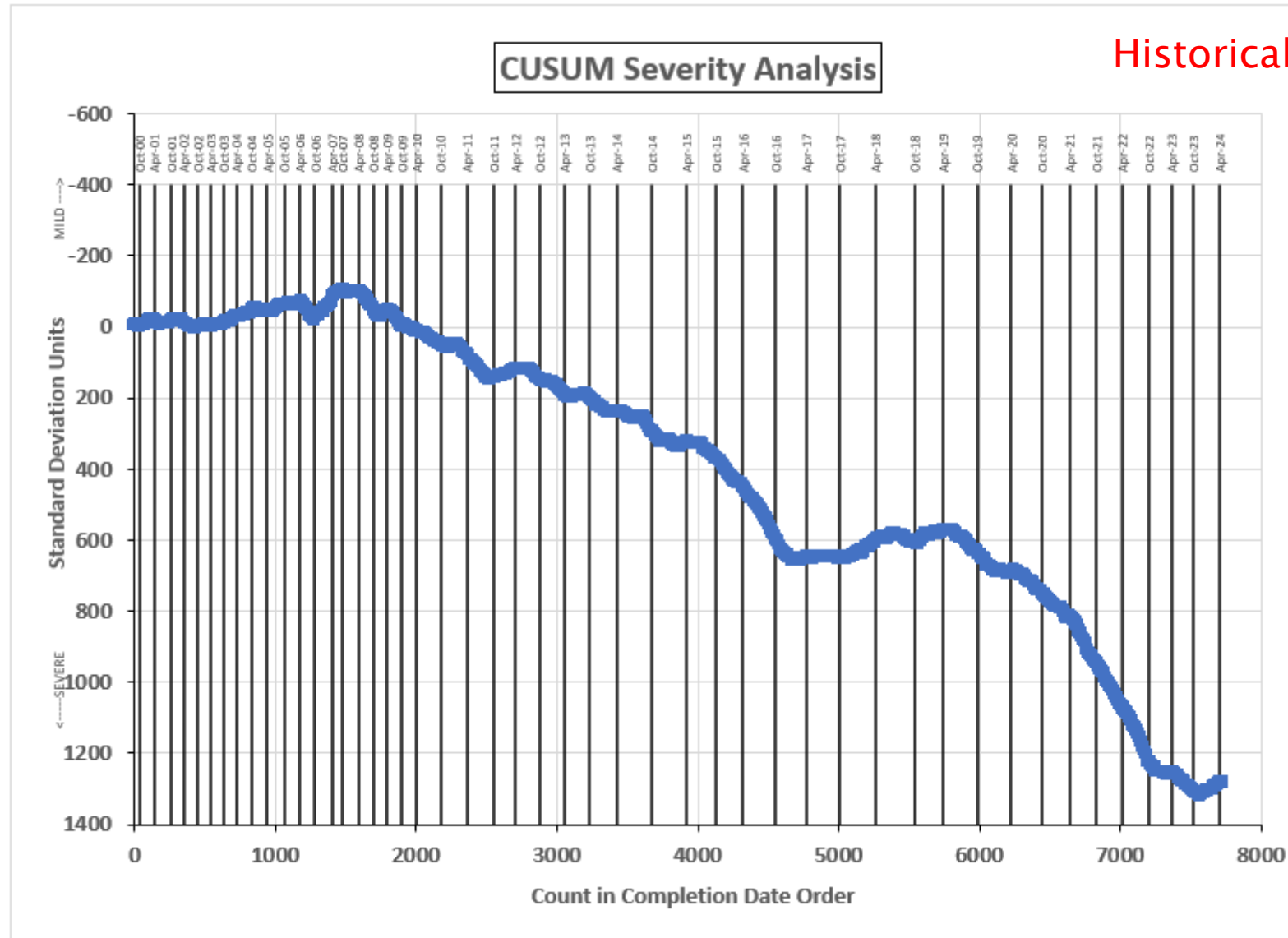


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EOWT INDUSTRY OPERATIONALY VALID DATA
CFA 0.6% Water Treat Rate
20 —25 ML CHANGE IN FLOWRATE AVG.



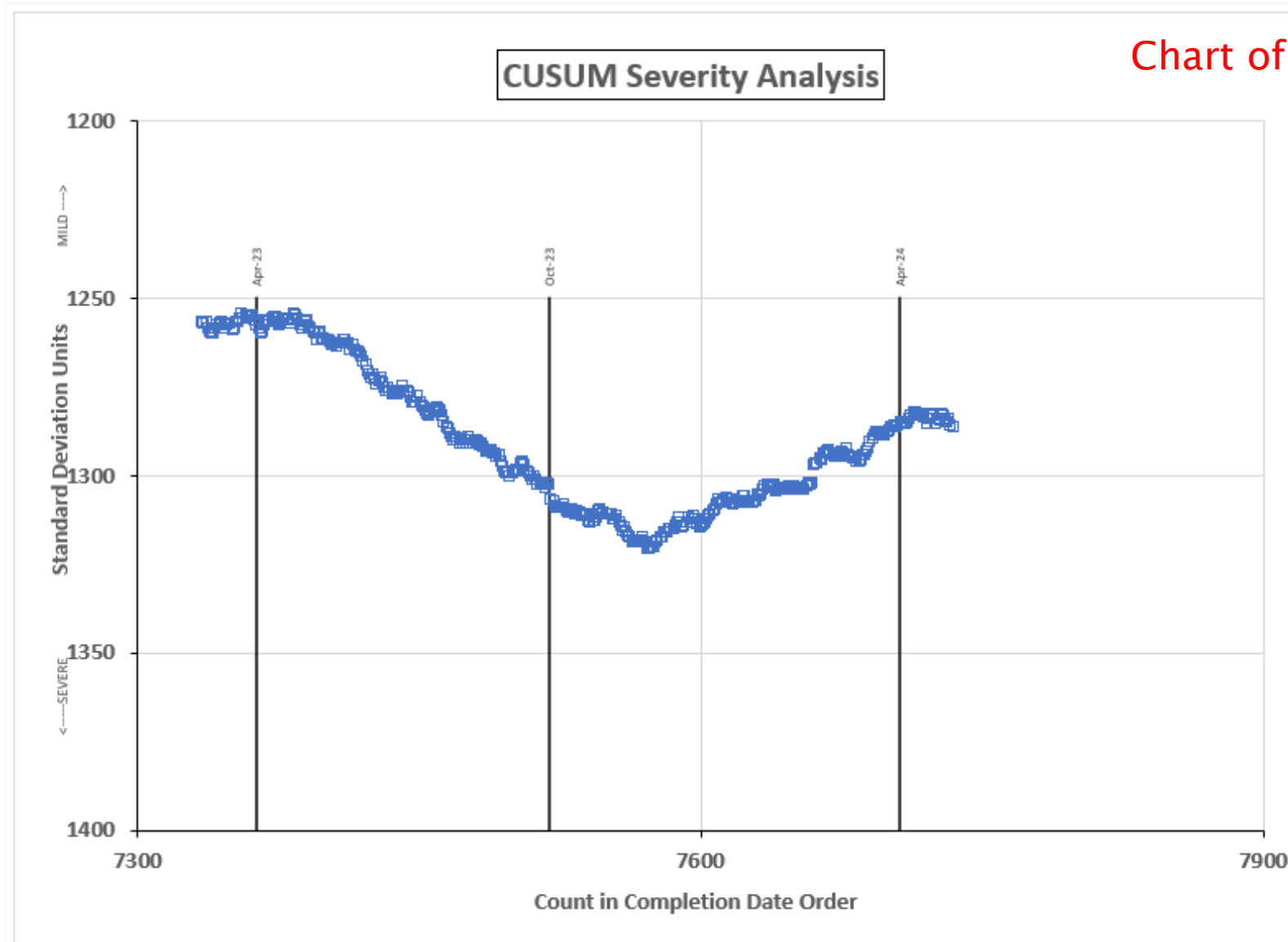
Historical Chart



EOWT INDUSTRY OPERATIONALLY VALID DATA
CFA 0.6% Water Treat Rate (Last 400 Data Points)
20 —25 ML CHANGE IN FLOWRATE AVG.



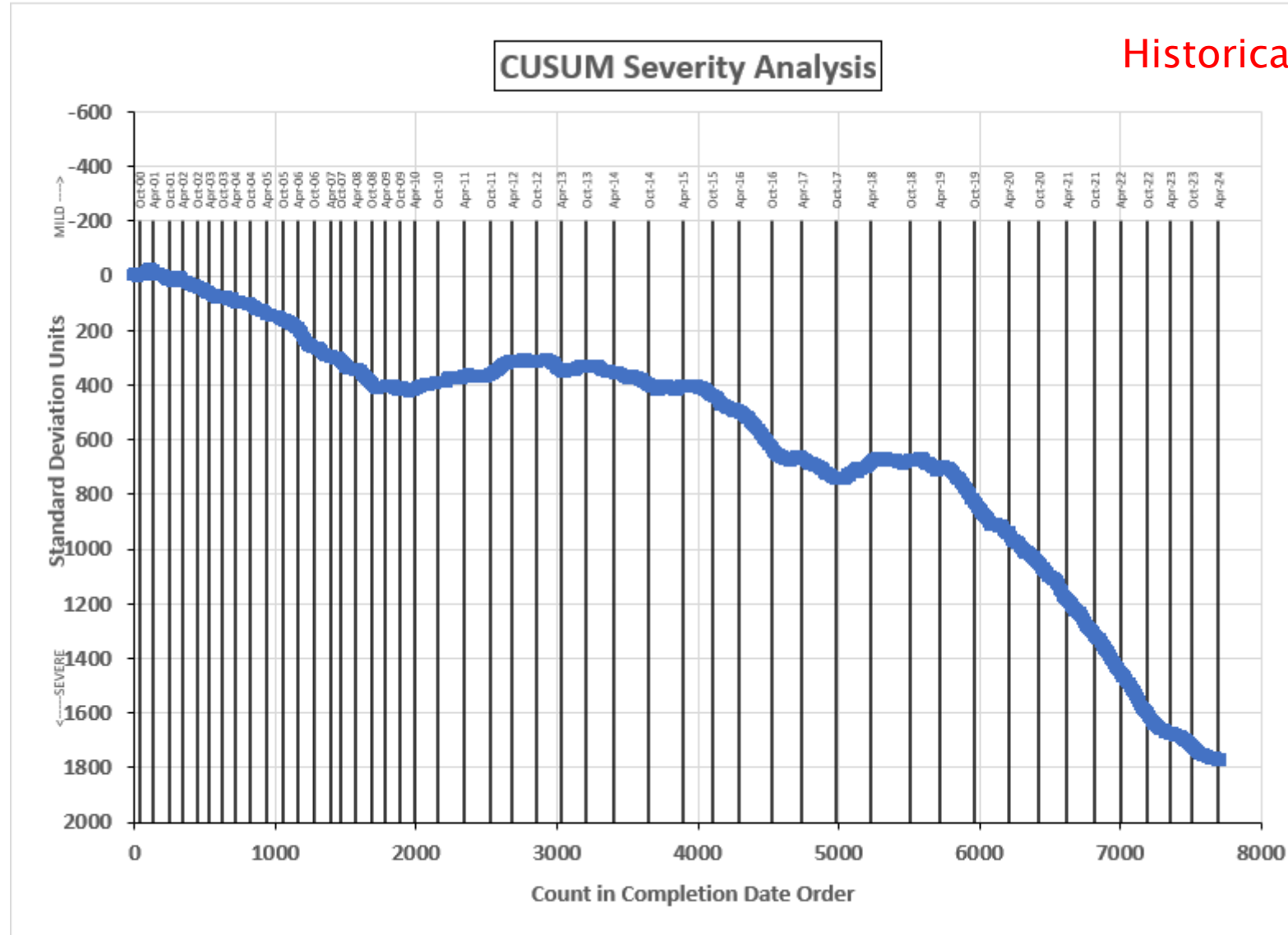
Chart of recent results



EOWT INDUSTRY OPERATIONALLY VALID DATA
CFA 1.0% Water Treat Rate
20 —25 ML CHANGE IN FLOWRATE AVG.



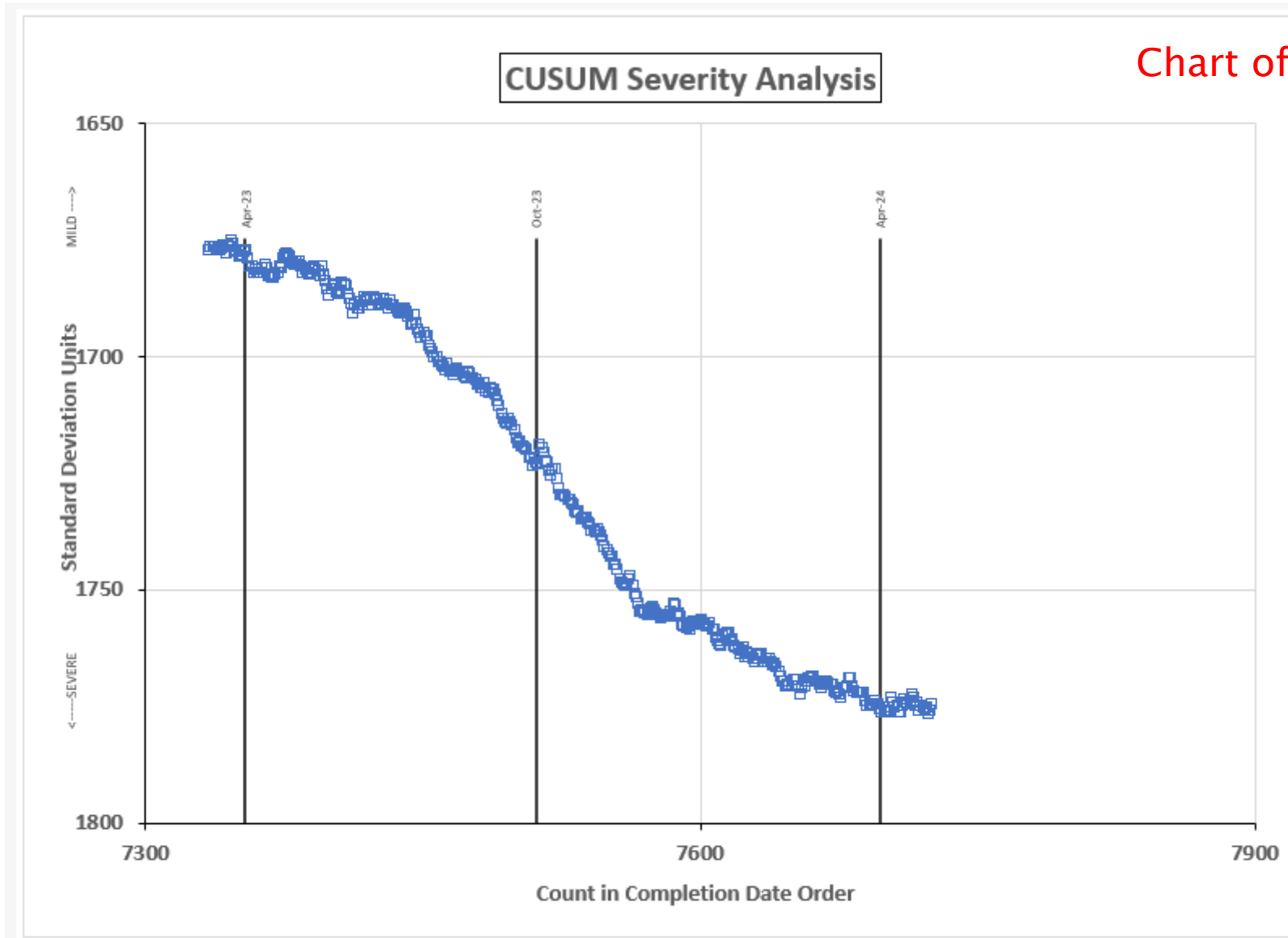
Historical Chart



EOWT INDUSTRY OPERATIONALLY VALID DATA
CFA 1.0% Water Treat Rate (Last 400 Data Points)
20 —25 ML CHANGE IN FLOWRATE AVG.



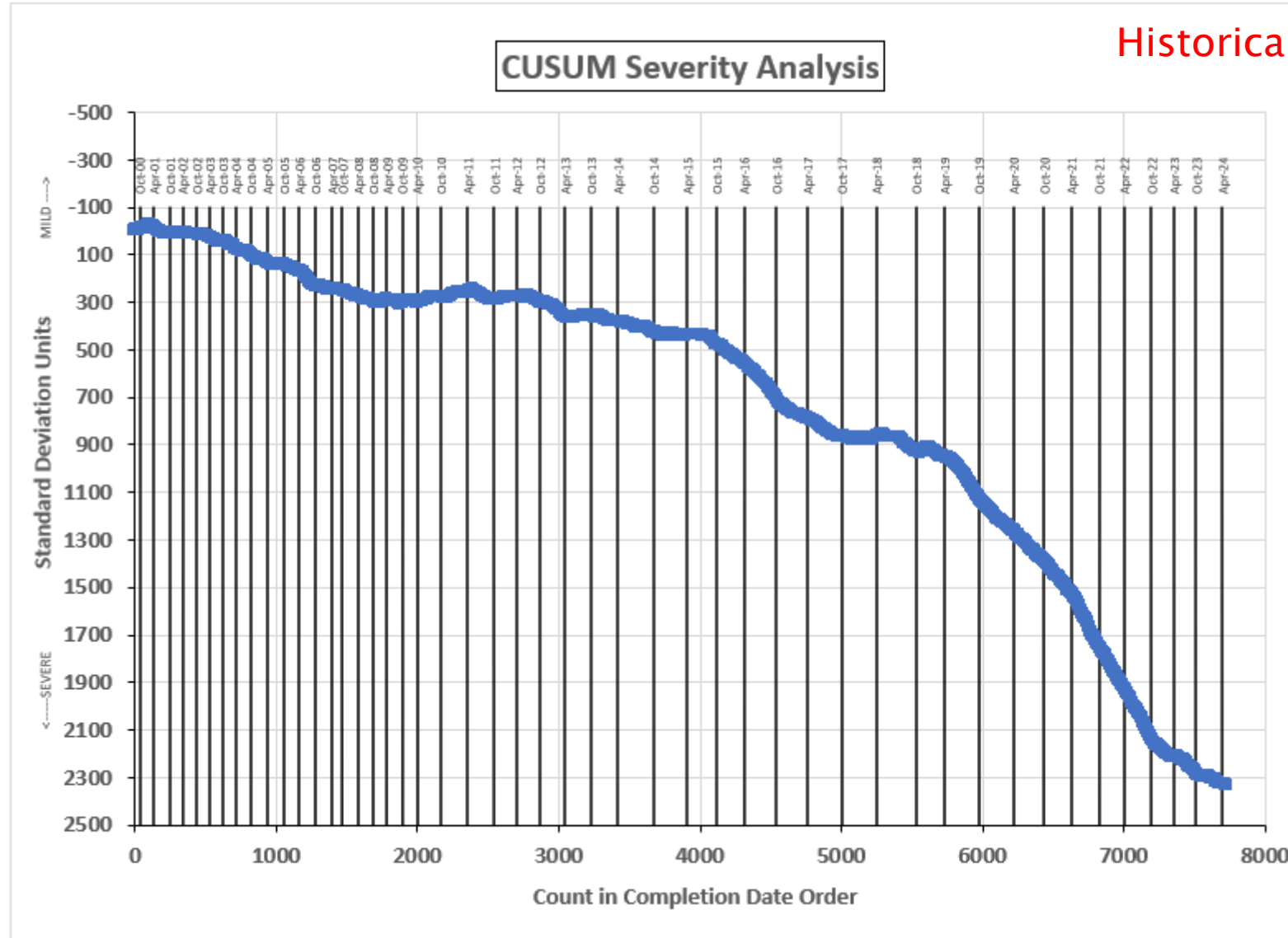
Chart of recent results



EOWT INDUSTRY OPERATIONALLY VALID DATA
CFA 2.0% Water Treat Rate
20 —25 ML CHANGE IN FLOWRATE AVG.



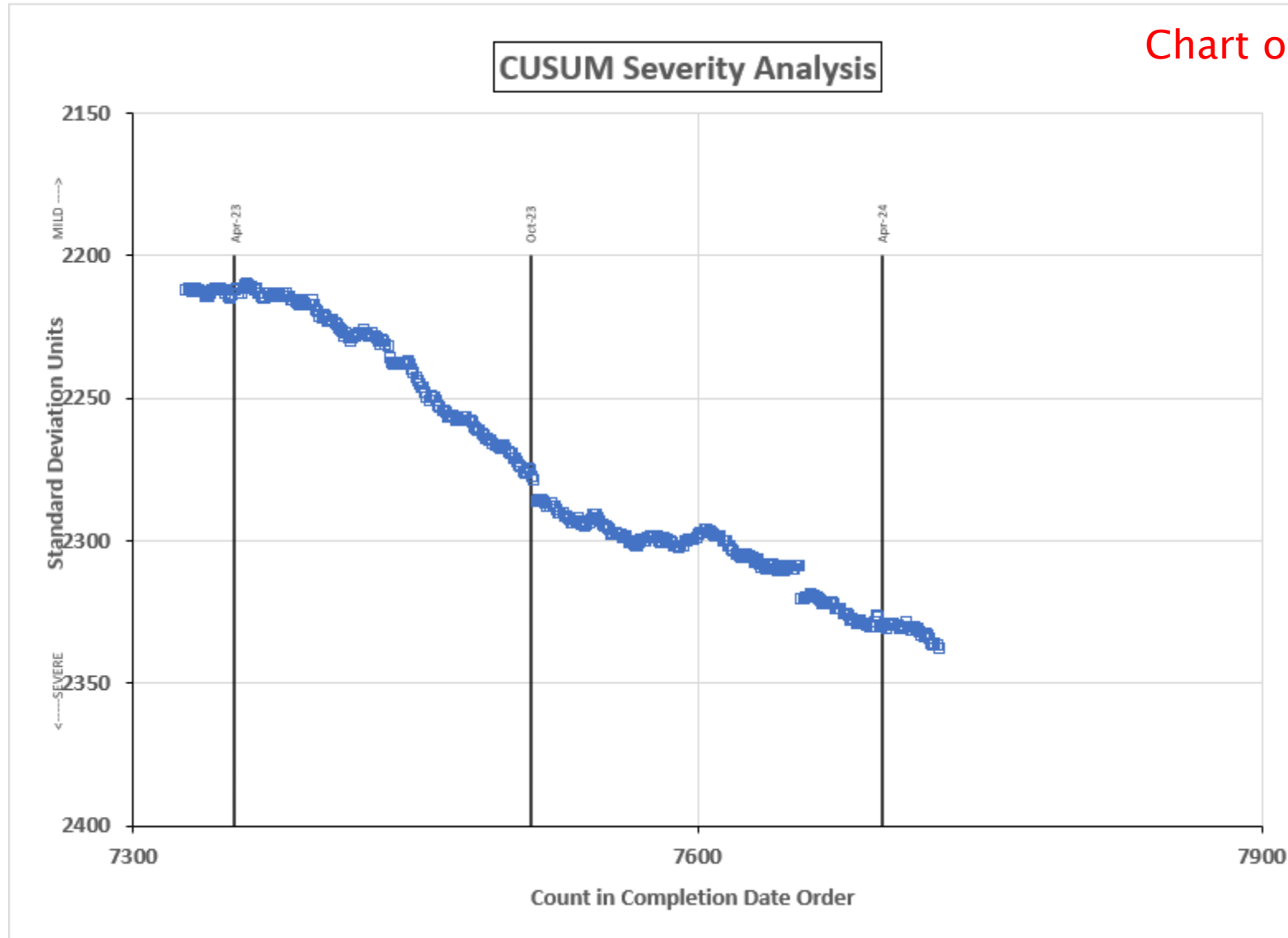
Historical Chart



EOWT INDUSTRY OPERATIONALLY VALID DATA
CFA 2.0% Water Treat Rate (Last 400 Data Points)
20 —25 ML CHANGE IN FLOWRATE AVG.

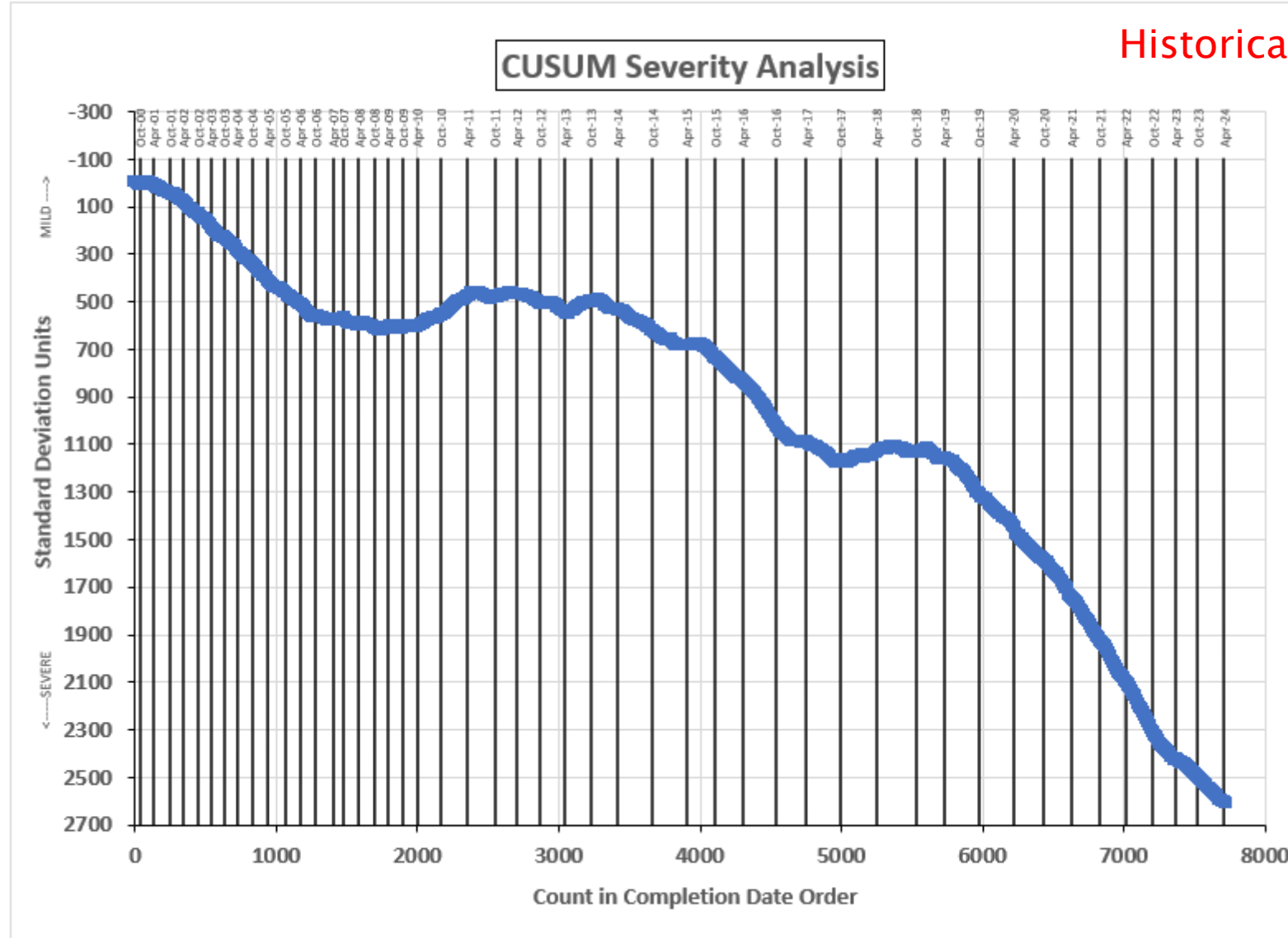


Chart of recent results



EOWT INDUSTRY OPERATIONALLY VALID DATA
CFA 3.0% Water Treat Rate
20 — 25 ML CHANGE IN FLOWRATE AVG.

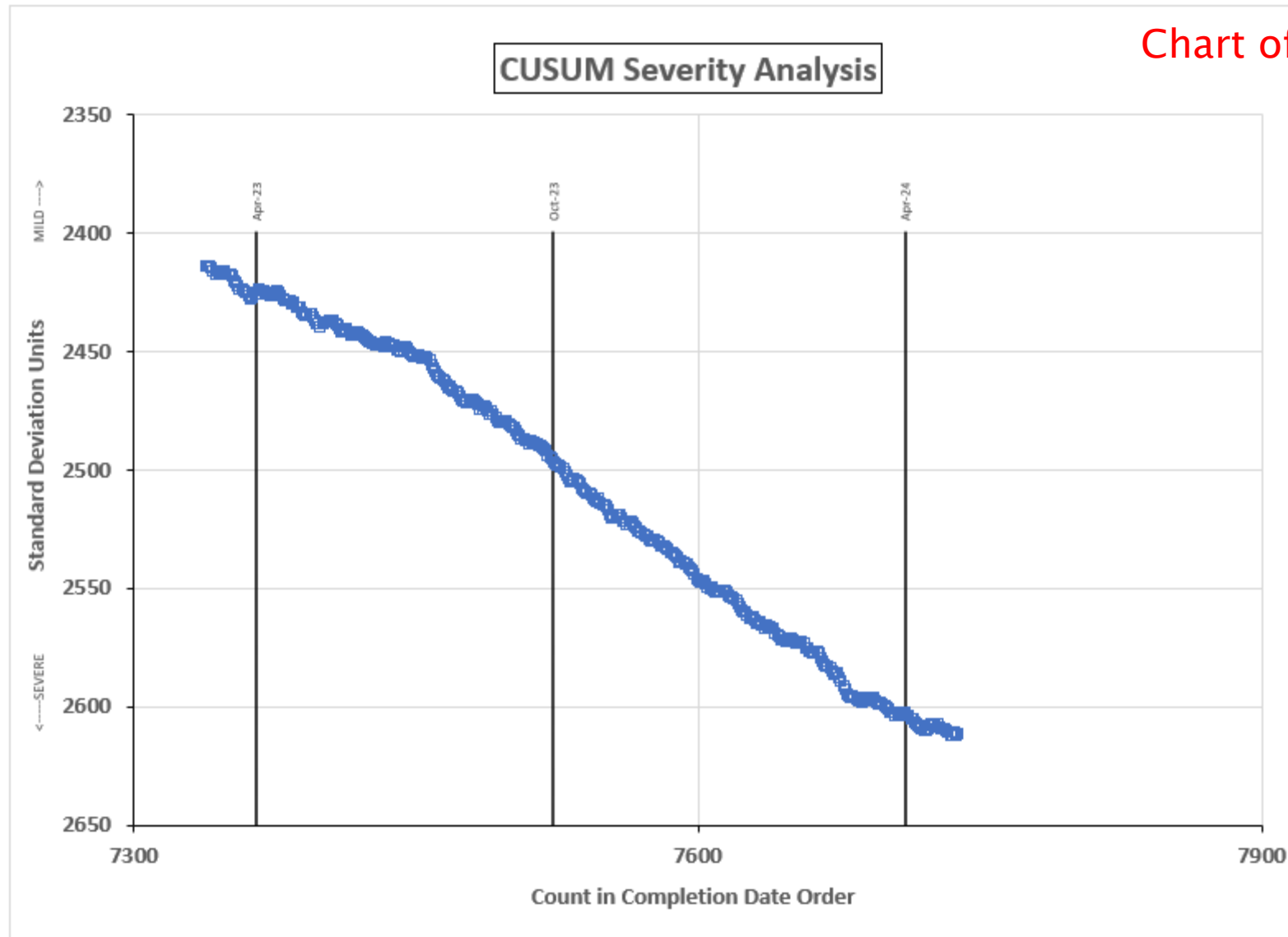
Historical Chart



EOWT INDUSTRY OPERATIONALLY VALID DATA
CFA 3.0% Water Treat Rate (Last 400 Data Points)
20 —25 ML CHANGE IN FLOWRATE AVG.

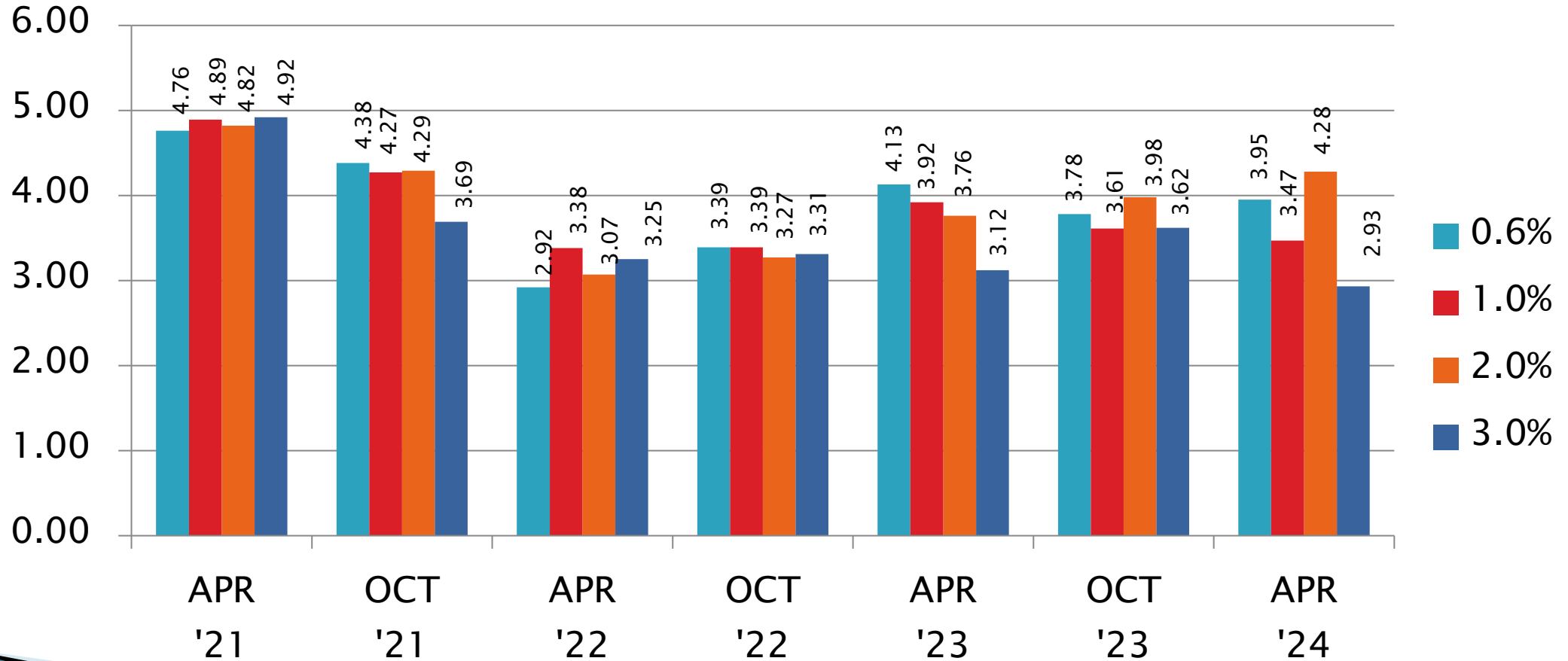


Chart of recent results



EOWT Precision (Pooled s) Estimates

CFA



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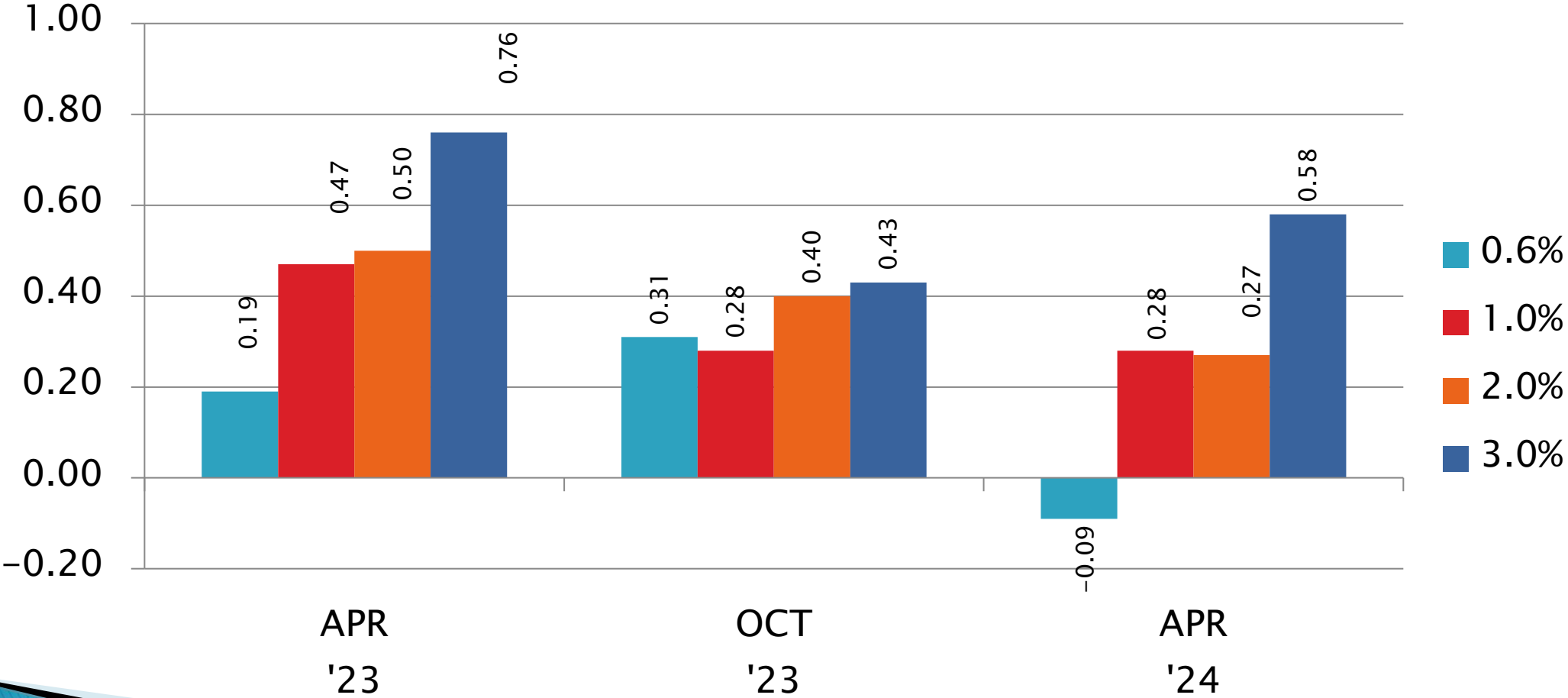
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EOWT Performance (Mean Δ/s) Estimates

CFA

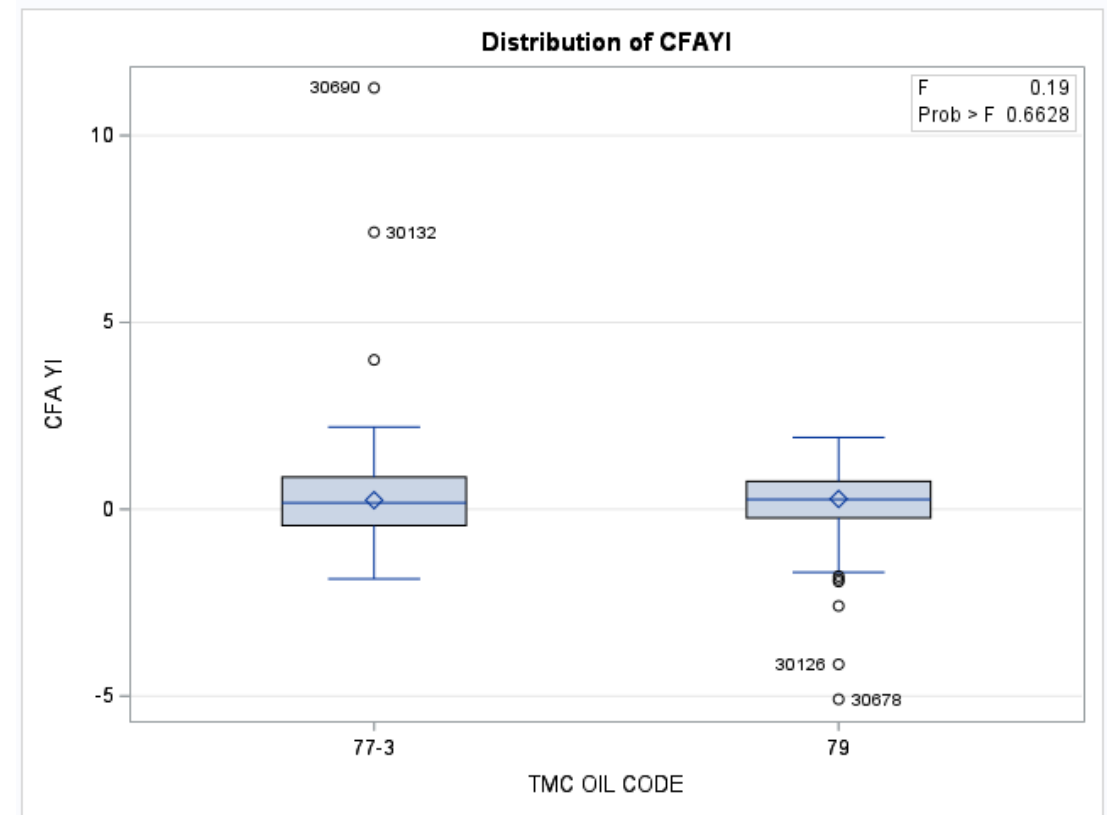
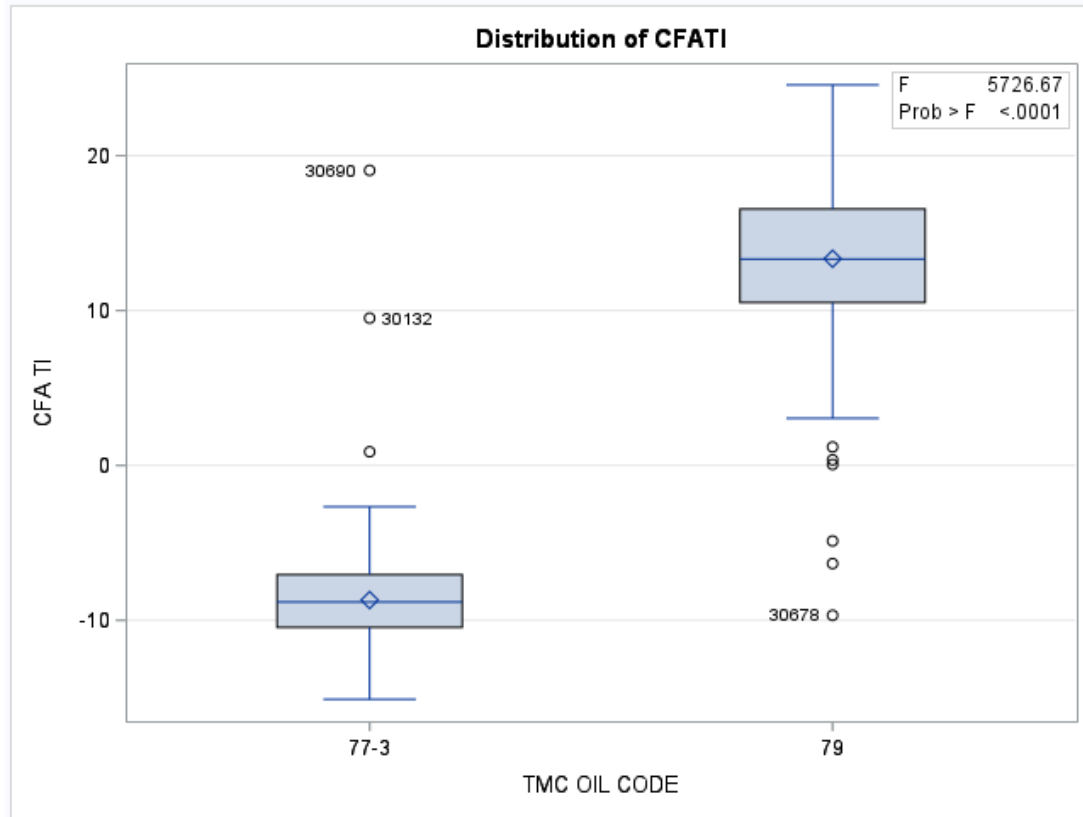


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EOWT Results by Reference Oil: All Water Levels

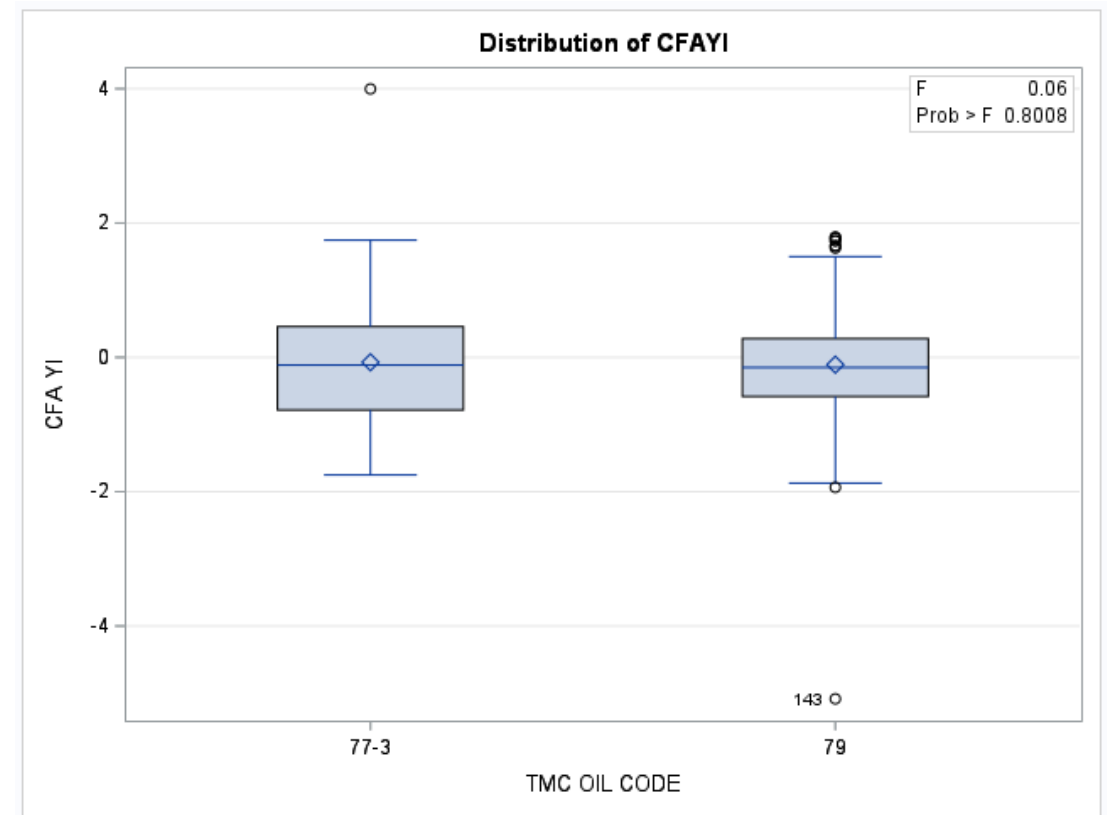
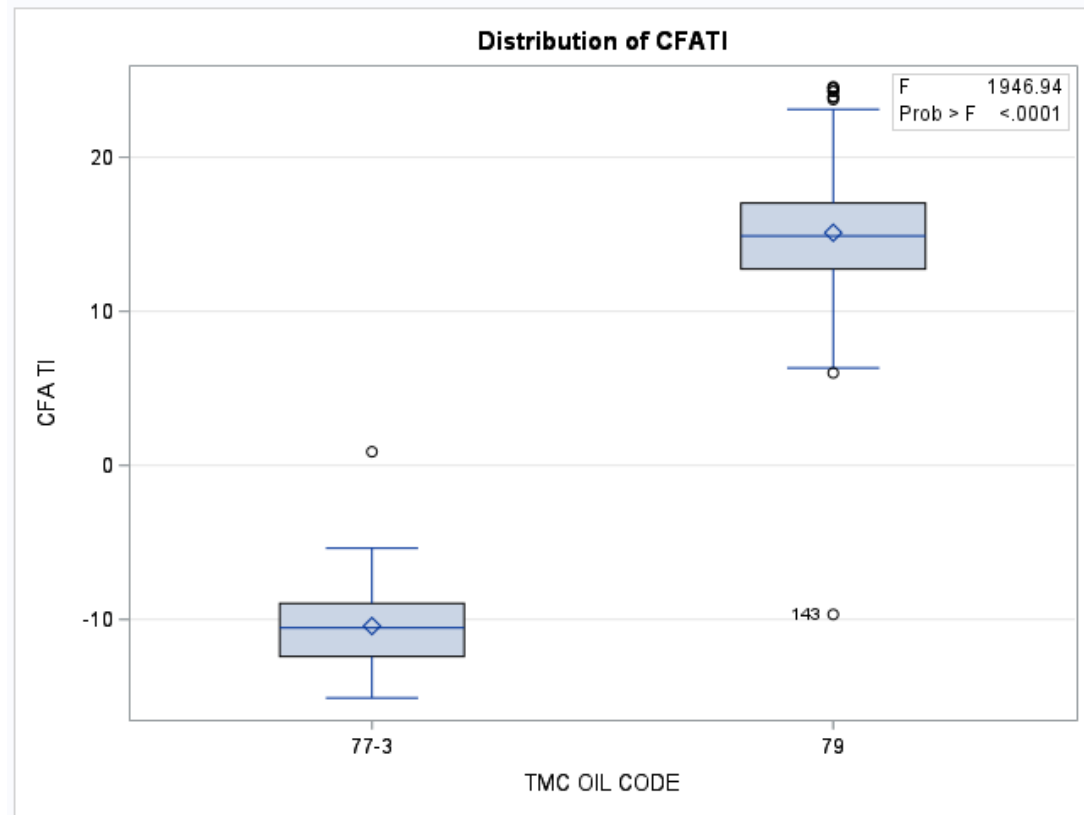


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EOWT 0.6% Results by Reference Oil

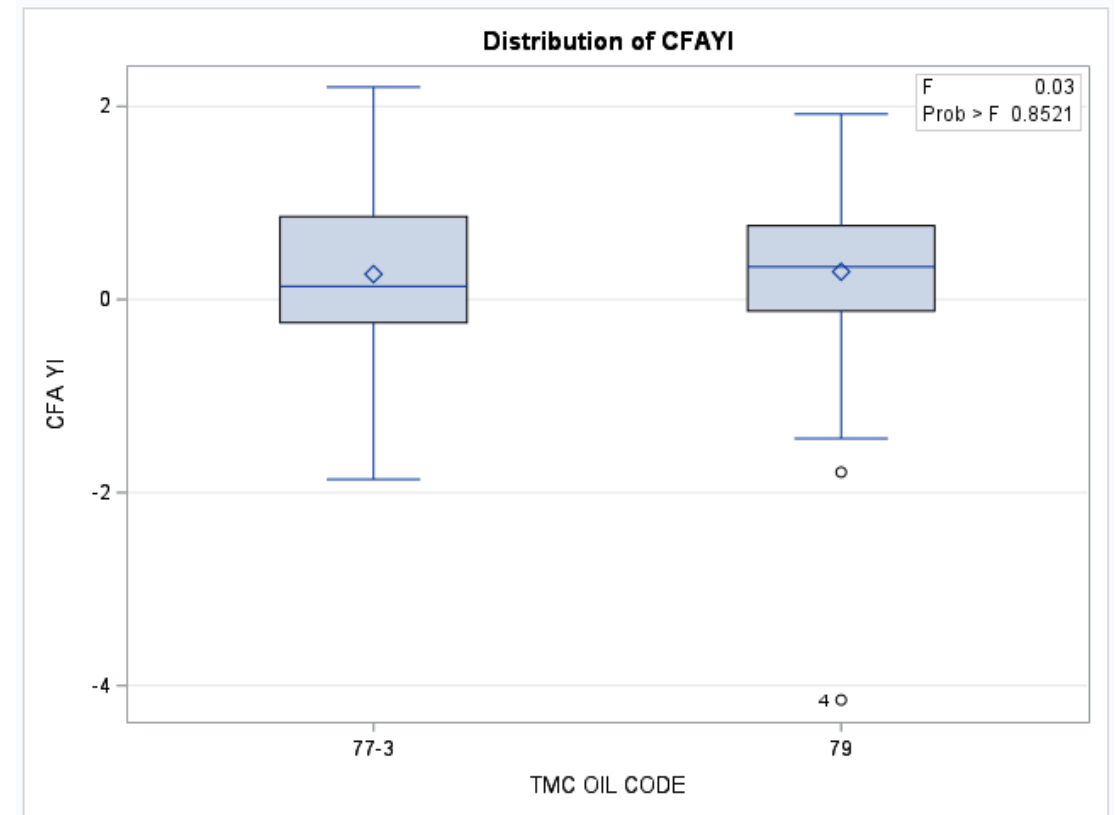
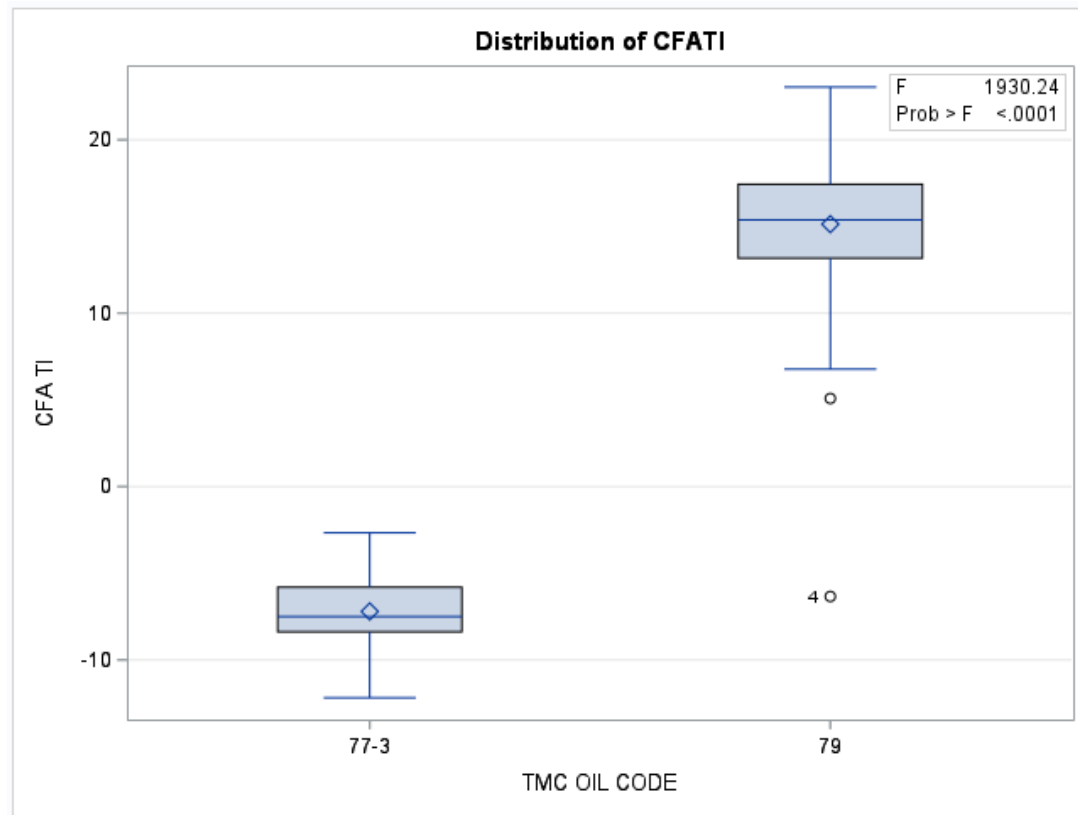


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EOWT 1.0% Results by Reference Oil

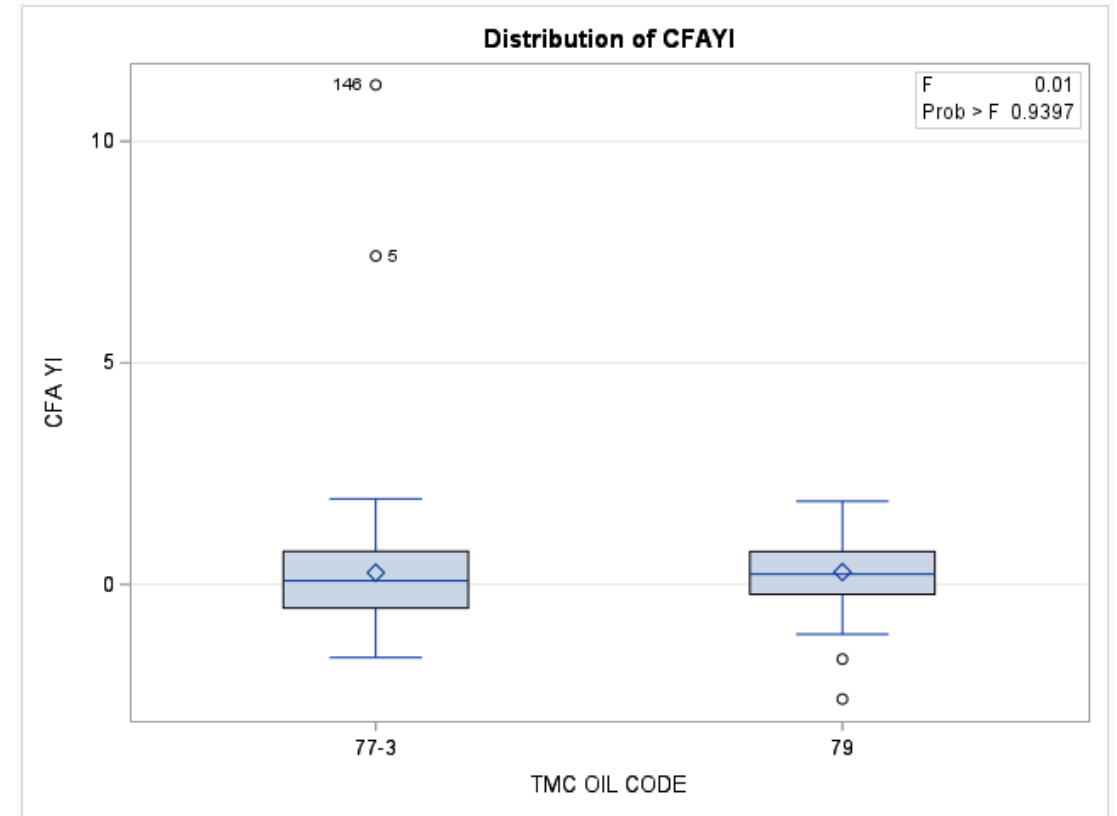
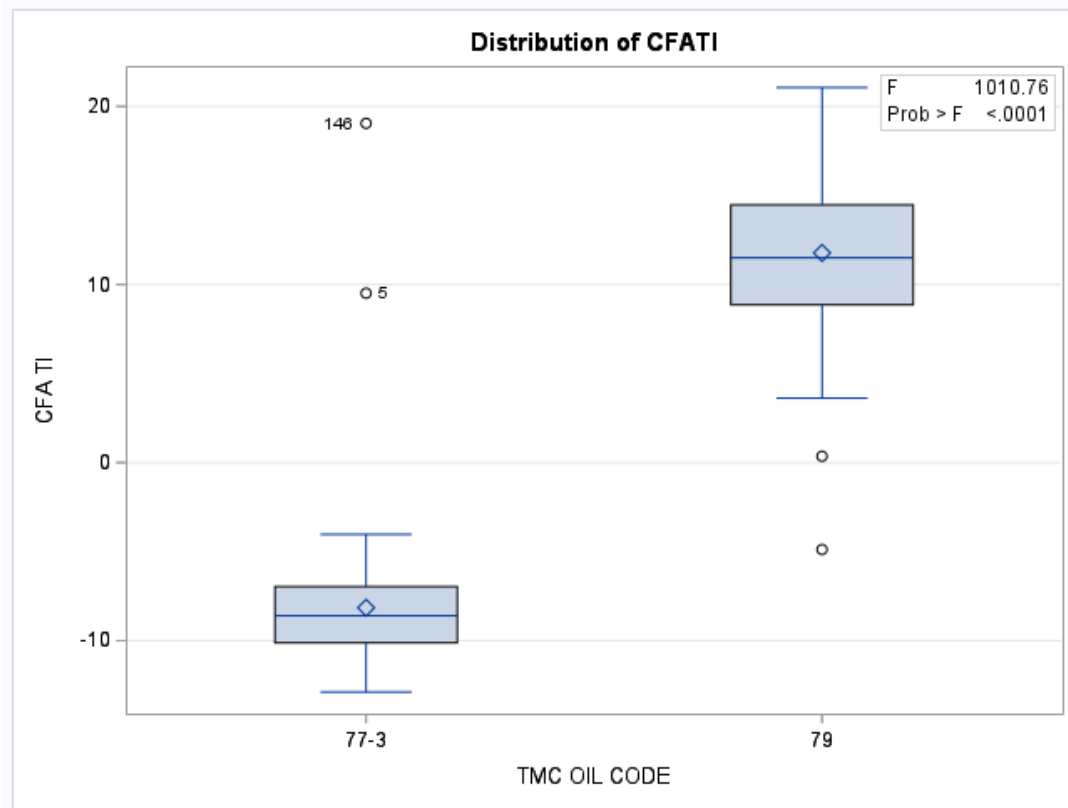


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EOWT 2.0% Results by Reference Oil

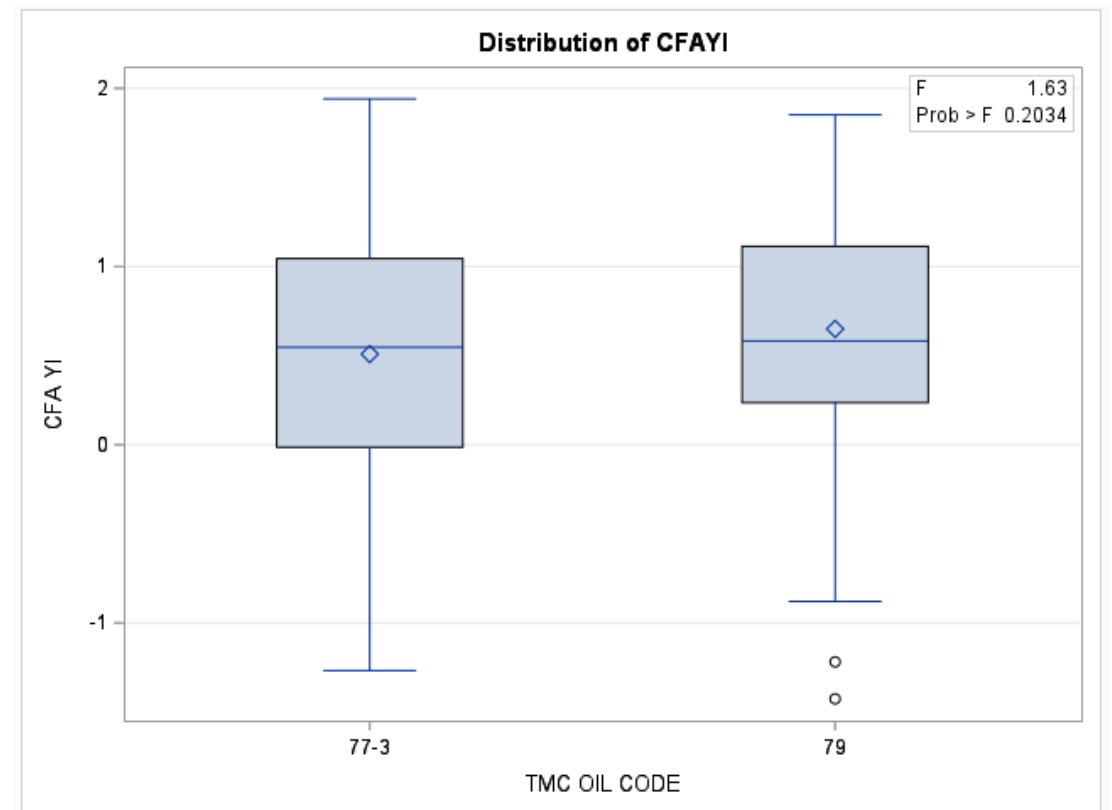
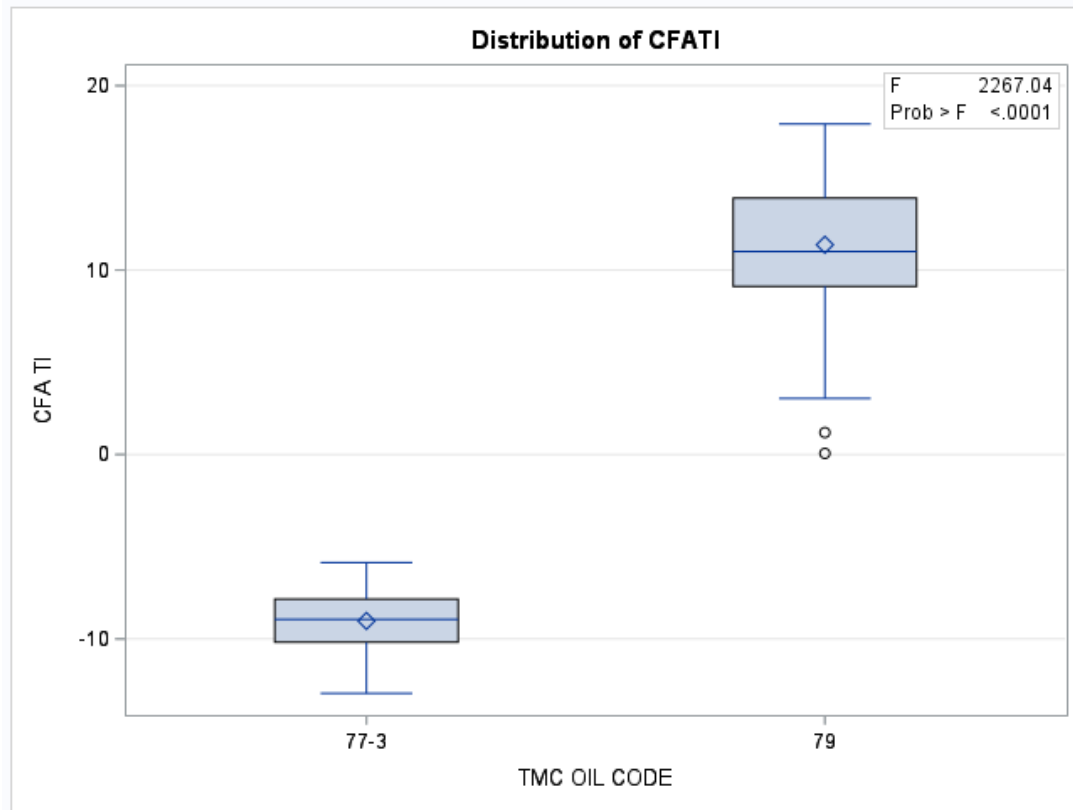


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<https://www.astmtmc.org>



EOWT 3.0% Results by Reference Oil



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<https://www.astmtmc.org>



Information Letters*

Test	Date	IL	Topic
			No new information letters this period.

*Available from TMC Website

October 1, 2023 – March 31, 2024

Test Monitoring Center
<https://www.astmtmc.org>



Reference Oil Inventory Estimated Life

EOWT & EOFT

Oil	TMC Inventory (gallons)	TEST	Total Assignments made over Semester	Volume of Samples Assigned (Gallons)	Estimated Life ¹
77-3	404.8 (-32.0)	EOWT	363	29.2	5+ years
79	154.7 (-46.3)	EOWT	362	29.2	1.7 years
		EOFT	127	10.2	

1 –Based upon Sample Assignment Rate from past 6 months.

D02.B0.07

TMC Monitored Tests



ASTM D 6795

Engine Oil Filterability Test (EOFT)

October 1, 2023 – March 31, 2024

Calibrated Labs and Stands*

(change since last Semi-Annual report)

Test	Labs	Stands
D6795	6 (+0)	N/A

*As of 3/31/2024

EOFT Test Activity*

Test Status	Validity Code	Number of Tests
Acceptable Calibration Test	AC	123
Failed Calibration Test	OC	2
Aborted Calibration Test	XC	1
Acceptable Shakedown Run	NN	0
Unacceptable/Aborted Shakedown Run	MN / XN	0
Total		126

- 98.4% Acceptable Calibration (AC) Testing Rate
 - 6 labs reported data this semester

October 1, 2023 – March 31, 2024

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EOFT Failed Tests

Failed Parameter	Number of Tests
Change in Flow Average (CIFA) Severe	2
Change in Flow Average (CIFA) Mild	0
Total	2

- TWO calibration fails this semester.

October 1, 2023 – March 31, 2024

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EOFT Failed Tests by Lab

Failed Parameter	LTMS Lab						#
	A	B	G	I	L	BE	
Change in Flow Average (CIFA) Severe	0	0	0	0	2	0	2
Change in Flow Average (CIFA) Mild	0	0	0	0	0	0	0
Totals	0	0	0	0	2	0	2

October 1, 2023 – March 31, 2024

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EOFT Lost Tests*

Status	Cause	No. of Tests
Invalid (L,R)		0
Aborted (X)	Sample container broke	1
Total		1

*Invalid and aborted calibration tests

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EOFT Information/Shakedown Tests

Informational / Shakedown Results	Number of Tests
None	0
Total	0

October 1, 2023 – March 31, 2024

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EOFT Test Severity

- ▶ Change in Flow Average (CIFA) is trending severe with a very consistent CUSUM slope over the past 3.5 years.

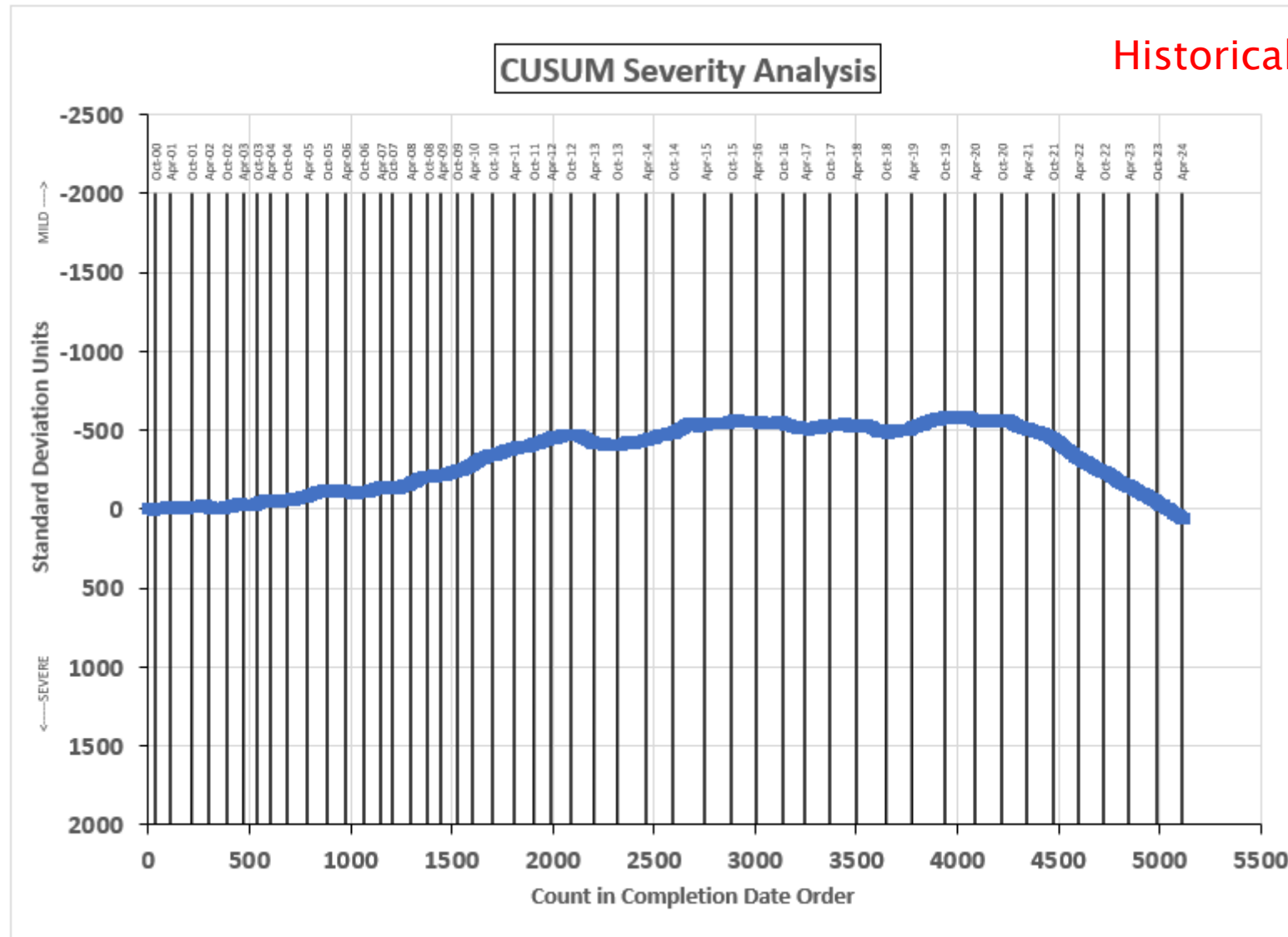
October 1, 2023 – March 31, 2024

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20 -25 ML CHANGE IN FLOWRATE AVERAGE (%)



EOFT INDUSTRY OPERATIONALLY VALID DATA
Last 250 Data Points
20 -25 ML CHANGE IN FLOWRATE AVERAGE (%)

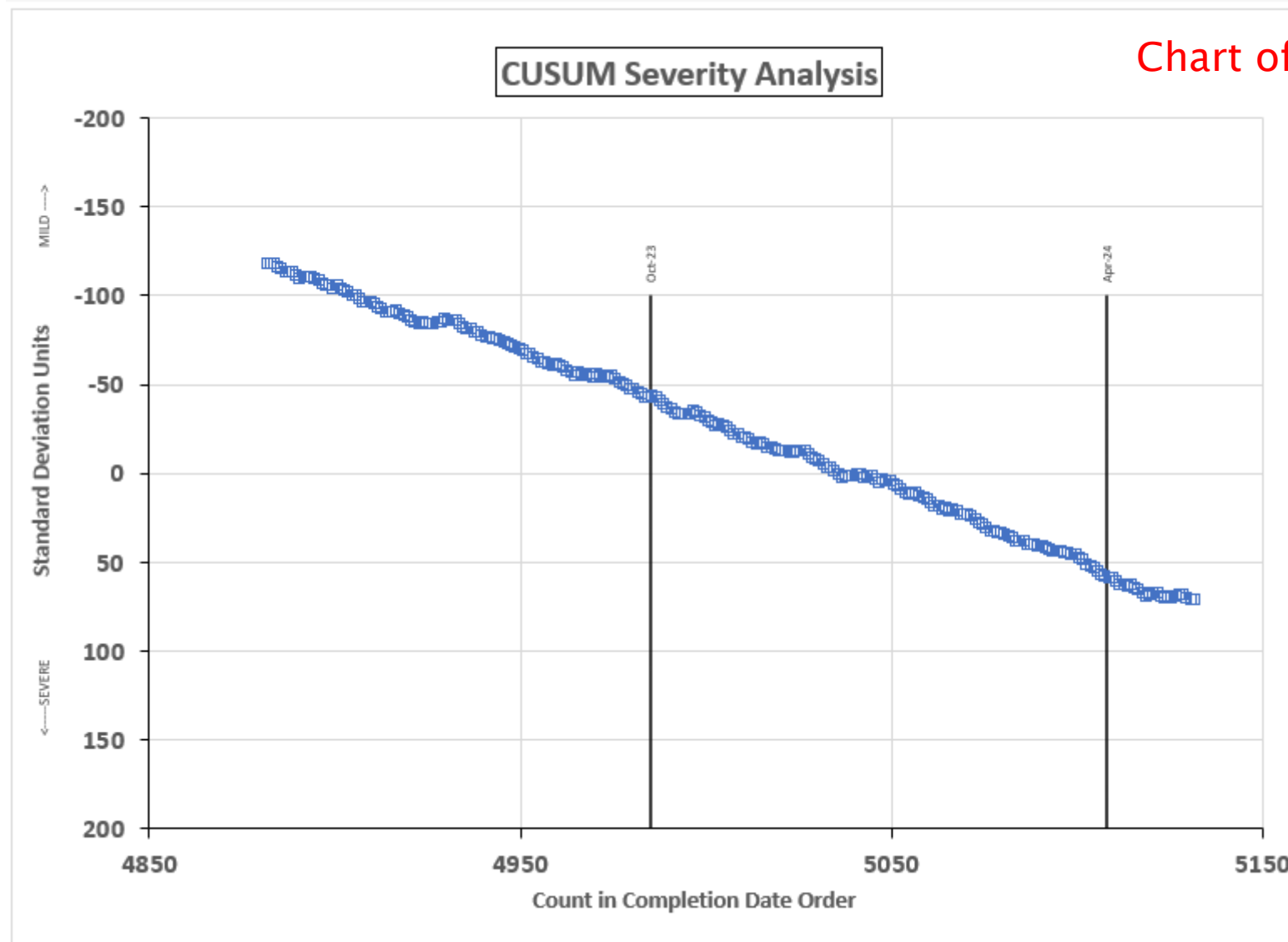
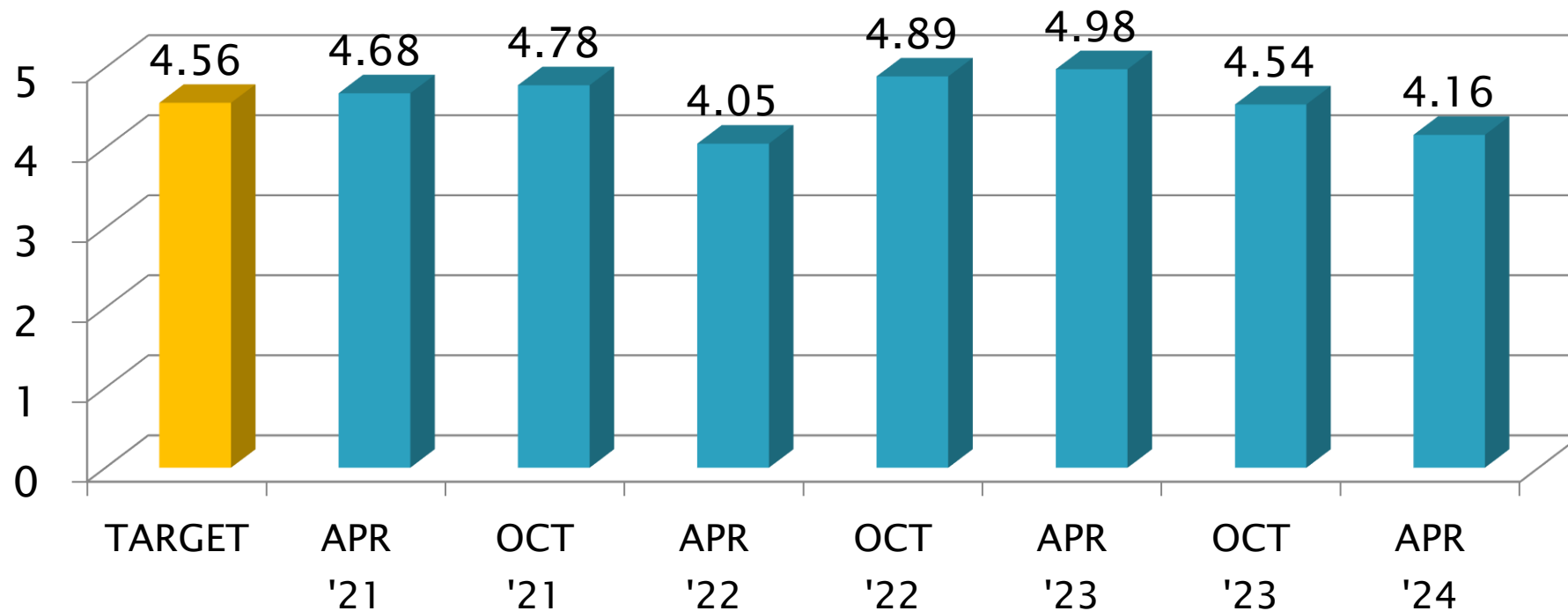


Chart of recent results

EOFT Precision Estimates

CIFA
Pooled s



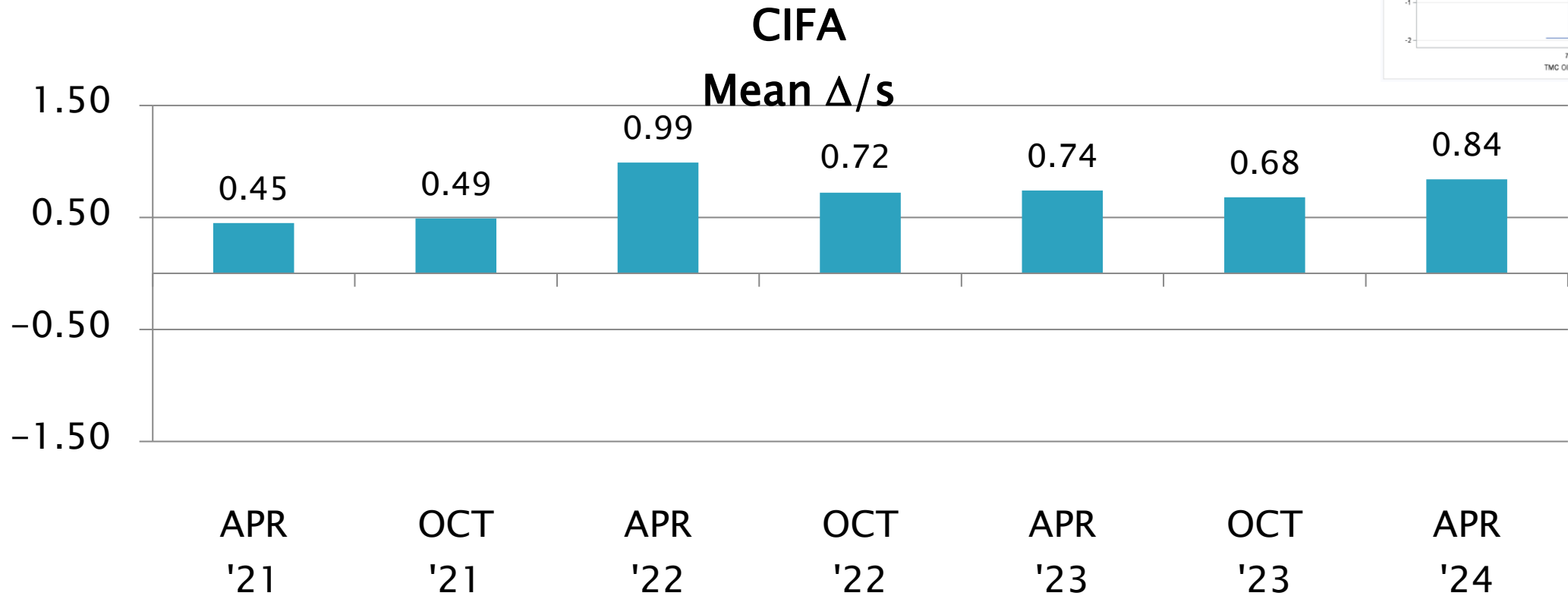
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EOFT Severity Estimates



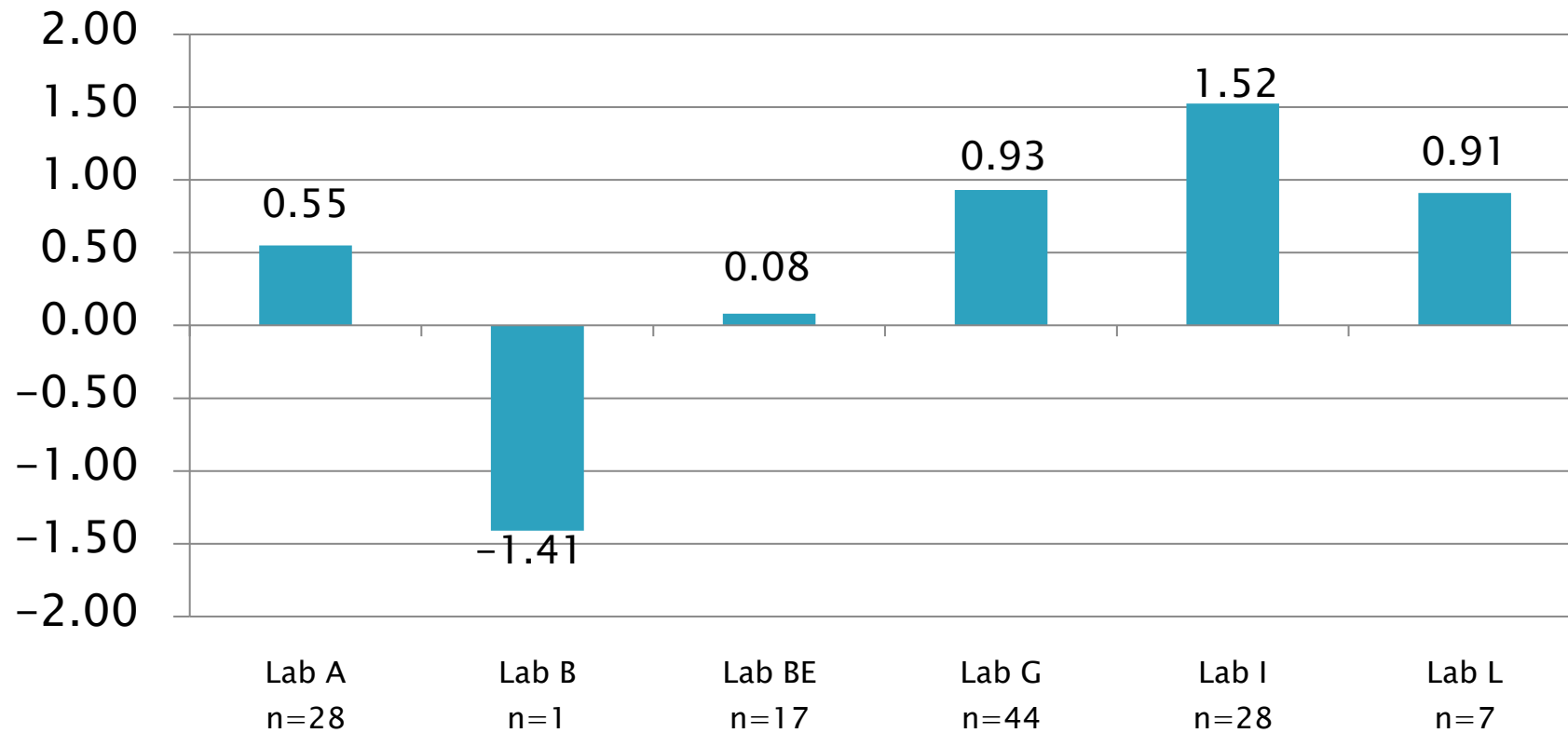
October 1, 2023 – March 31, 2024

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EOFT Lab Severity Estimates

CIFA
Mean Δ/s



October 1, 2023 - March 31, 2024

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Information Letters*

Test	Date	IL	Topic
			No new information letters this period.

*Available from TMC Website

October 1, 2023 – March 31, 2024

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Reference Oil Inventory Estimated Life

EOWT & EOFT

Oil	TMC Inventory (gallons)	TEST	Total Assignments made over Semester	Volume of Samples Assigned (Gallons)	Estimated Life ¹
77-3	404.8 (-32.0)	EOWT	363	29.2	5+ years
79	154.7 (-46.3)	EOWT	362	29.2	1.7 years
		EOFT	127	10.2	

1 –Based upon Sample Assignment Rate from past 6 months.

D02.B0.07

TMC Monitored Tests



ASTM D 7097

Medium High Temperature TEOST (MTEOS)

October 1, 2023 – March 31, 2024

Calibrated Labs and Stands*

(change since last Semi-Annual report)

Test	Labs	Stands
D7097	10 (+0)	37 (-4)

*As of 3/31/2024

D7097: Deposits by MTEOS

Test Status	Validity Code	No. Tests
Acceptable Calibration Test	AC	60
Failed Calibration Test	OC	5
Operationally Invalidated by Lab	LC	5
Operationally Invalid (Aborted)	XC	3
Acceptable Informational Run	NN	0
Unacceptable Informational Run	MN	0
Total		73

Number of Labs Reporting Data: 10 (+0)
Fail Rate of Operationally Valid Tests: 7.7% (6.8% last period)

October 1, 2023 – March 31, 2024

Test Monitoring Center
<https://www.astmtmc.org>



D7097: Deposits by MTEOS

Statistically Unacceptable Tests (OC)	No. Of Tests
Total Deposits Severe	5
Total Deposits Mild	0
Total	5

FOUR Labs had OC results.

October 1, 2023 – March 31, 2024

Test Monitoring Center
<https://www.astmtmc.org>



D7097: Deposits by MTEOS

Summary of Invalid Tests

Operationally Invalid Tests (LC, XC)	Validity Code	No. Of Tests
Lab aborted run due to sampling failure	XC	2
Lost sample during test due to sampling failure	XC	1
Pump speed incorrect	LC	1
Pump issues detected after run completed	LC	1
Missing Ceramic Isolator	LC	1
Thermocouple positioning problem	LC	2
Total		8

October 1, 2023 – March 31, 2024

Test Monitoring Center
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D7097: Deposits by MTEOS

Summary of Informational Tests

Informational / Shakedown Tests (NN, MN)	Validity Code	No. Of Tests
Shakedown run, Deposits in Range	NN	0
Shakedown run, Deposits not in Range (Severe)	MN	0
Total		0

October 1, 2023 – March 31, 2024

Test Monitoring Center
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D7097: Deposits by MTEOS

Period Precision and Severity Estimates

Total Deposits, mg	n	df	Pooled s	Mean Δ/s
Current Targets 9/30/2021 ¹	38	36	4.94	-----
4/1/19 through 9/30/19	109	107	6.40	-0.30
10/1/19 through 3/31/20	103	101	7.02	-0.02
4/1/20 through 9/30/20	72	70	4.87	-0.22
10/1/20 through 3/31/21	101	99	8.40	0.17
4/1/21 through 9/30/21	81	78	7.25	-0.02
10/1/21 through 3/31/22	75	73	8.86	0.18
4/1/22 through 9/30/22	77	75	7.69	0.69
10/1/22 through 3/31/23	67	65	7.03	0.41
4/1/22 through 9/30/23	74	71	7.42	0.31
10/1/23 through 3/31/24	65	62	6.04	0.19

¹Target precision updated to reference oils 432 and 434-3 preliminary

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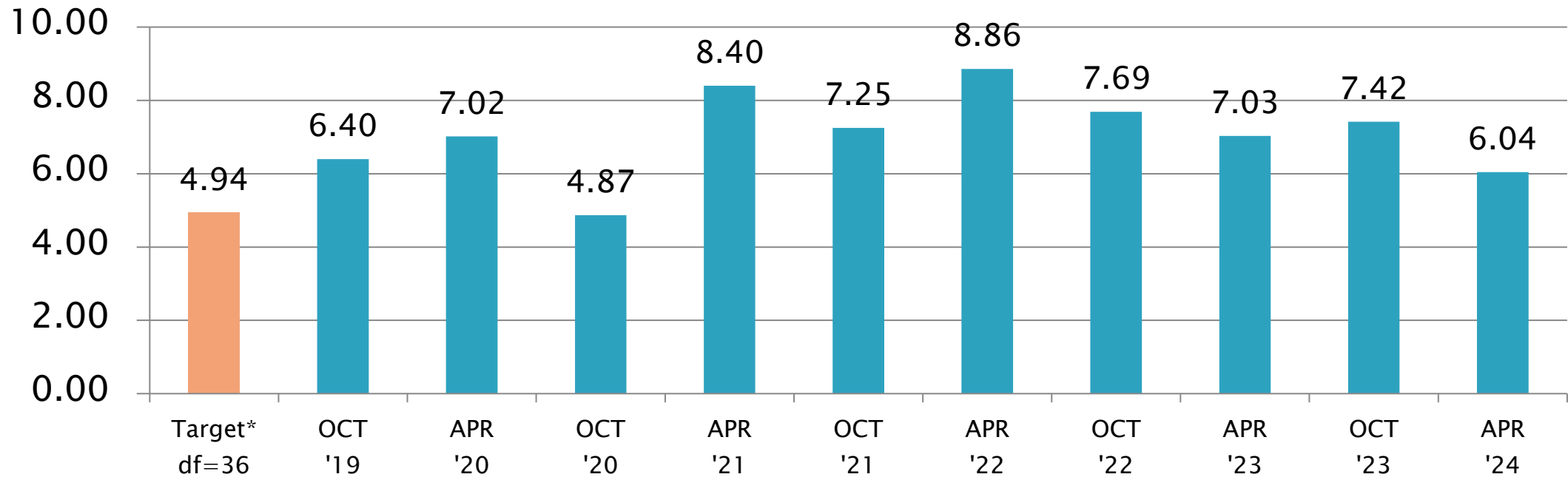
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D7097 Precision Estimates

Total Deposits, mg

Pooled s



*Target precision updated to reference oils 432 and 434-3 preliminary

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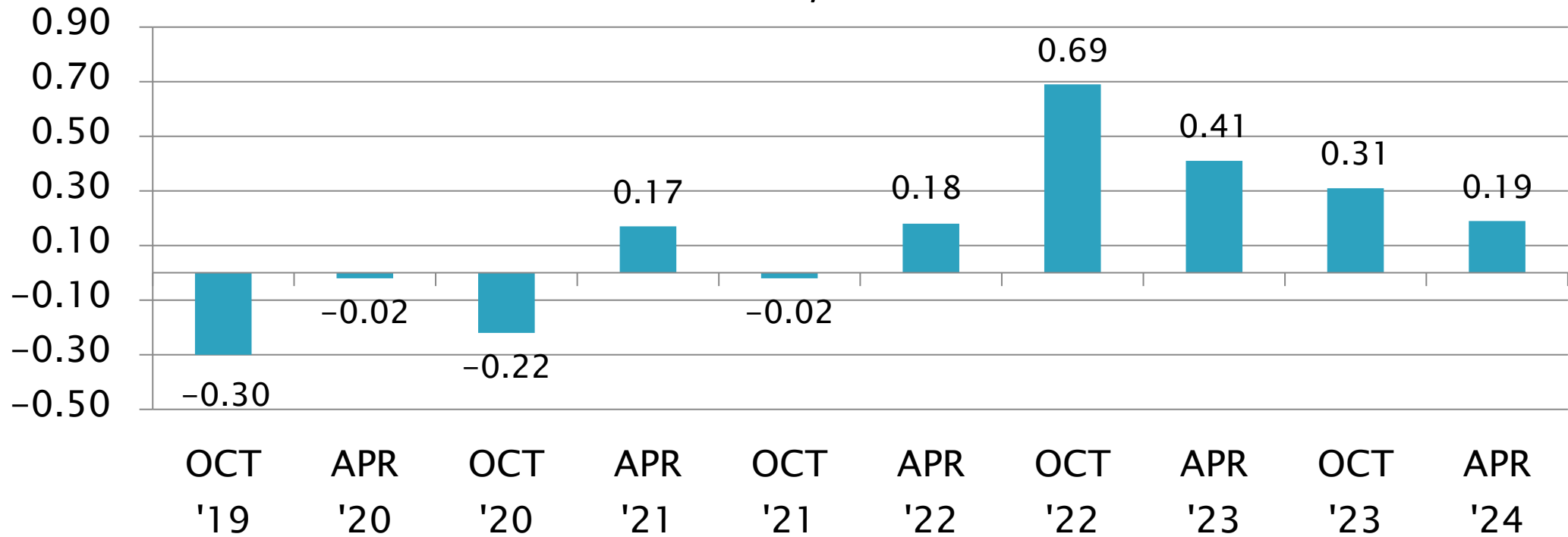
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D7097 Severity Estimates

Total Deposits, mg

Mean Δ/s



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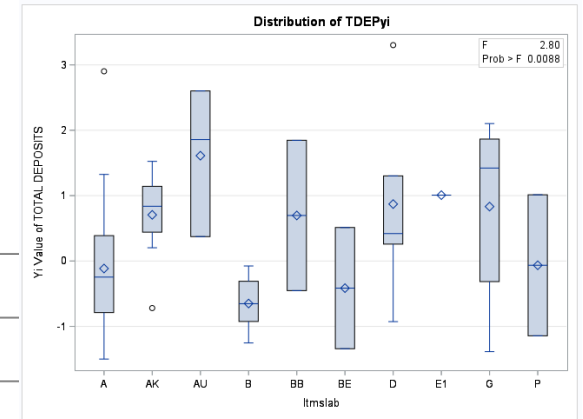
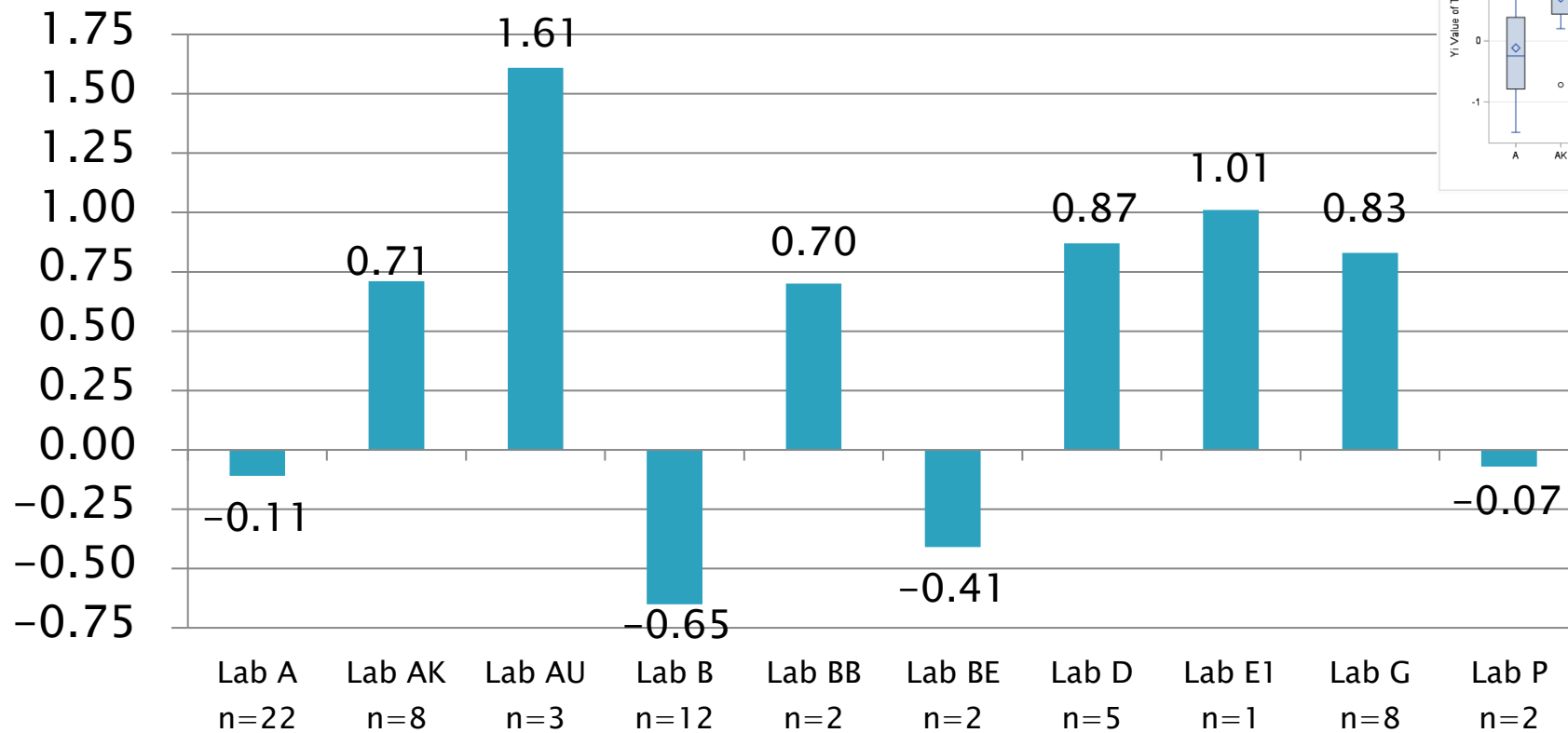
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D7097 Lab Severity Estimates

Total Deposits, mg
Mean Δ/s



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D7097: Deposits by MTEOS

- ▶ Precision (Pooled s) improved to 6.04 s this reporting period
- ▶ Performance (Mean Δ/s) continued to improve, moving from 0.31 s down to 0.19 s this semester.
- ▶ All operationally valid tests this period report using Rod Batch N (n=65).
- ▶ Most operationally valid calibration tests this period report using Catalyst Batch 20AB (n=60)
 - Catalyst Batch 23AB (n=5). This is the second semester that some labs used this batch.
 - No runs used Catalyst Batch 19BA this semester

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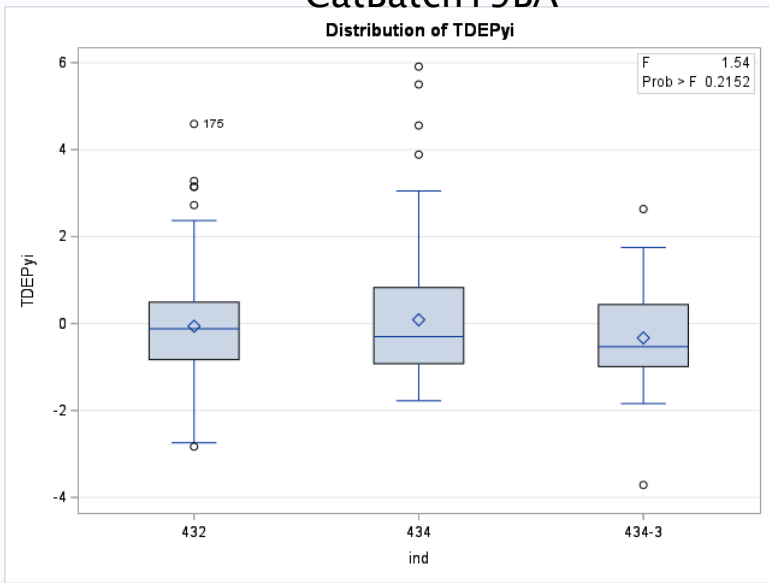
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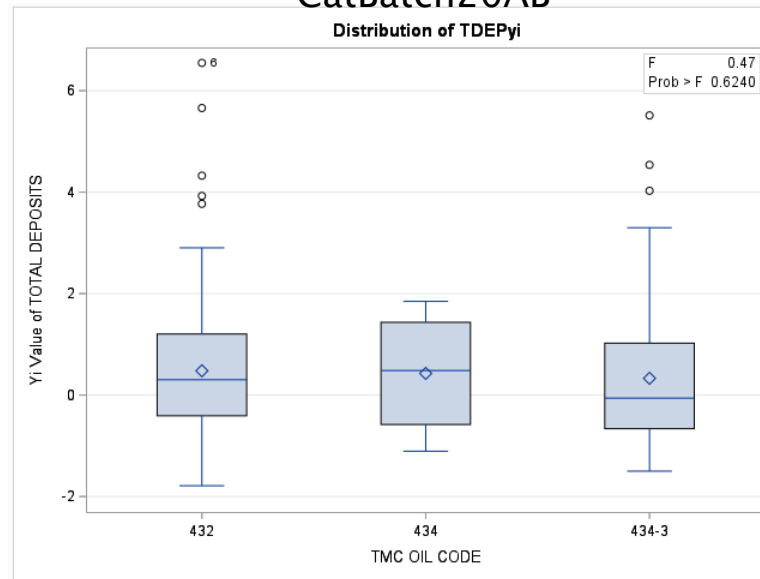
D7097: Deposits by MHT TEOST

- ▶ No new runs on catalyst batch 19BA this semester
 - Total Runs and Y_i statistic for batch 19BA remain at $n=349$, $Y_i = -0.02$.
- ▶ Severity on catalyst batch 20AB ($n=306$) appears to be slightly severe of target for oils 432, 434 and 434-3 ($Y_i = 0.40$), but continuing to improve from previous reports ($Y_i = 0.65$ OCT '22, $Y_i = 0.54$ APR '23, $Y_i = 0.48$ OCT '23)
- ▶ New catalyst batch 23AB now has eight runs. ($n=8$, $Y_i=1.39$)

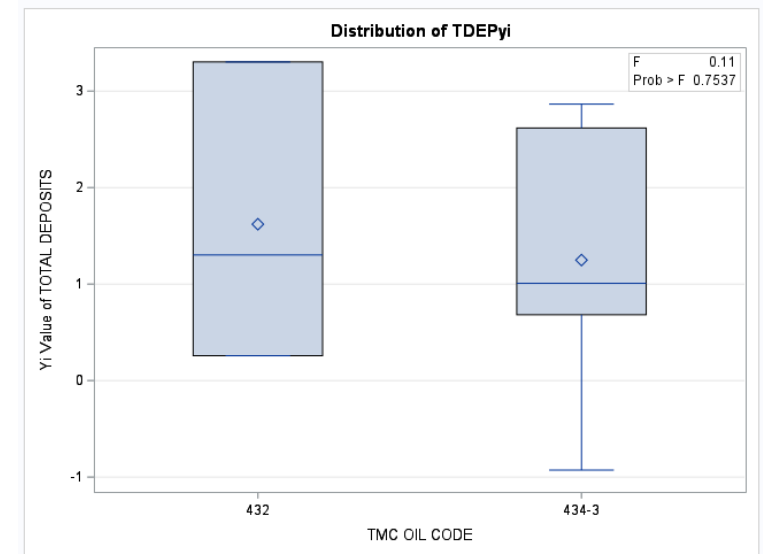
CatBatch19BA



CatBatch20AB



CatBatch23AB



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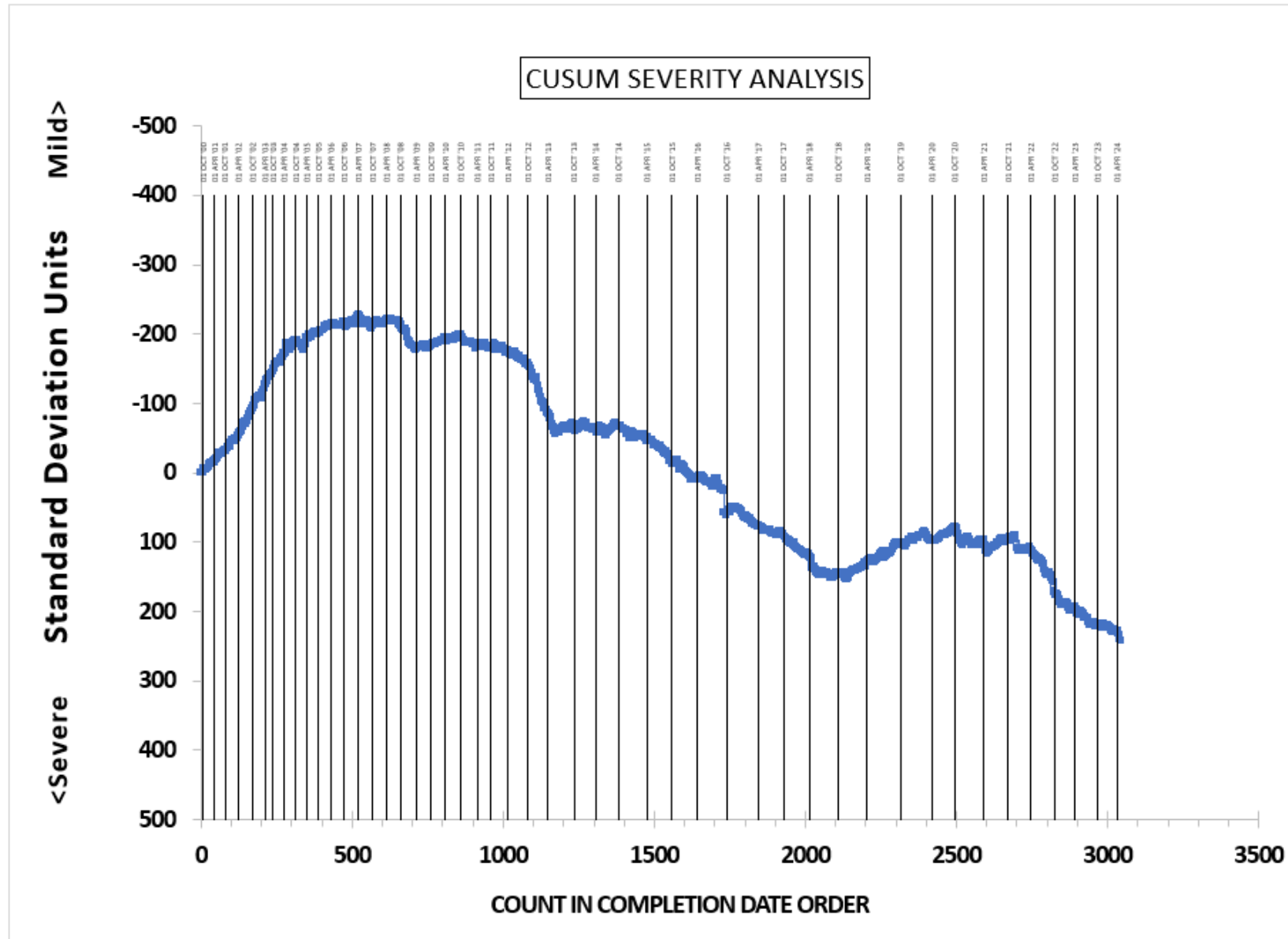
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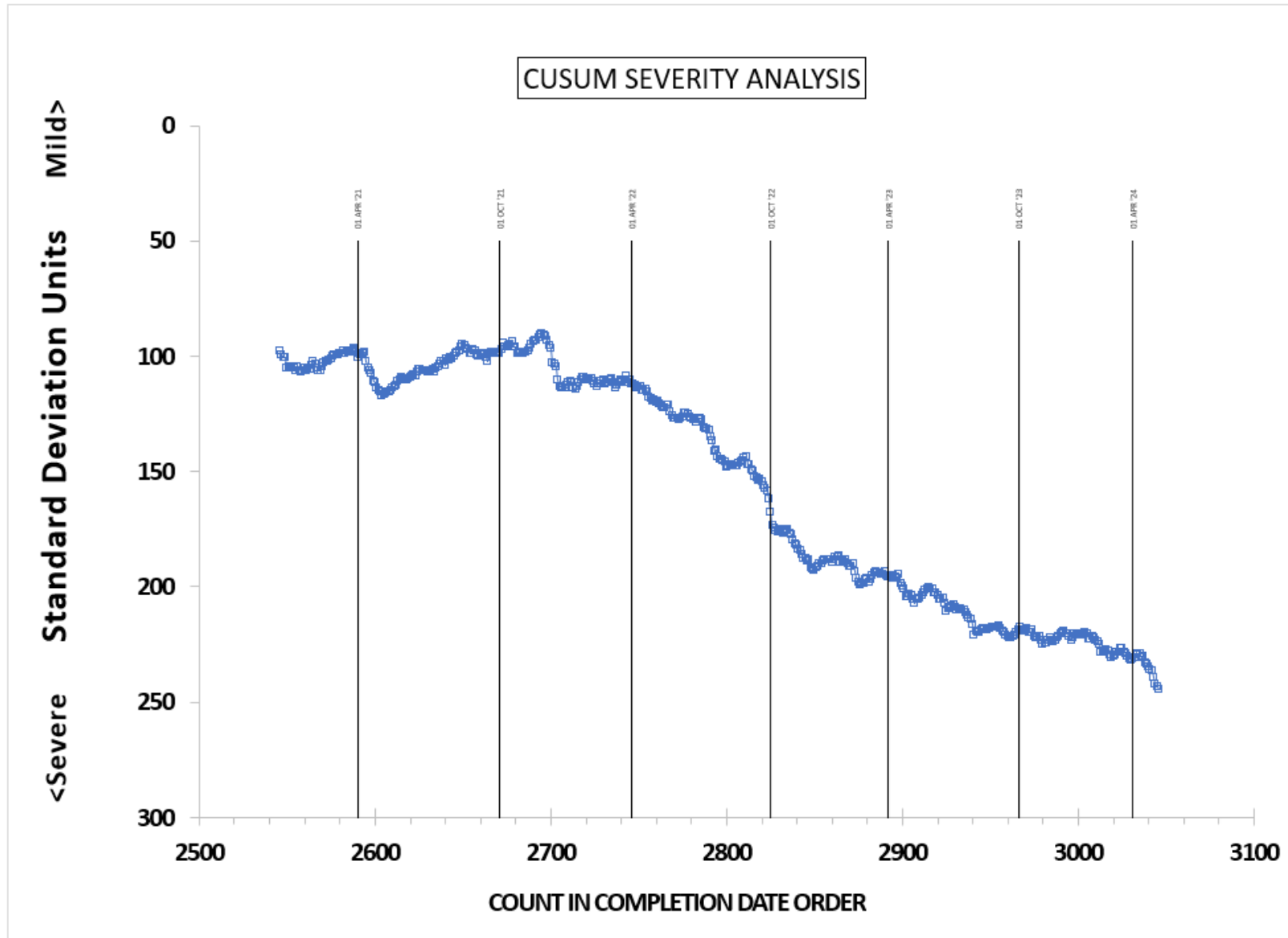
MHT → TEOST INDUSTRY OPERATIONALLY VALID DATA



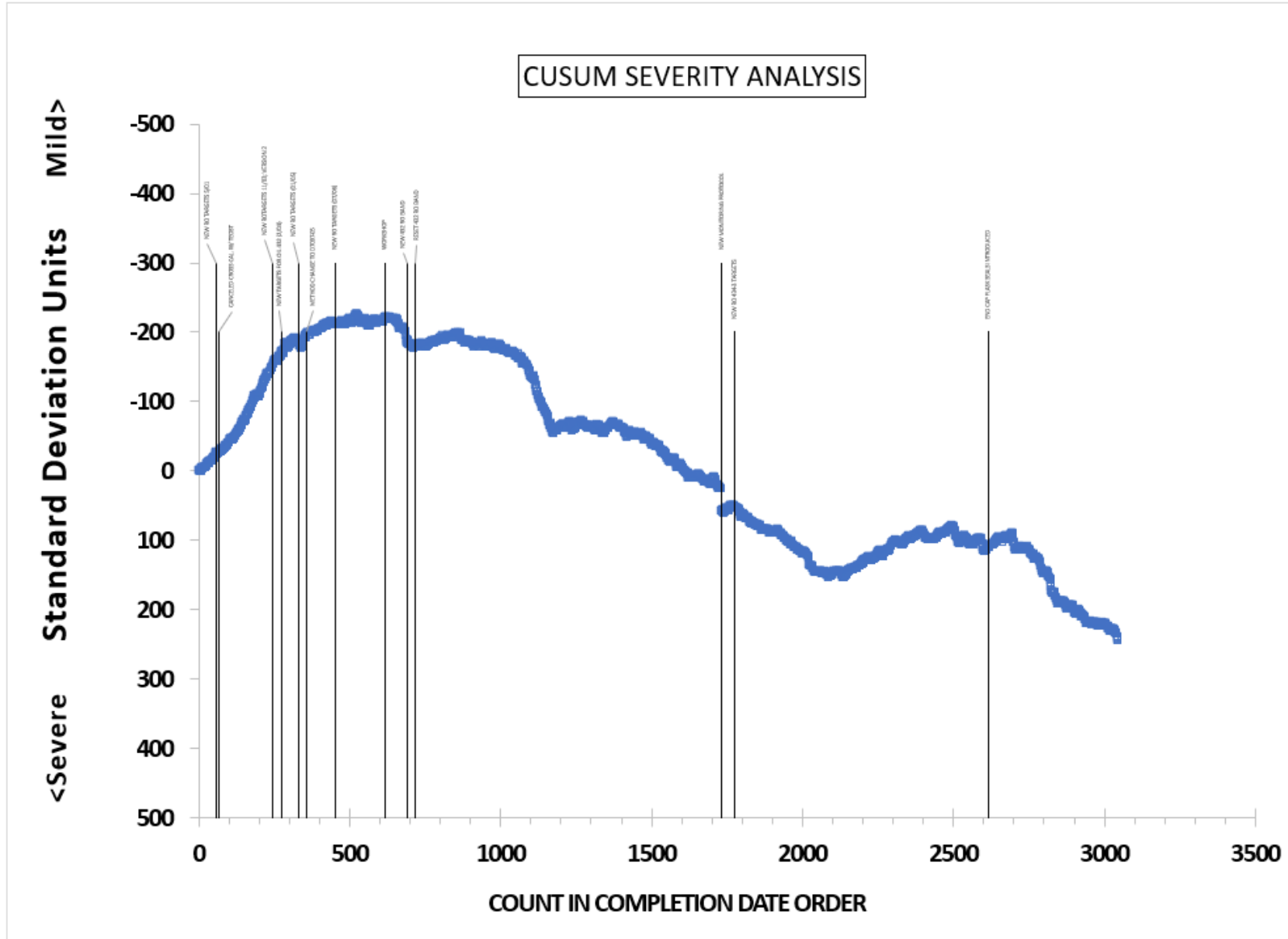
TOTAL DEPOSITS MG



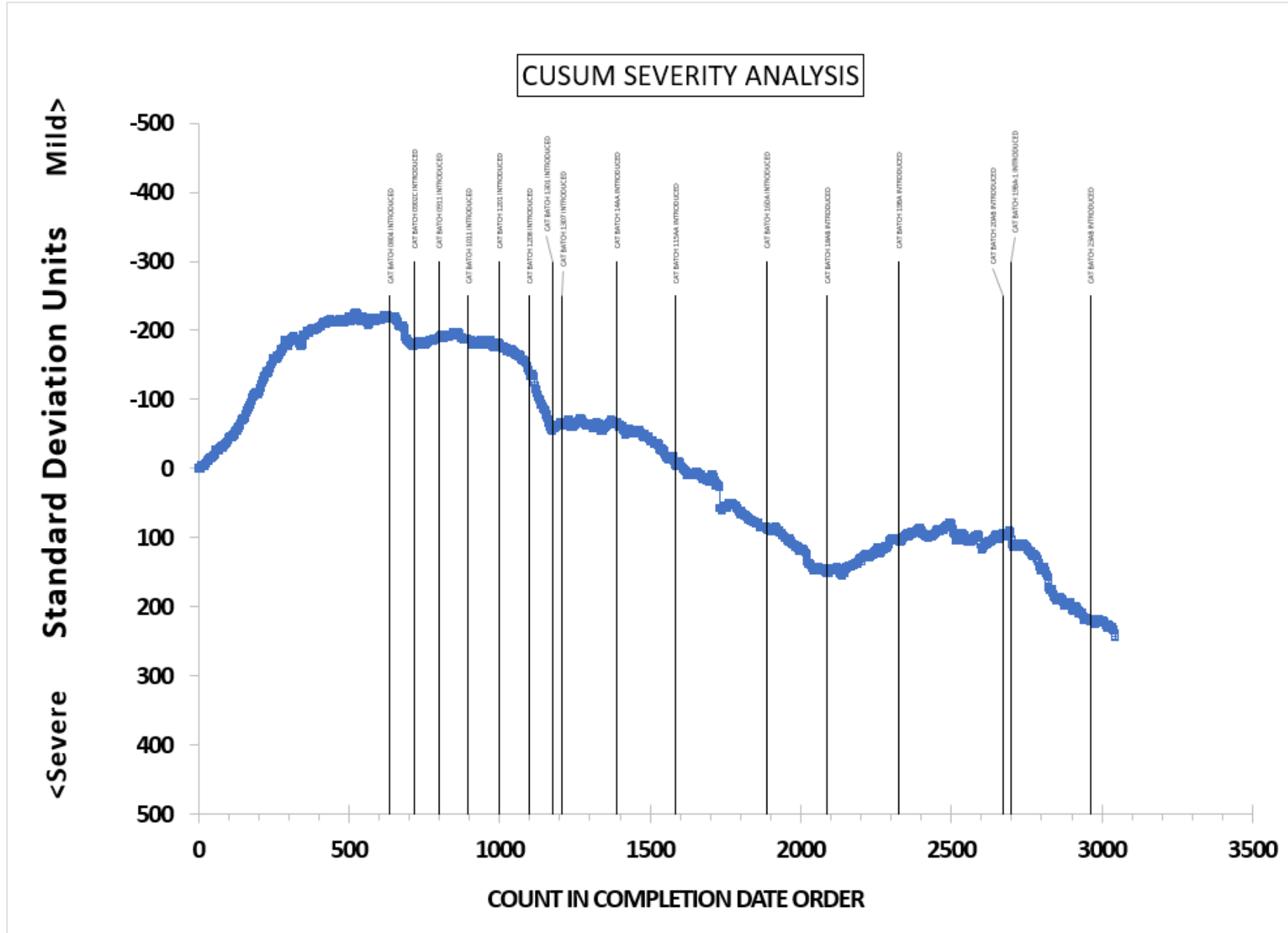
MHT-4 TEOST INDUSTRY OPERATIONALLY VALID DATA
Last 500 Points
TOTAL DEPOSITS MG



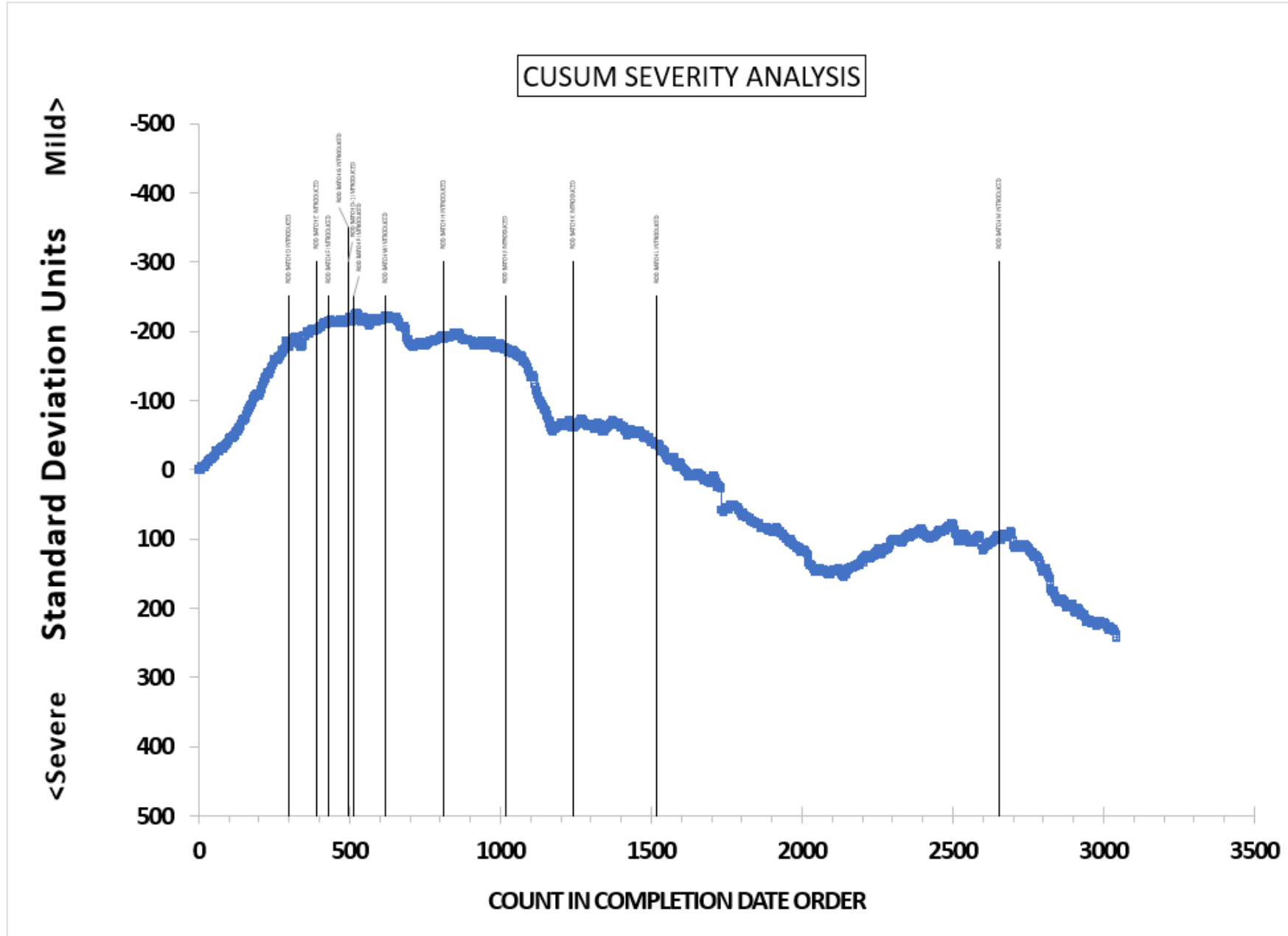
MHT-4 TEOST INDUSTRY OPERATIONALLY VALID DATA
SEVERITY DATES
TOTAL DEPOSITS MG



MHT-4 TEOST INDUSTRY OPERATIONALLY VALID DATA
CATALYST BATCH
TOTAL DEPOSITS MG

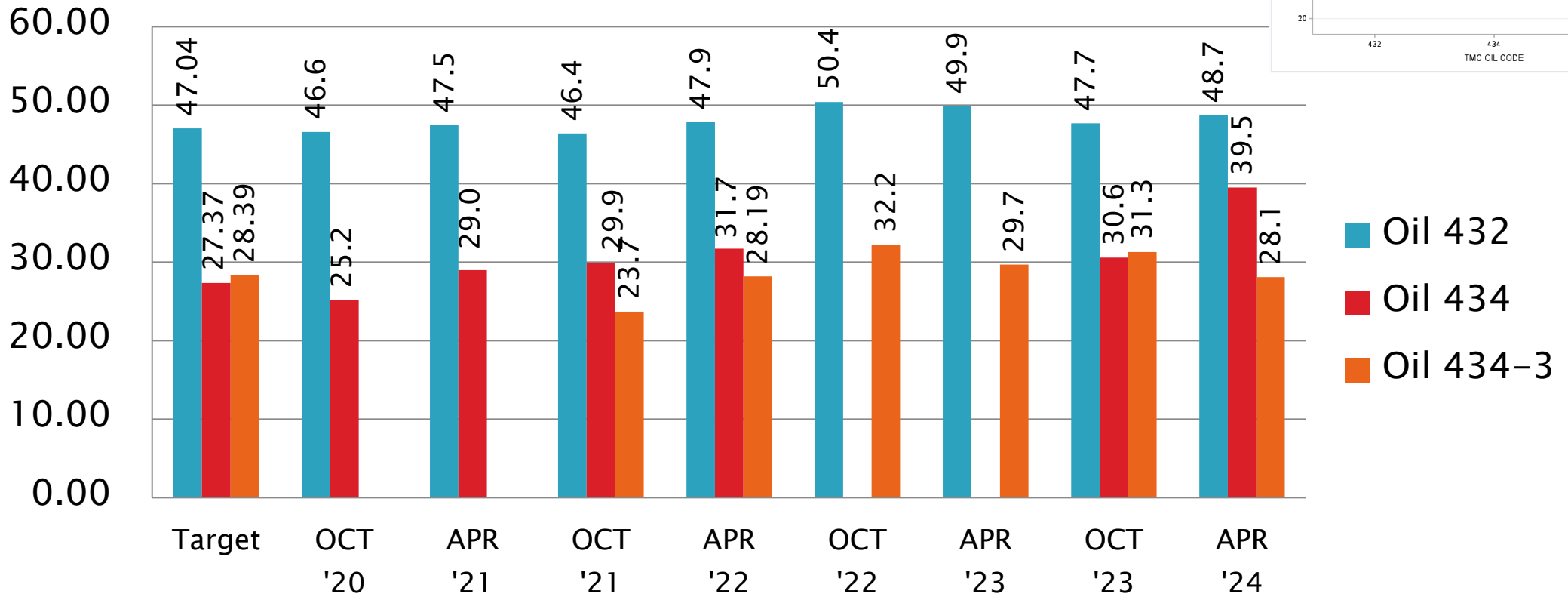
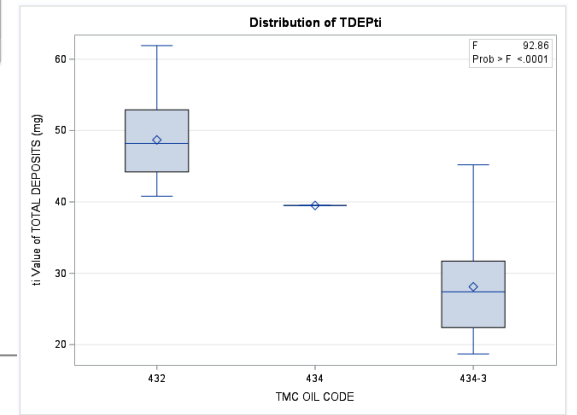


MHT-4 TEOST INDUSTRY OPERATIONALLY VALID DATA
ROD BATCH
TOTAL DEPOSITS MG



D7097 Performance by Oil

Total Deposits, mg
Mean



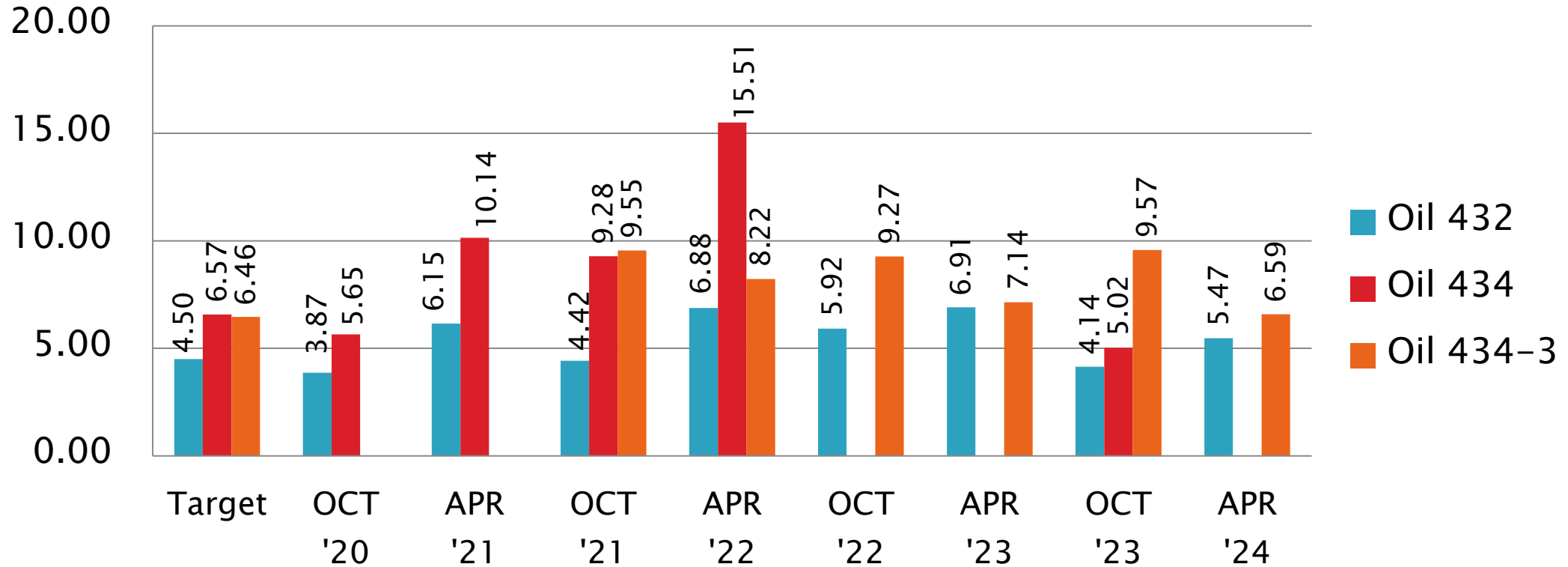
*Only a single RO 434 run for APR'24.

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D7097: Deposits by MHT TEOST

Total Deposits, mg

S_R



*Only a single RO 434 run this semester. No StDEV result available for APR'24.

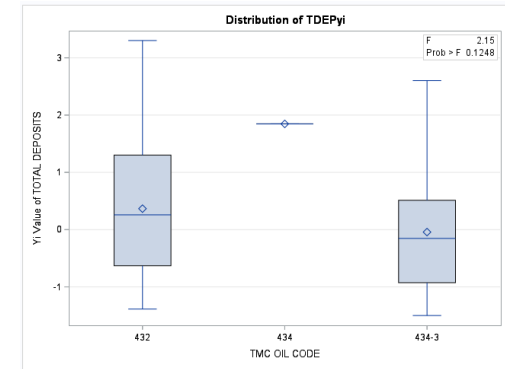
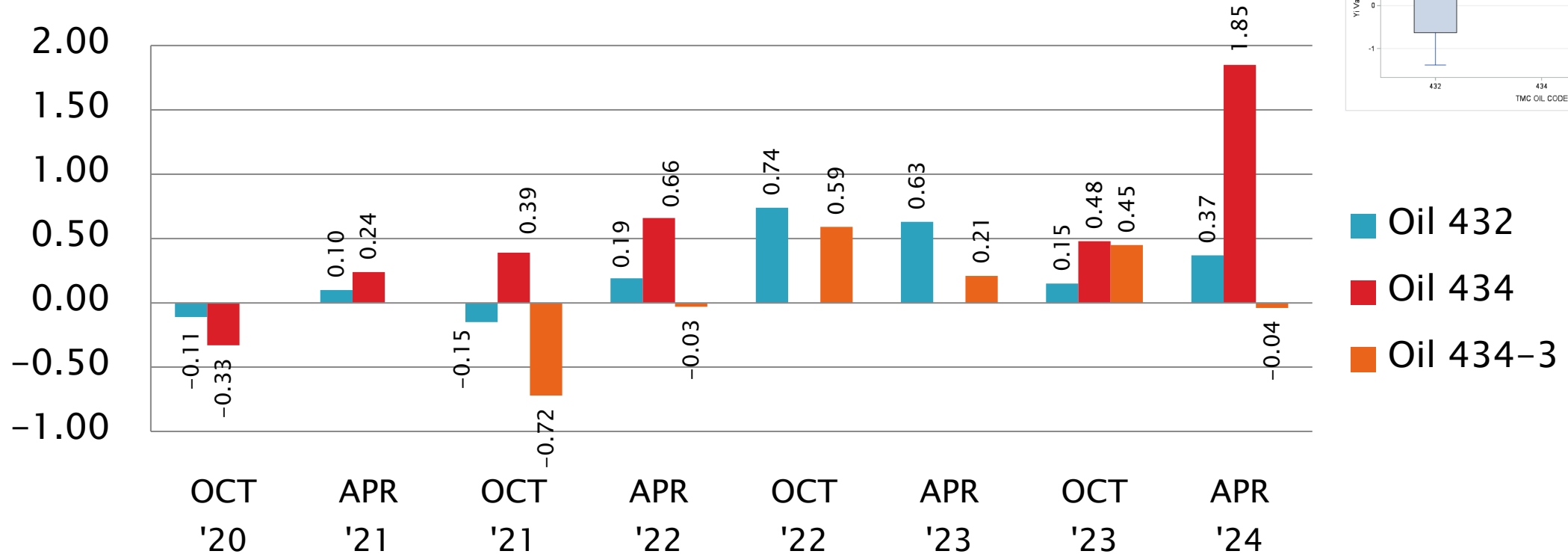
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D7097: Deposits by MHT TEOST

Total Deposits, mg
Mean Δ/s



*Only a single RO 434 run for APR'24.

TABLE of CONTENTS

Reference Oil Inventory

MTEOS

Oil	Year Rec'd By TMC ^A	Tests	TMC Inventory, gallons	Gallons Shipped last 6 months	Estimated Life
432	1998	MTEOS	101.52	0.24	5+ years
434-3 ^B	2017	MTEOS	18.39	4.42	2 years

^A Integrity of TMC reference oils is confirmed annually by analytical QC testing of chemical and physical properties.

^B Multi-test oil; estimated aliquot reserved for bench testing.

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D02.B0.07

TMC Monitored Tests



ASTM D 7216

Engine Oil Elastomer Compatibility (EOEC/LDEOC)

October 1, 2023 – March 31, 2024



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ASTM Reference Testing Semi-Annual Report D7216 EOEC

October 1, 2023 – March 31, 2024

ASTM D 7216

Engine Oil Elastomer Compatibility (EOEC/HDEOC)

OHT CURRENT ELASTOMER BATCH CODES FOR ASTM D7216

AS OF: 4/23/2024

EOEC	
OHT PART NUMBER	BATCH CODE
OHTEOEC-NBR-A	31
OHTEOEC-ACM-B	32
OHTEOEC-FKM-A	31
OHTEOEC-MAC-A	24

LDEOC	
OHT PART NUMBER	BATCH CODE
OHTLDEOC-HNBR1-A	32
OHTDLEOC-FKM1-A	29
OHTLDEOC-ACM1-B	26
OHTLDEOC-VMQ1-A	42
OHTLDEOC-AEM1-B	31
OHTLDEOC-ACM2-A	1
OHTLDEOC-AEM2-A	1
OHTLDEOC-FKM3-A	1
OHTLDEOC-AEM3-A	1

Calibrated Labs and Stands¹

(change since last Semi-Annual report)

Test	Labs	Stands
D7216 EOEC	7 ² (+1)	N/A

¹ As of 3/31/2024

² Six Labs ran EOECV

EOEC Test Activity*

Test Status		Fluoroelast.	Nitrile	Polyacrylate	Silicone	Ethylene Acrylate	Total
	LABS	7	7	7	7	7	
Acceptable Calibration Test	AC	77	78	78	68	66	367
Failed Calibration Test	OC	1	4	0	3	3	11
Operationally Invalid, by lab	LC	0	0	0	1	0	1
Operationally Invalid, by TMC	RC	1	0	0	1	0	2
Aborted	XC	0	1	0	0	0	1
Total		79	83	78	73	69	382

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EOEC Failed Calibration Tests*

Cause	Elastomer	No. of Tests
VOLUME (SEVERE)	FKM	1
TENSILE STRENGTH (SEVERE)	4-NBR, 2-VMQ, 3-MAC	9
VOLUME (MILD)	VMQ	1
Total		11

* ELEVEN failing calibration tests from TWO different labs

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EOEC Lost Tests*

Validity	Cause	No. of Tests
RC	TEST LENGTH (EOECF)	1
XC	ABORTED, NO DATA (EOECF)	1
LC	INVALIDATED BY LAB. NO DATA (EOECS)	1
Total		3

*Invalid and aborted calibration tests

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EOEC Test Severity

Fluoroelastomer (FKM)

Parameter	Period Mean Δ/s	Status
Volume Change	-0.0277	On-target
Points Hardness Change	0.3431	Slightly Severe
Tensile Strength Change	0.3488	Slightly Severe
Elongation Change	-0.5227	Mild

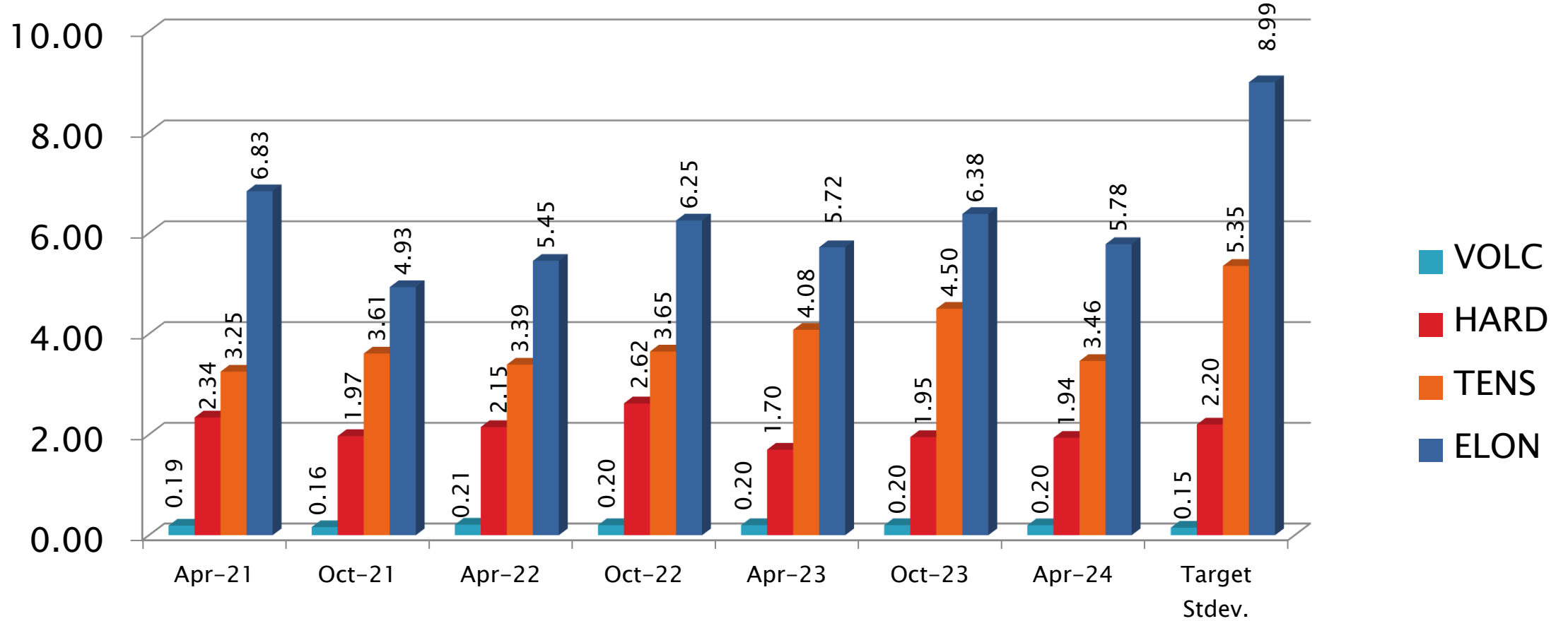
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EOEC Precision (Pooled s) Estimates: Fluoroelastomer



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EOEC Precision Estimates by Lab: FKM

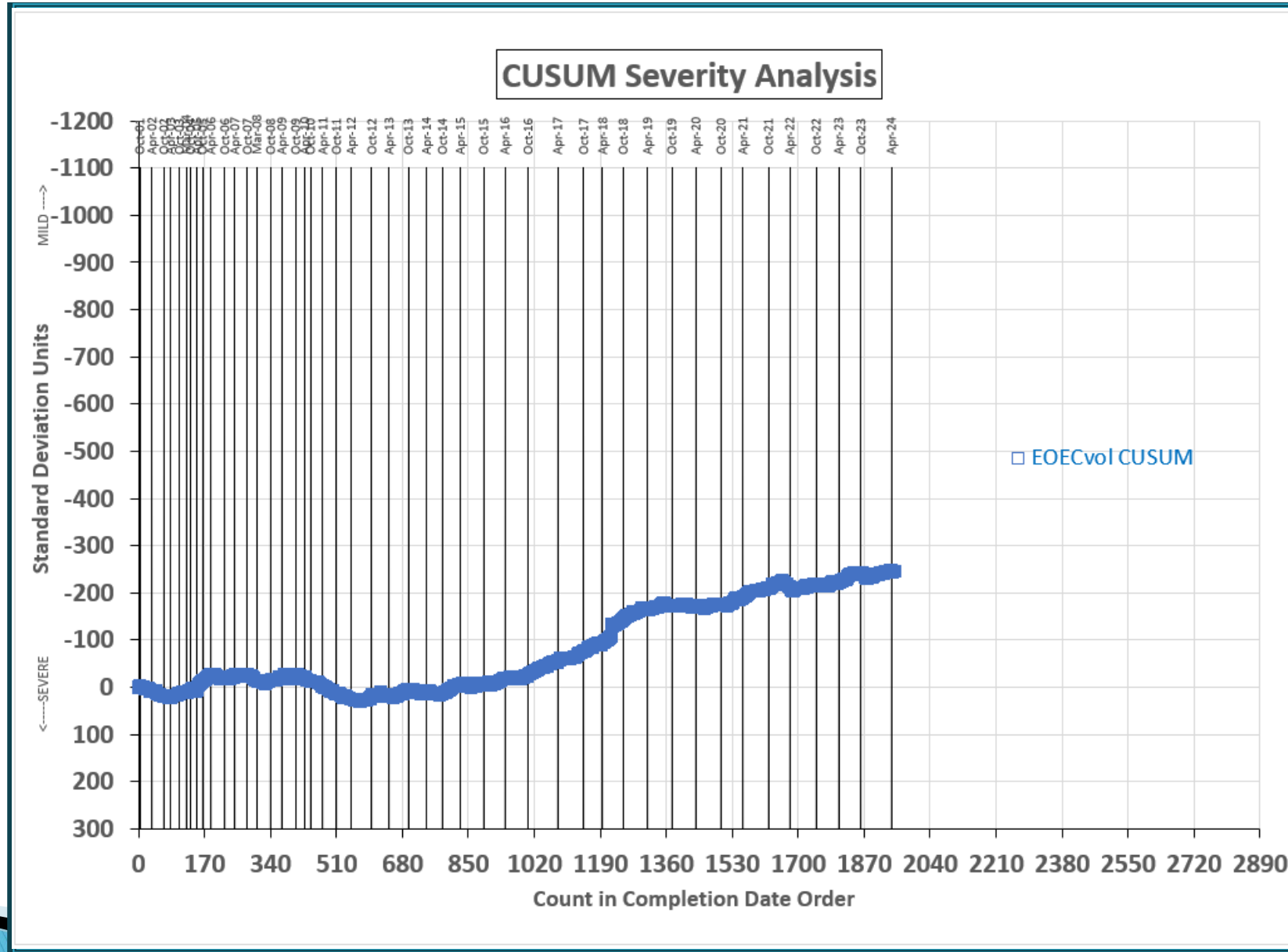
Test Parameter	Statistic	LTMS Lab						
		A	B	G	I	L	P	V
	n=	30	9	22	11	3	2	1
Volume	Mean	0.3870	0.4078	0.5200	0.4682	0.3700	0.3700	0.2800
	Pooled s	0.0936	0.0746	0.2643	0.3012	0.1054	0.1838	N/A
	Mean /s	-0.3581	-0.2177	0.5405	0.1904	-0.4730	-0.4730	-1.0811
Hardness	Mean	9.5000	9.8889	7.0000	8.7273	9.6667	10.000	13.000
	Pooled s	1.0422	1.0541	2.1602	1.7373	0.5774	0	N/A
	Mean /s	0.6636	0.8404	-0.4727	0.3124	0.7394	0.8909	2.2545
Tensile Strength	Mean	-71.717	-70.822	-67.155	-66.000	-70.033	-70.850	-73.300
	Pooled s	1.5186	1.7817	4.0772	1.9565	1.5631	0.6364	N/A
	Mean /s	-0.0741	0.0930	0.7786	0.9944	0.2405	0.0879	-0.3701
Elongation	Mean	-67.153	-62.422	-58.523	-60.827	-67.133	-60.900	-71.800
	Pooled s	2.5119	2.0055	7.2502	2.8097	3.3501	2.4042	N/A
	Mean /s	-0.9648	-0.4385	-0.0048	-0.2611	-0.9626	-0.2692	-1.4816

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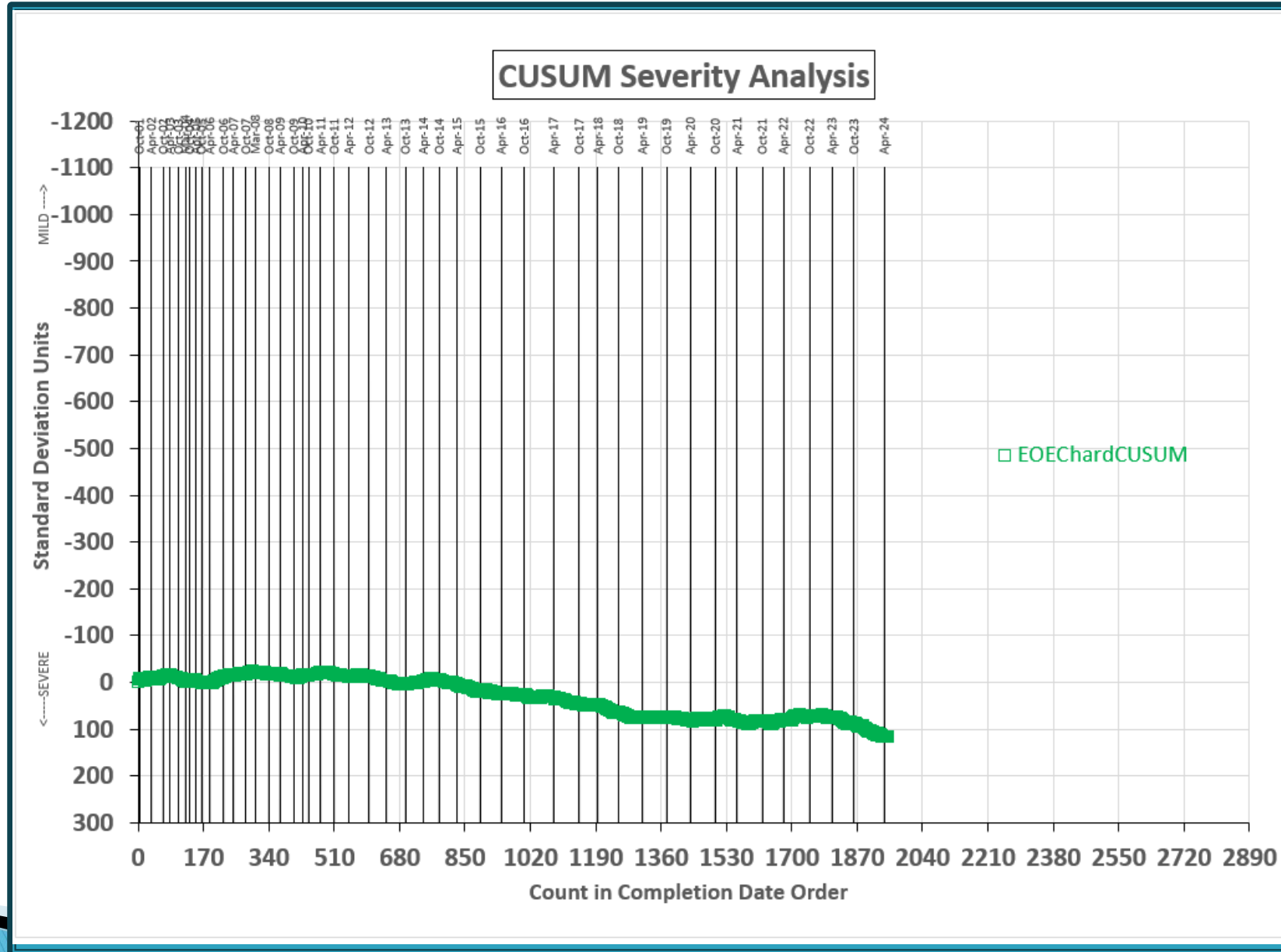
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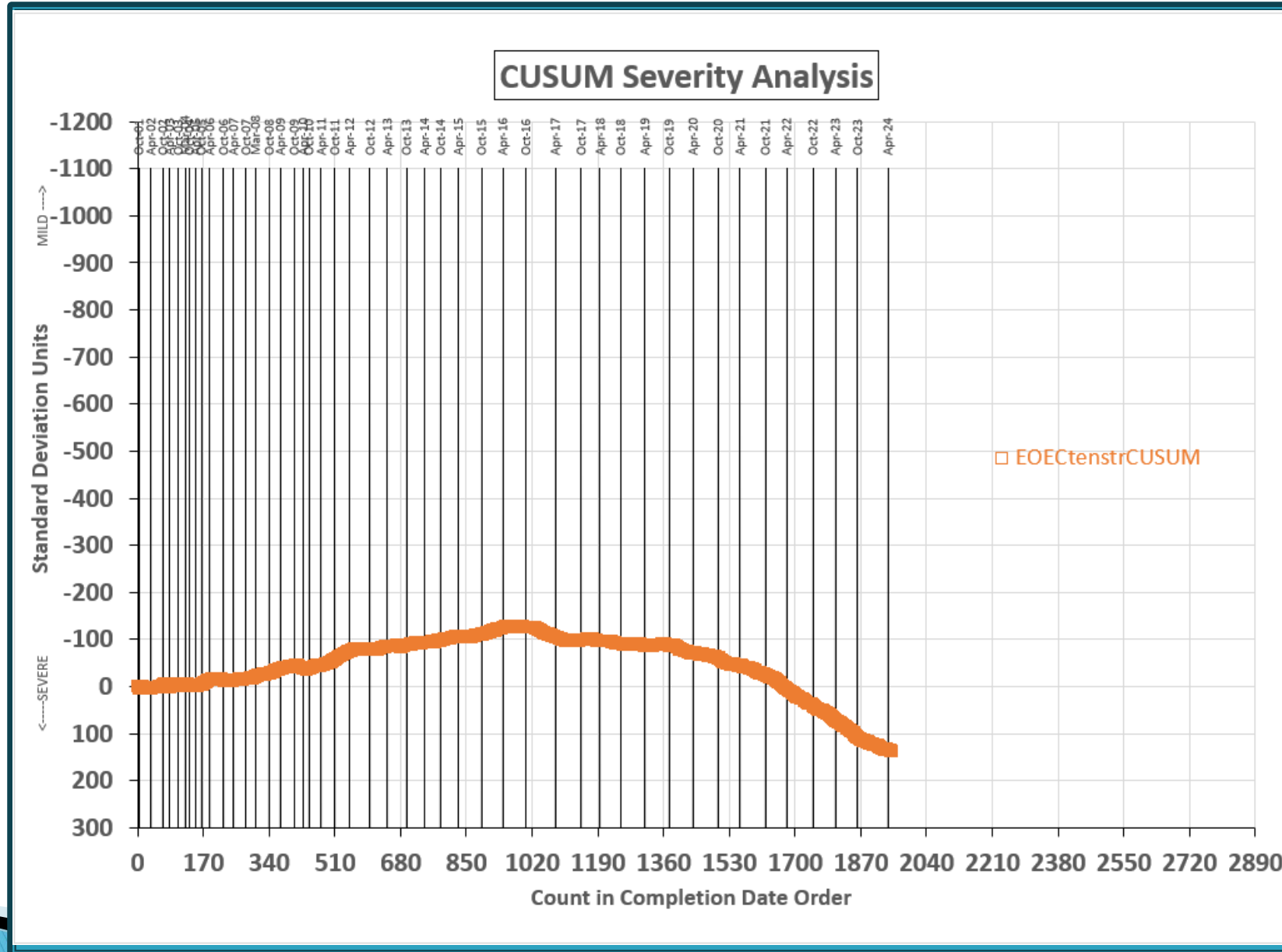
FLUROELASTOMER VOLUME CHANGE CORRECTED AVERAGE



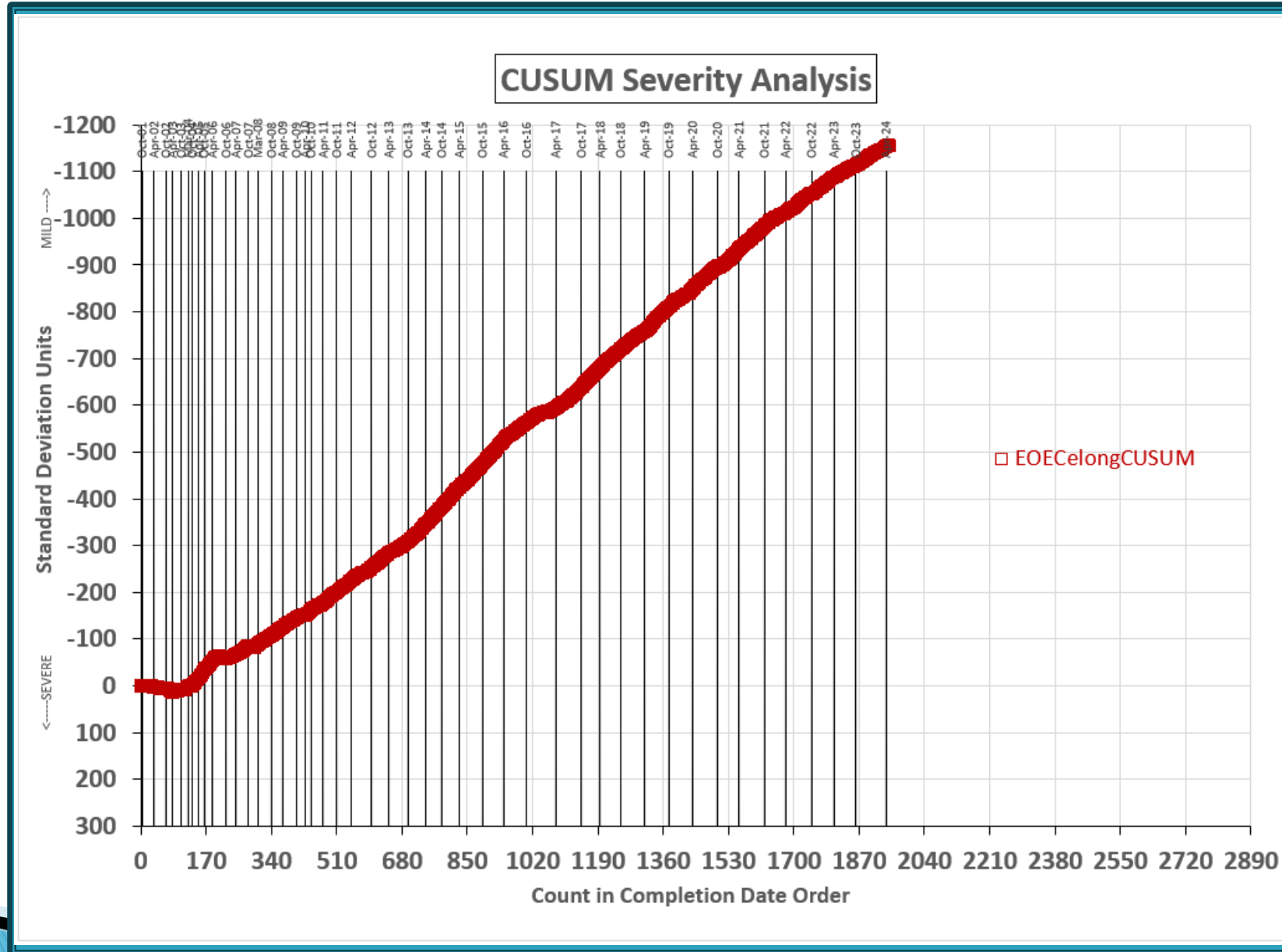
FLUOROELASTOMER PTS HARDNESS CHANGE CORRECTED AVG



FLUROELASTOMER TENS STRENGTH CHANGE CORRECTED AVG



FLUROELASTOMER ELONGATION CHANGE CORRECTED AVG



EOEC Test Severity

Nitrile (NBR)

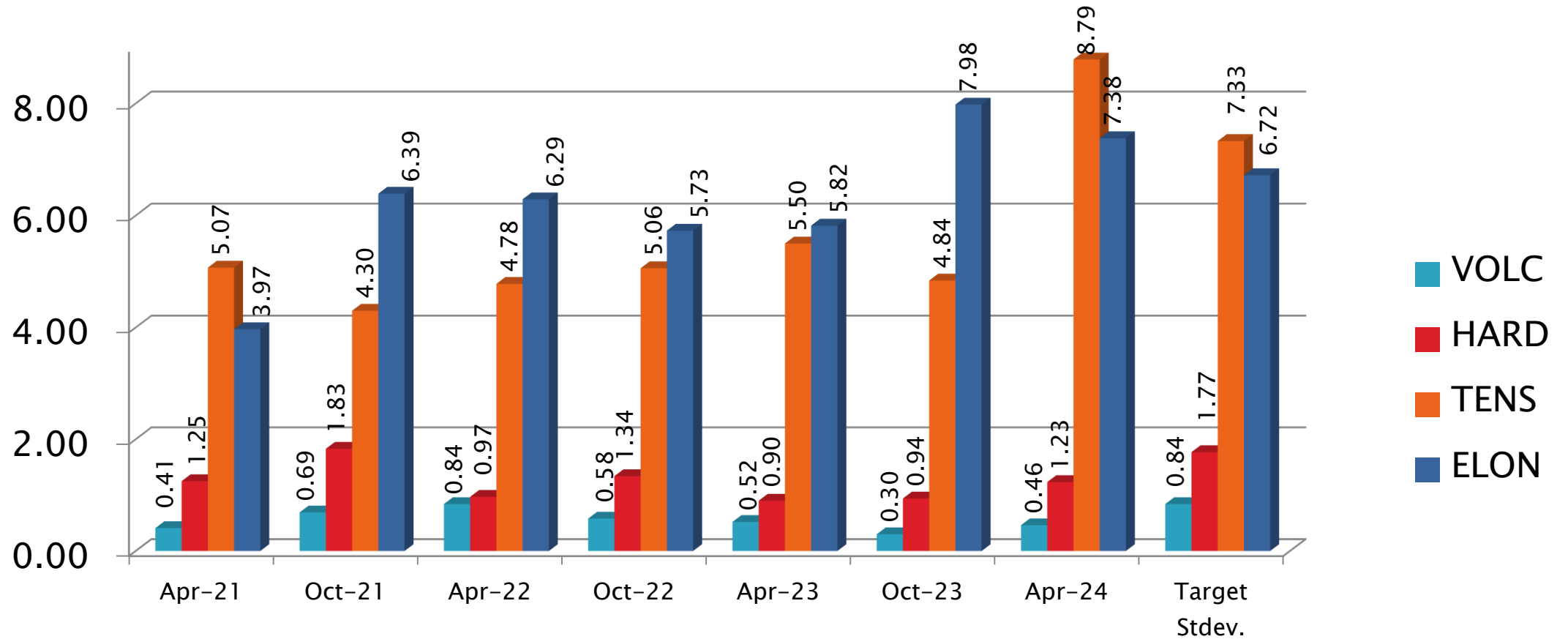
Parameter	Period Mean Δ/s	Status
Volume Change	0.2121	Slightly Severe
Points Hardness Change	0.6059	Severe
Tensile Strength Change	-1.0919	Very Mild
Elongation Change	-0.2766	Slightly Mild

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EOEC Precision Estimates – Nitrile



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EOEC Precision Estimates by Lab: NBR

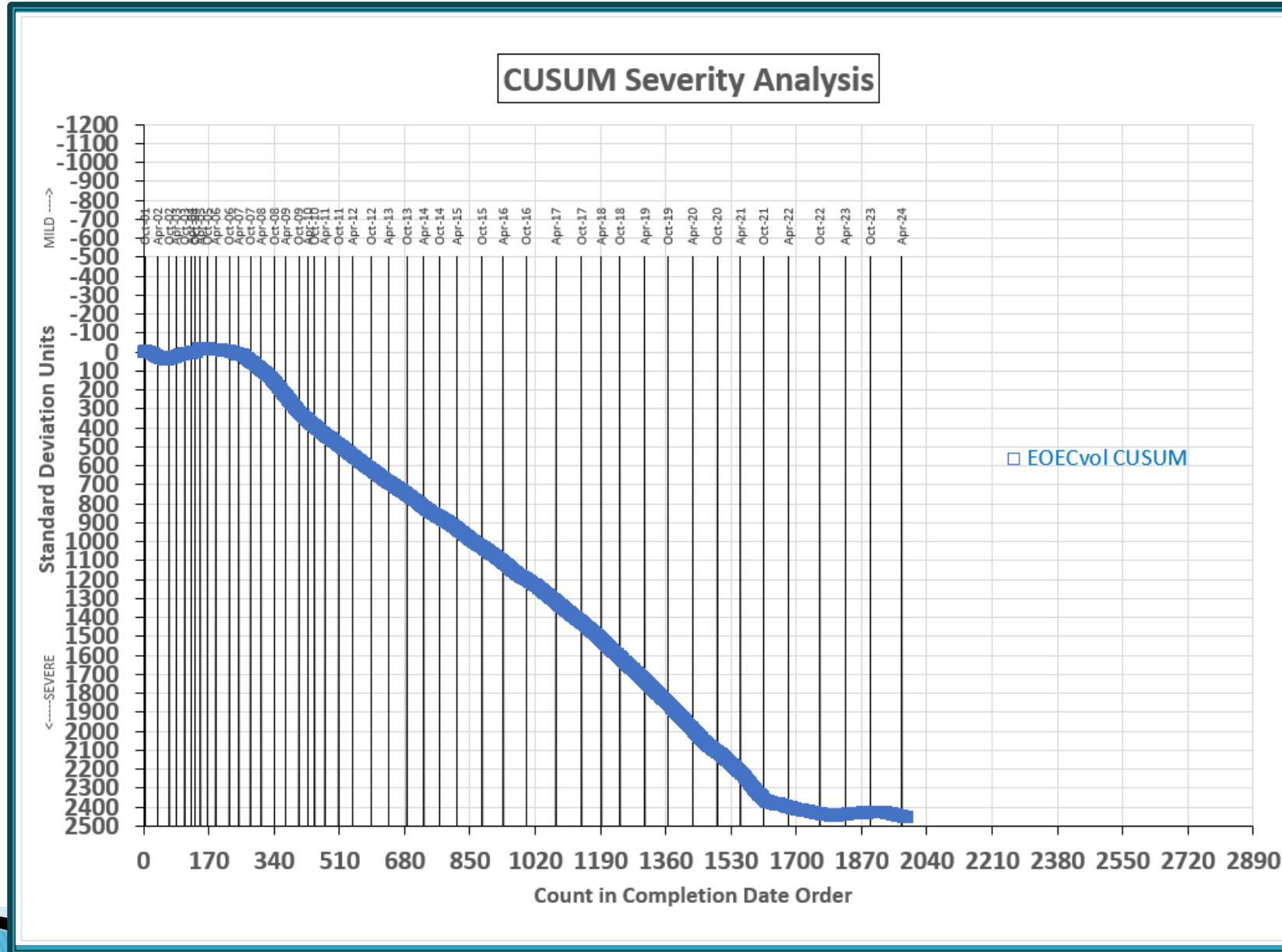
Test Parameter	Statistic	LTMS Lab						
		A	B	G	I	L	P	V
	n=	31	10	20	14	3	2	2
Volume	Mean	1.8565	2.1210	1.6305	2.1957	2.0133	1.9400	2.6300
	Pooled s	0.2749	0.3161	0.4858	0.5861	0.5316	0.4384	0.2121
	Mean /s	0.1386	0.4536	-0.1304	0.5425	0.3254	0.2381	1.0595
Hardness	Mean	3.1290	3.7000	1.8000	3.5000	2.6667	3.0000	2.5000
	Pooled s	0.8059	0.8233	1.5761	0.9405	0.5774	0	0.7071
	Mean /s	0.7339	1.0565	-0.0169	0.9435	0.4727	0.6610	0.3785
Tensile Strength	Mean	-6.5484	-8.5200	-2.4200	-4.1143	0.6333	-7.8000	-9.4000
	Pooled s	8.9681	3.6116	12.724	2.7762	0.7637	6.0811	4.5254
	Mean /s	-1.2754	-1.5443	-0.7124	-0.9432	-0.2956	-1.4461	-1.6643
Elongation	Mean	-36.823	-38.330	-31.805	-37.236	-32.033	-37.150	-31.200
	Pooled s	4.7753	1.5420	12.364	3.9432	4.3016	5.3033	2.5456
	Mean /s	-0.4662	-0.6905	0.2805	-0.5276	0.2465	-0.5149	0.3705

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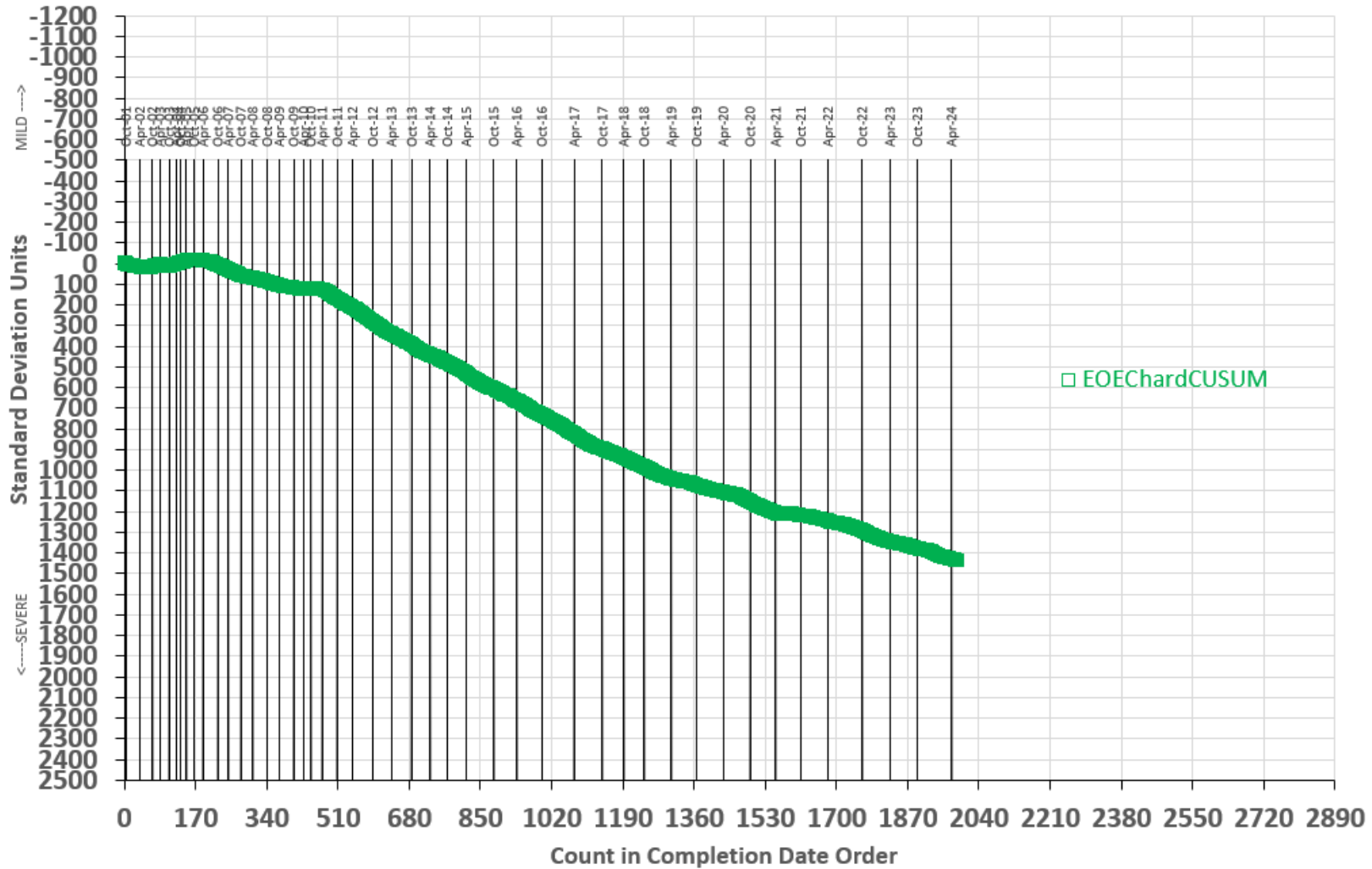


REFERENCE NITRILE VOLUME CHANGE CORRECTED AVERAGE



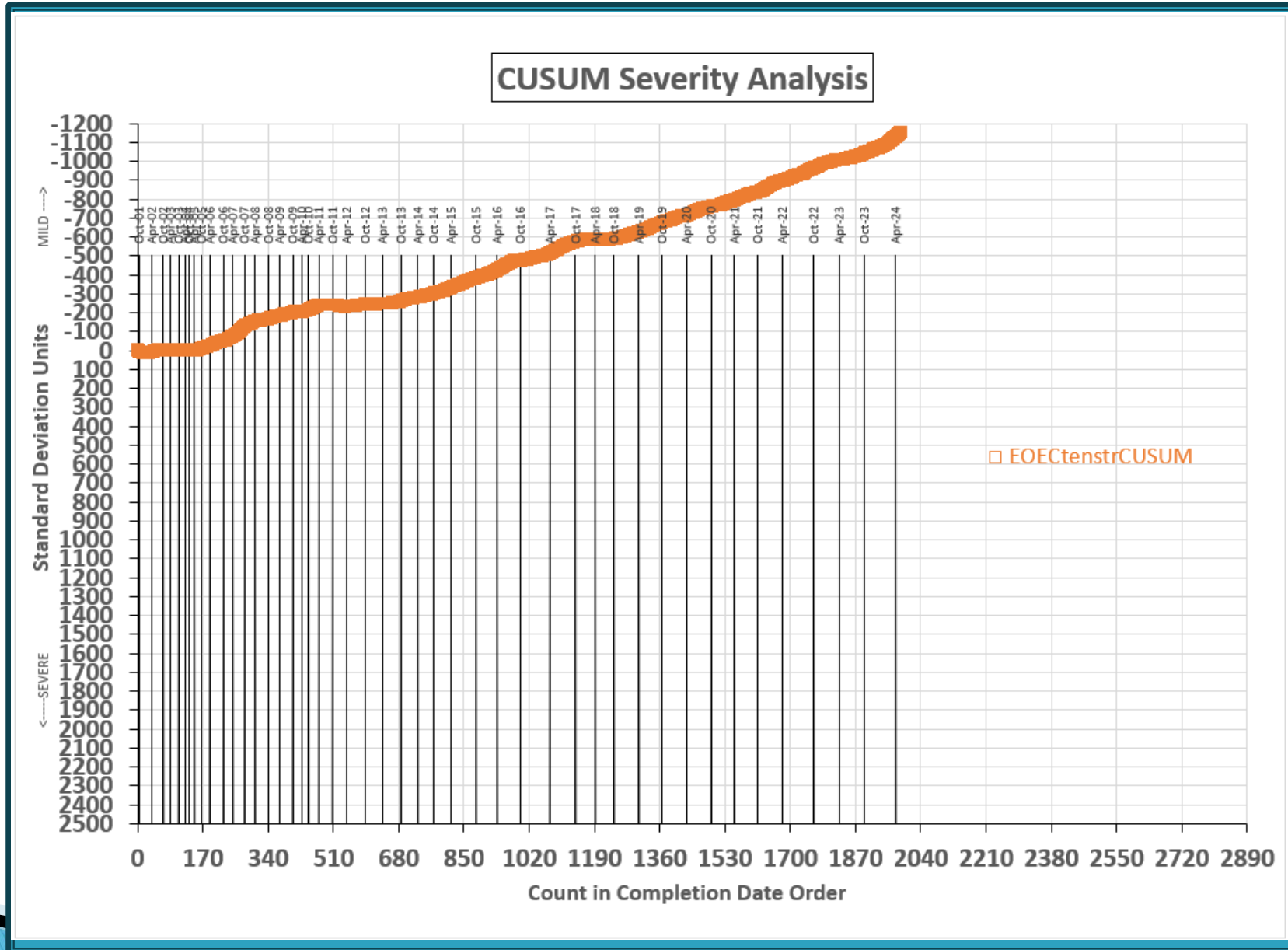
REFERENCE NITRILE PTS HARD CHANGE CORRECTED AVG

CUSUM Severity Analysis

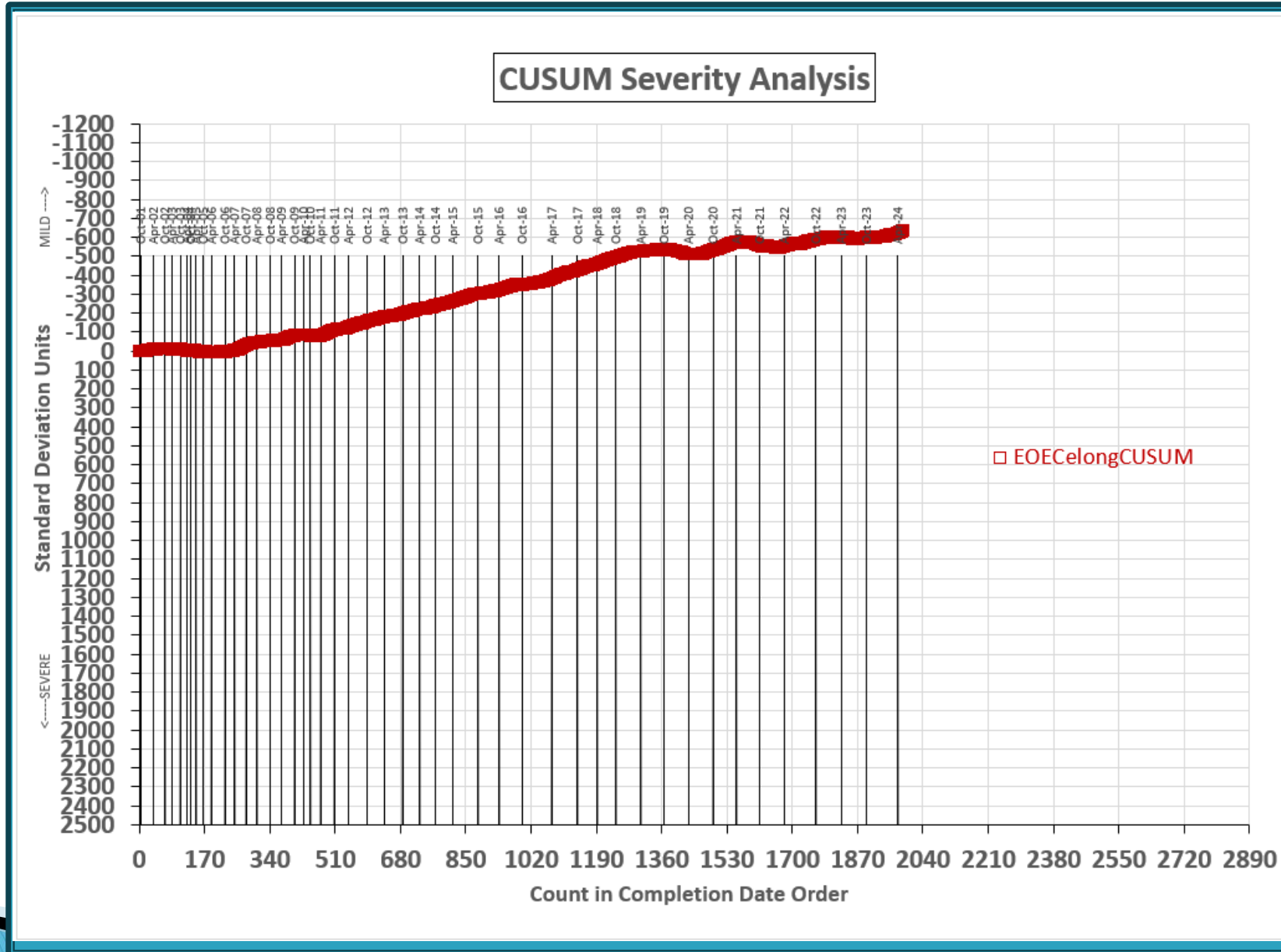


□ EOEChardCUSUM

REF NITRILE TENS STRENGTH CHANGE CORRECTED AVG



REF NITRILE ELONGATION CHANGE CORRECTED AVERAGE



EOEC Test Severity

Polyacrylate (ACM)

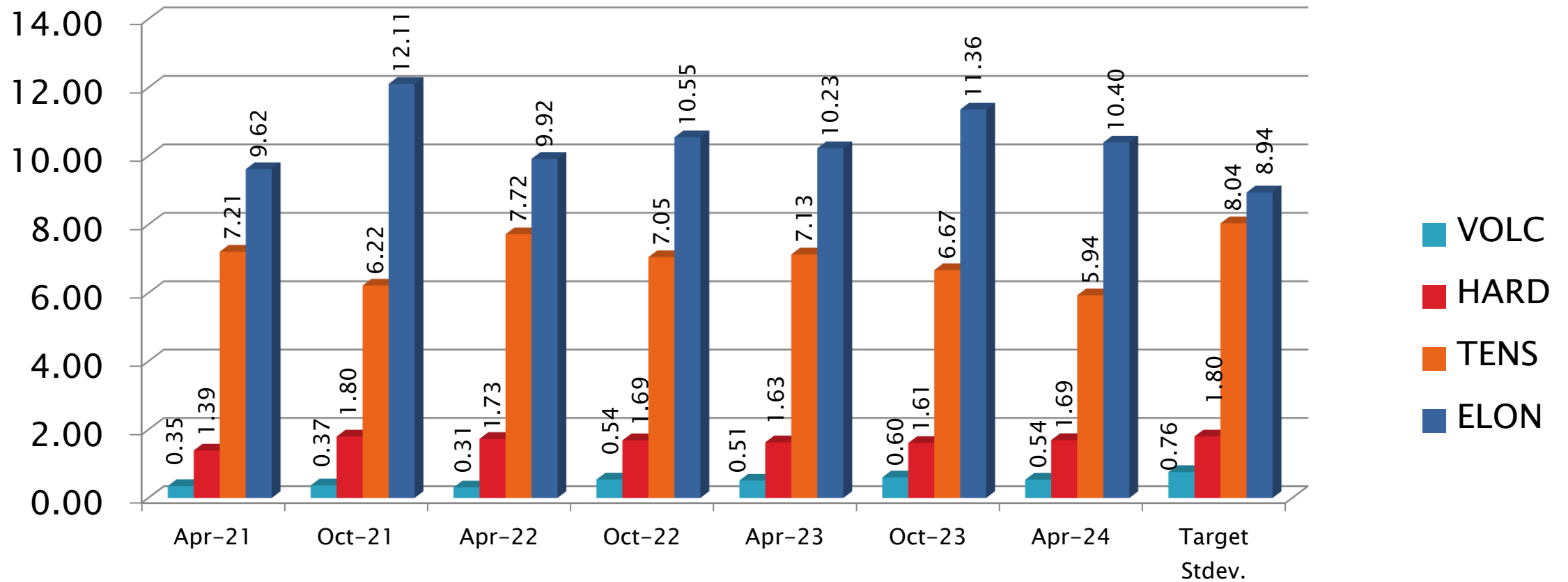
Parameter	Period Mean Δ/s	Status
Volume Change	2.02	Severe
Points Hardness Change	-0.79	Mild
Tensile Strength Change	0.13	On-target
Elongation Change	0.63	Severe

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EOEC Precision Estimates – Polyacrylate



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EOEC Precision Estimates by Lab: ACM

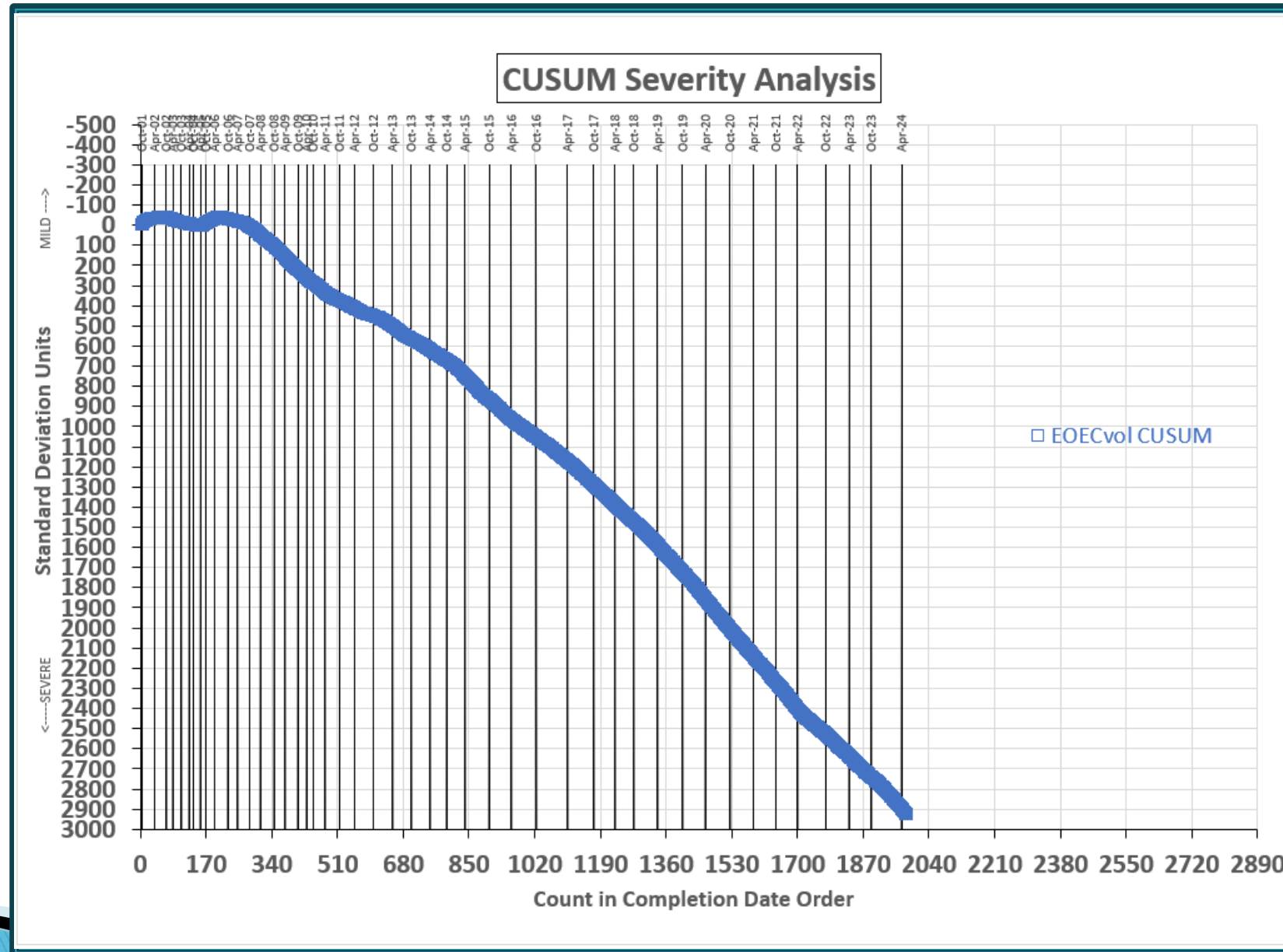
Test Parameter	Statistic	LTMS Lab						
		A	B	G	I	L	P	V
	n=	31	9	21	11	3	2	1
Volume	Mean	1.6897	2.0056	1.5095	2.1854	1.3033	1.9550	1.5100
	Pooled s	0.2294	0.2781	0.8349	0.3384	0.1617	0.2333	N/A
	Mean /s	1.9601	2.3757	1.7231	2.6124	1.4518	2.3092	1.7237
Hardness	Mean	-2.2258	-2.4444	-0.5238	-0.9091	1.0000	-0.5000	-2.0000
	Pooled s	1.0866	0.7265	2.2050	1.1362	1.0000	0.7071	N/A
	Mean /s	-1.2310	-1.3525	-0.2854	-0.4995	0.5611	-0.2722	-1.1056
Tensile Strength	Mean	1.3258	0.9778	0.8952	3.7636	-2.8000	6.3000	-1.9000
	Pooled s	6.0743	4.5213	7.0608	4.5697	4.8816	2.8284	N/A
	Mean /s	0.1201	0.0768	0.0666	0.4233	-0.3930	0.7388	-0.2811
Elongation	Mean	-14.6613	-14.811	-21.124	-20.800	-11.533	-7.2000	-9.4000
	Pooled s	8.9919	5.6860	13.207	9.7696	6.2517	7.2125	N/A
	Mean /s	0.8858	0.8690	0.1629	0.1991	1.2356	1.7204	1.4743

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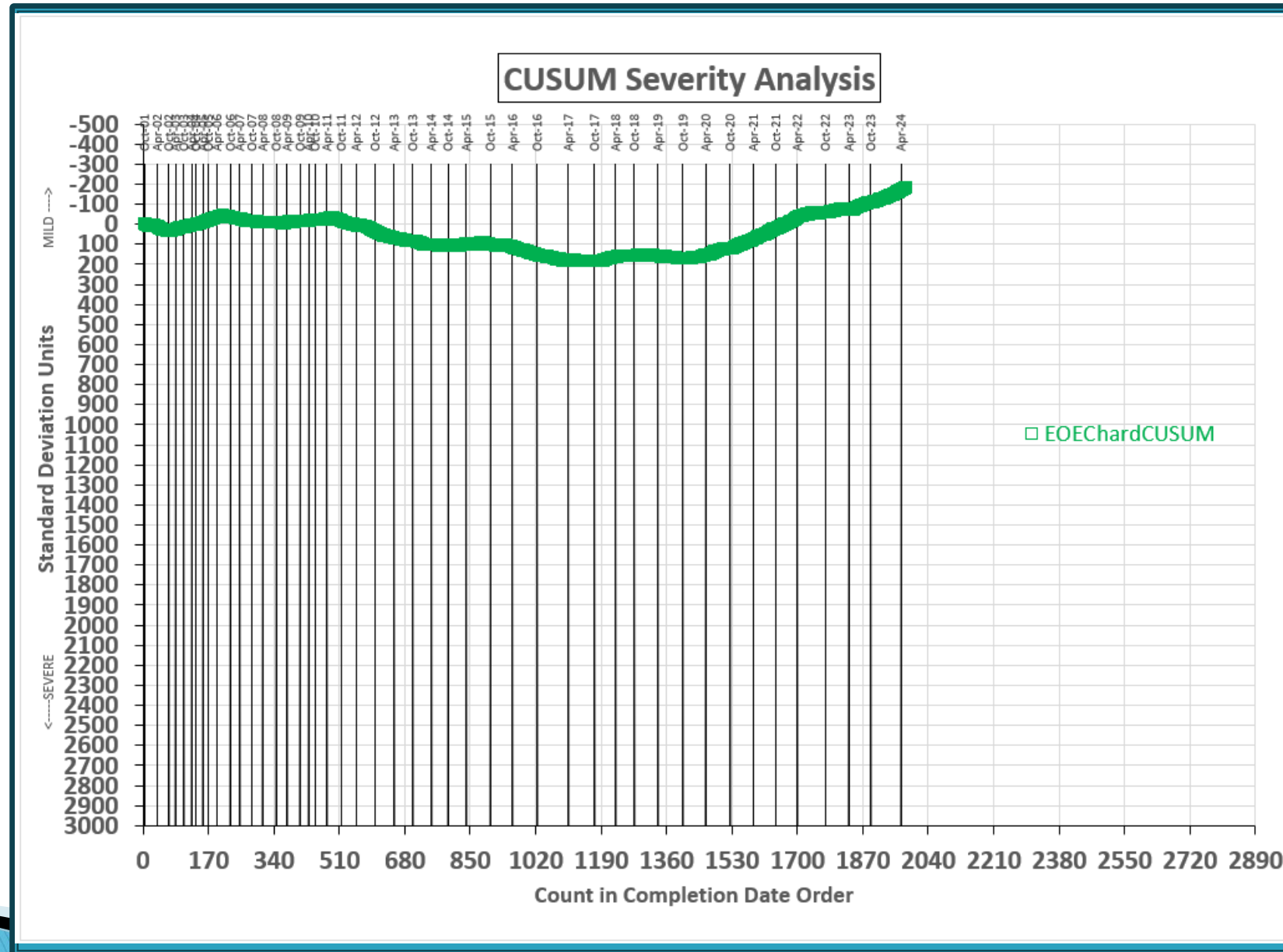
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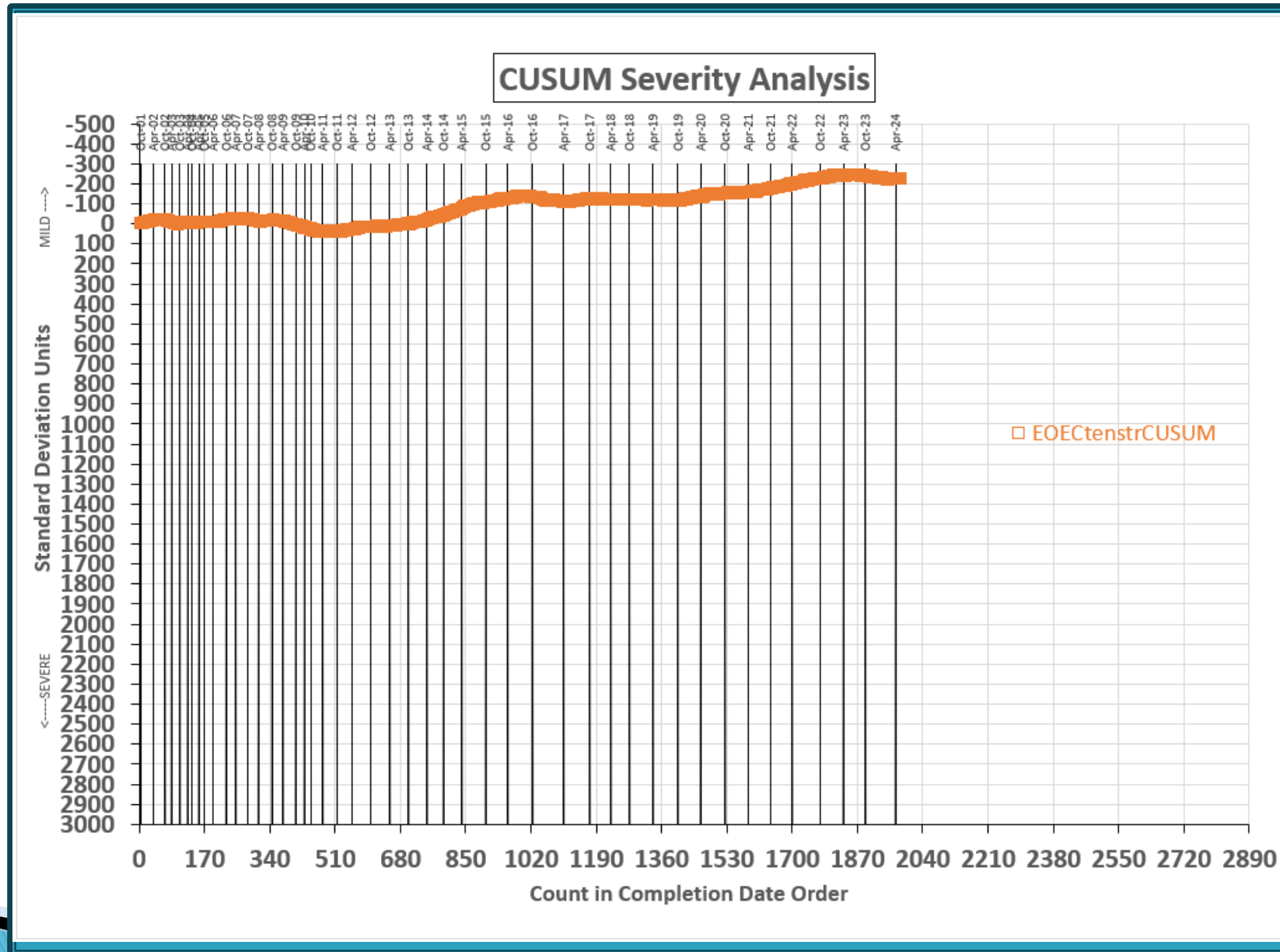
REFERENCE POLYACRYLATE VOLUME CHANGE CORRECTED AVG



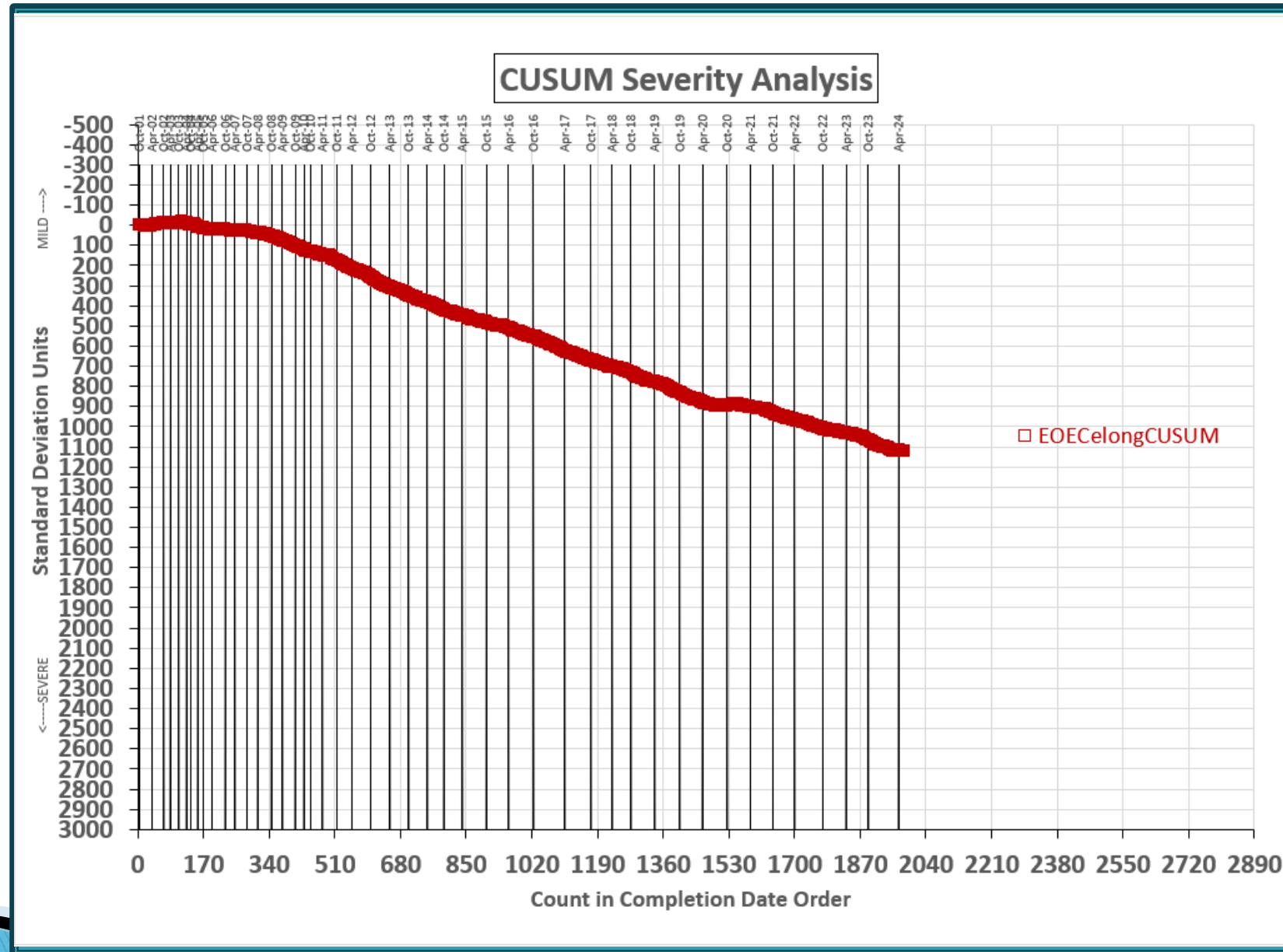
REF POLYACRYLATE PTS HARD CHANGE CORRECTED AVG



REF POLYACRYLATE TENS STRNGTH CHANGE CORRECTED AVG



REF POLYACRYLATE ELONGATION CHANGE CORRECTED AVG



EOEC Test Severity

Silicone (VMQ)

Parameter	Period Mean Δ/s	Status
Volume Change	0.7269	Severe
Points Hardness Change	-0.7990	Mild
Tensile Strength Change	-0.1745	Slightly Severe
Elongation Change	-0.3345	Mild

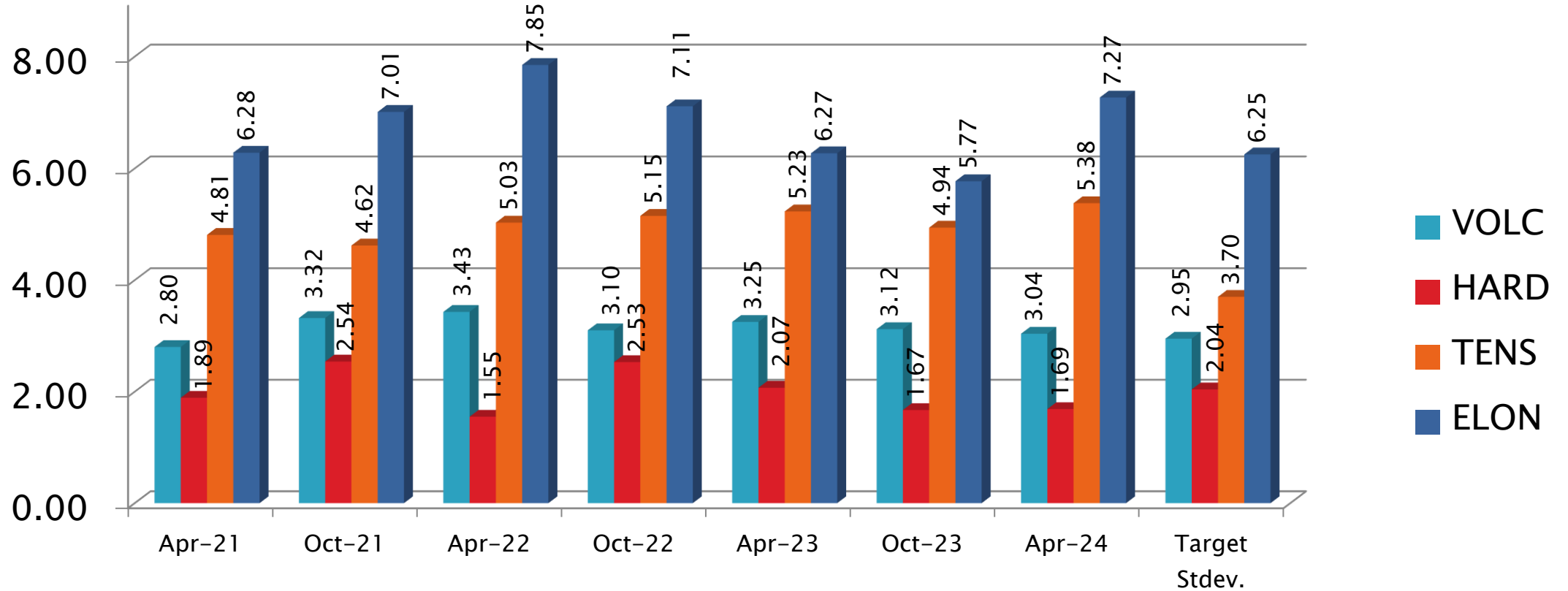
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EOEC Precision Estimates – Silicone



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EOEC Precision Estimates by Lab: VMQ

Test Parameter	Statistic	LTMS Lab						
		A	B	G	I	L	P	V
	n=	26	9	20	10	3	2	1
Volume	Mean	33.500	33.7311	37.708	31.2070	31.200	33.355	35.170
	Pooled s	2.5814	0.7968	2.0340	1.0054	1.8159	1.667	N/A
	Mean /s	0.4510	0.5291	1.8775	-0.3264	-0.3288	0.4017	1.0169
Hardness	Mean	-23.538	-23.444	-24.550	-21.900	-17.667	-23.000	-23.000
	Pooled s	0.8593	0.8819	0.8870	1.1005	0.5774	0.000	N/A
	Mean /s	-0.9110	-0.8649	-1.407	-0.1078	1.9673	-0.647	-0.6471
Tensile Strength	Mean	-33.815	-32.400	-35.895	-37.010	-27.533	-33.850	-33.000
	Pooled s	6.2524	3.010	5.5869	2.9153	0.0577	1.6263	N/A
	Mean /s	-0.0177	0.3649	-0.5797	-0.8810	1.6801	-0.0270	0.2027
Elongation	Mean	-27.2423	-25.733	-29.260	-26.020	-14.600	-25.800	-28.800
	Pooled s	5.2881	2.8434	10.5728	4.8417	1.0440	1.2728	N/A
	Mean /s	-0.3892	-0.1477	-0.7120	-0.1936	1.6336	-0.1584	-0.6384

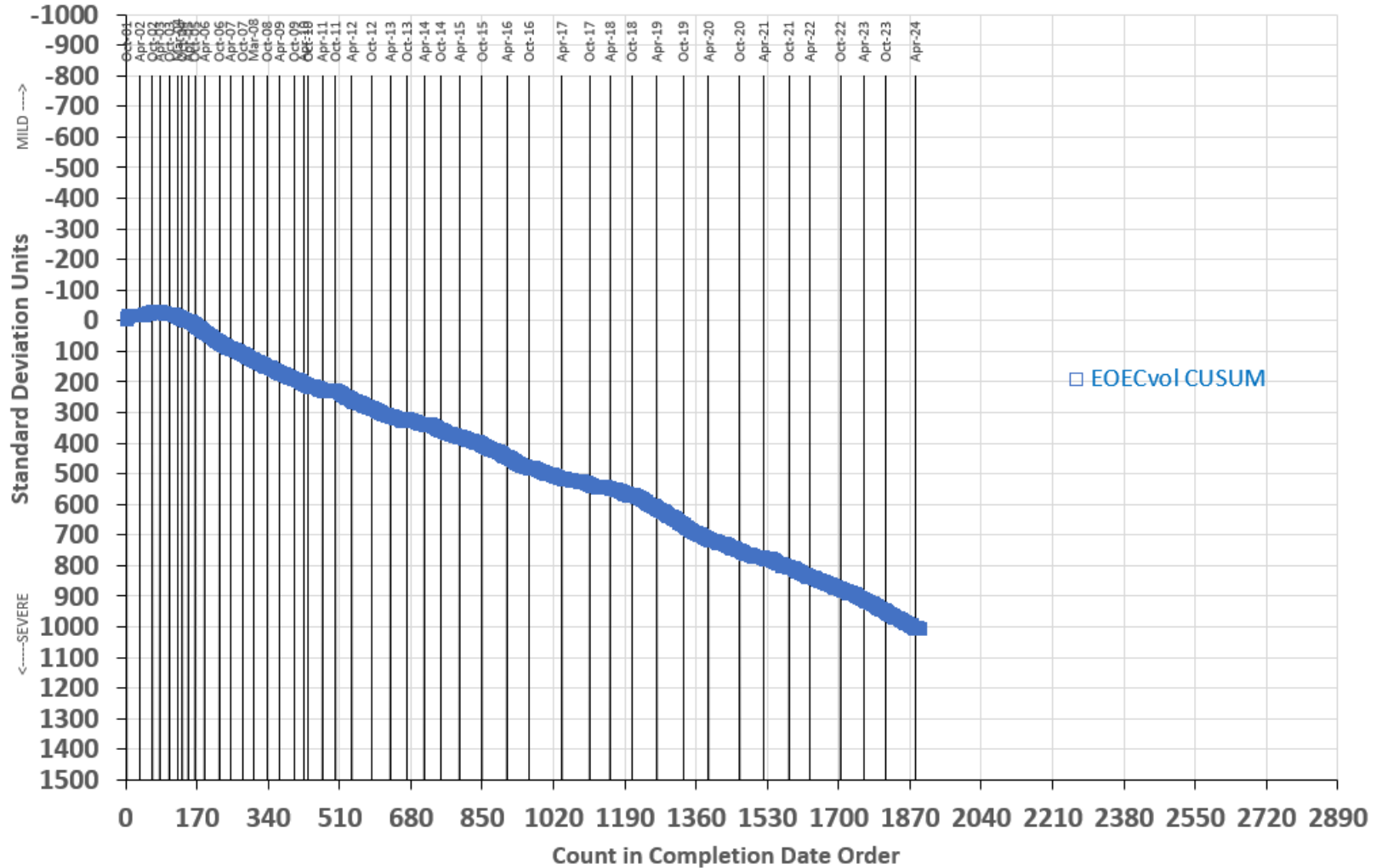
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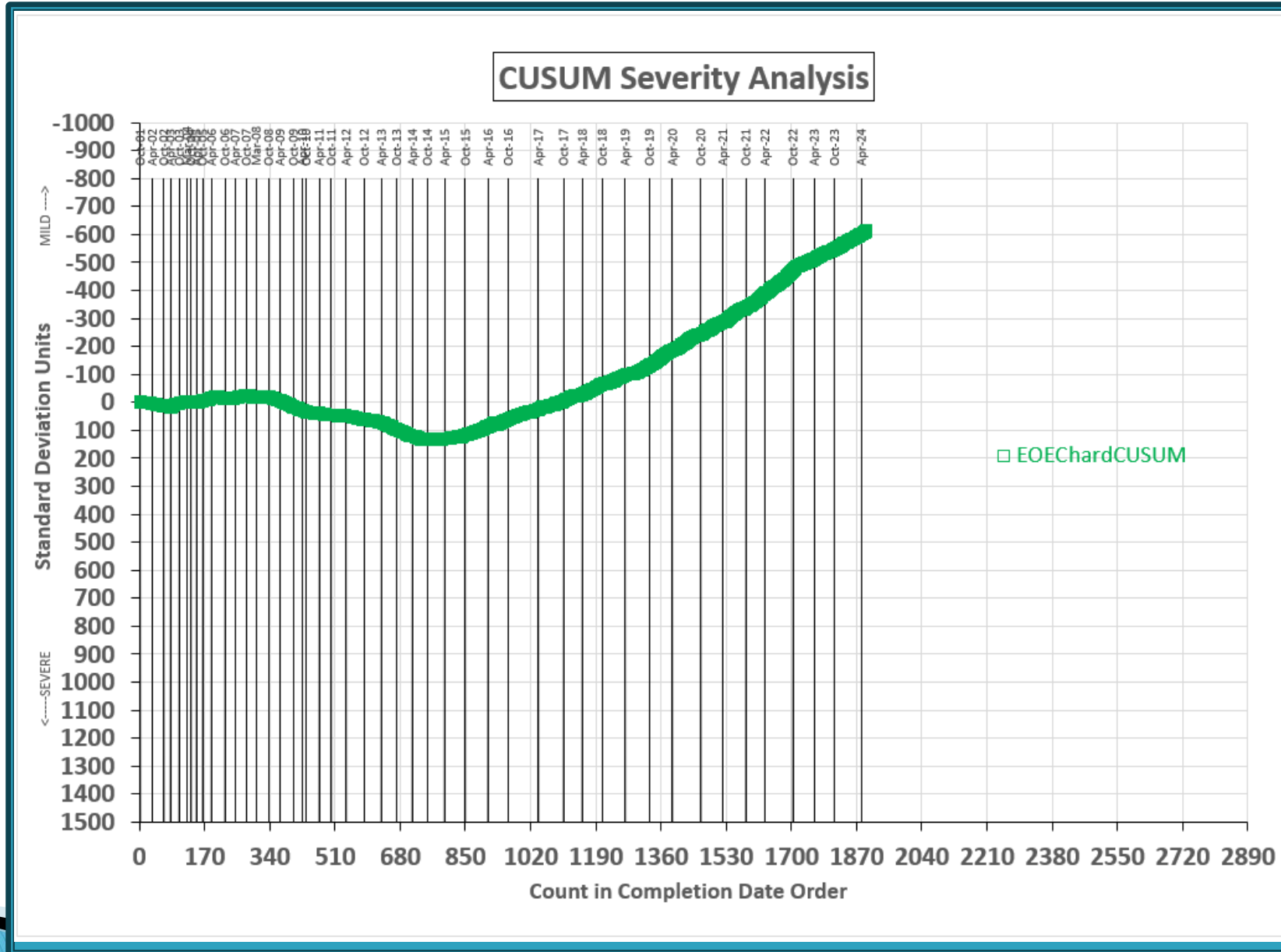
REFERENCE SILICON VOLUME CHANGE CORRECTED AVG

CUSUM Severity Analysis



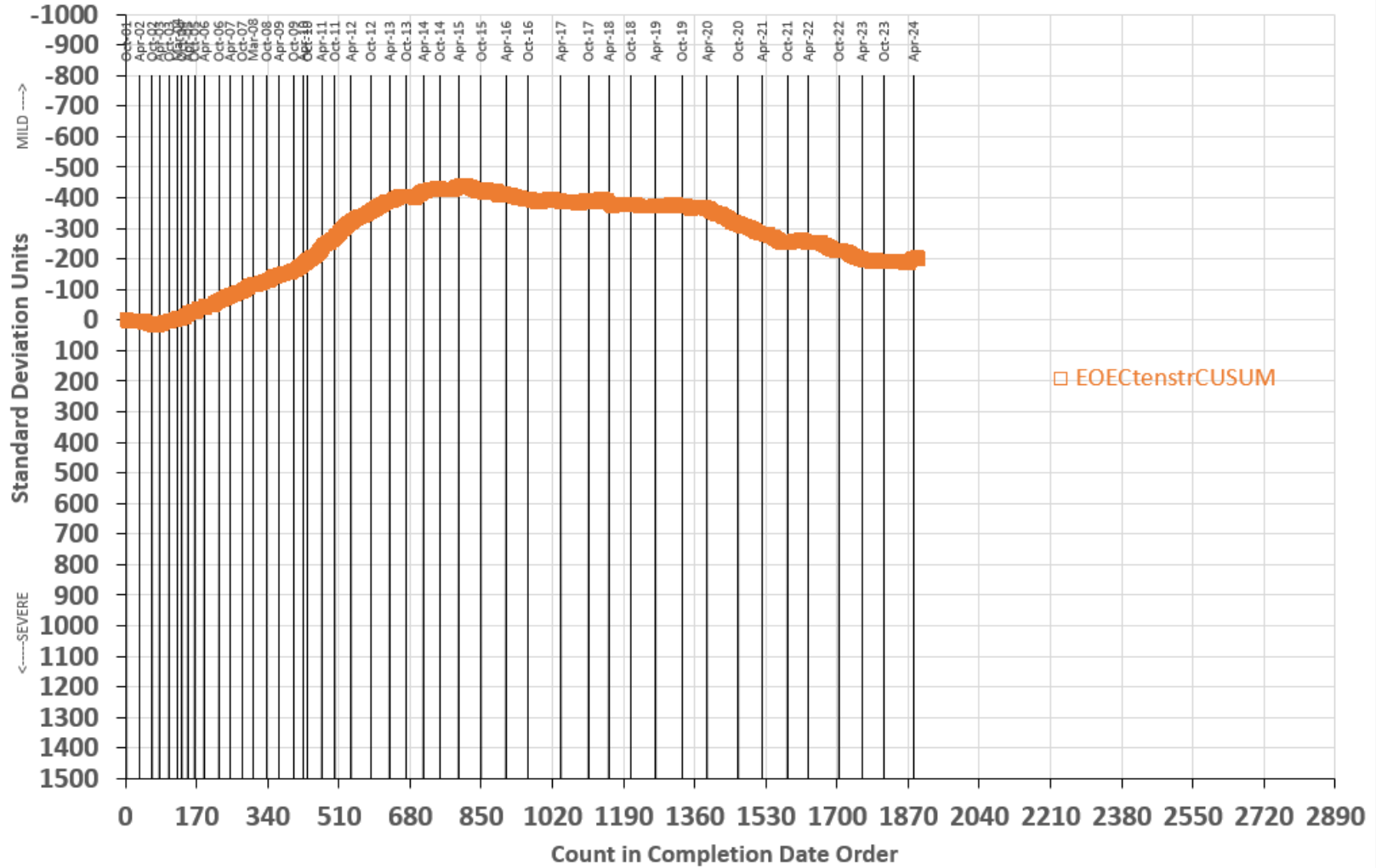
EOECvol CUSUM

REFERENCE SILICON PTS HARD CHANGE CORRECTED AVG



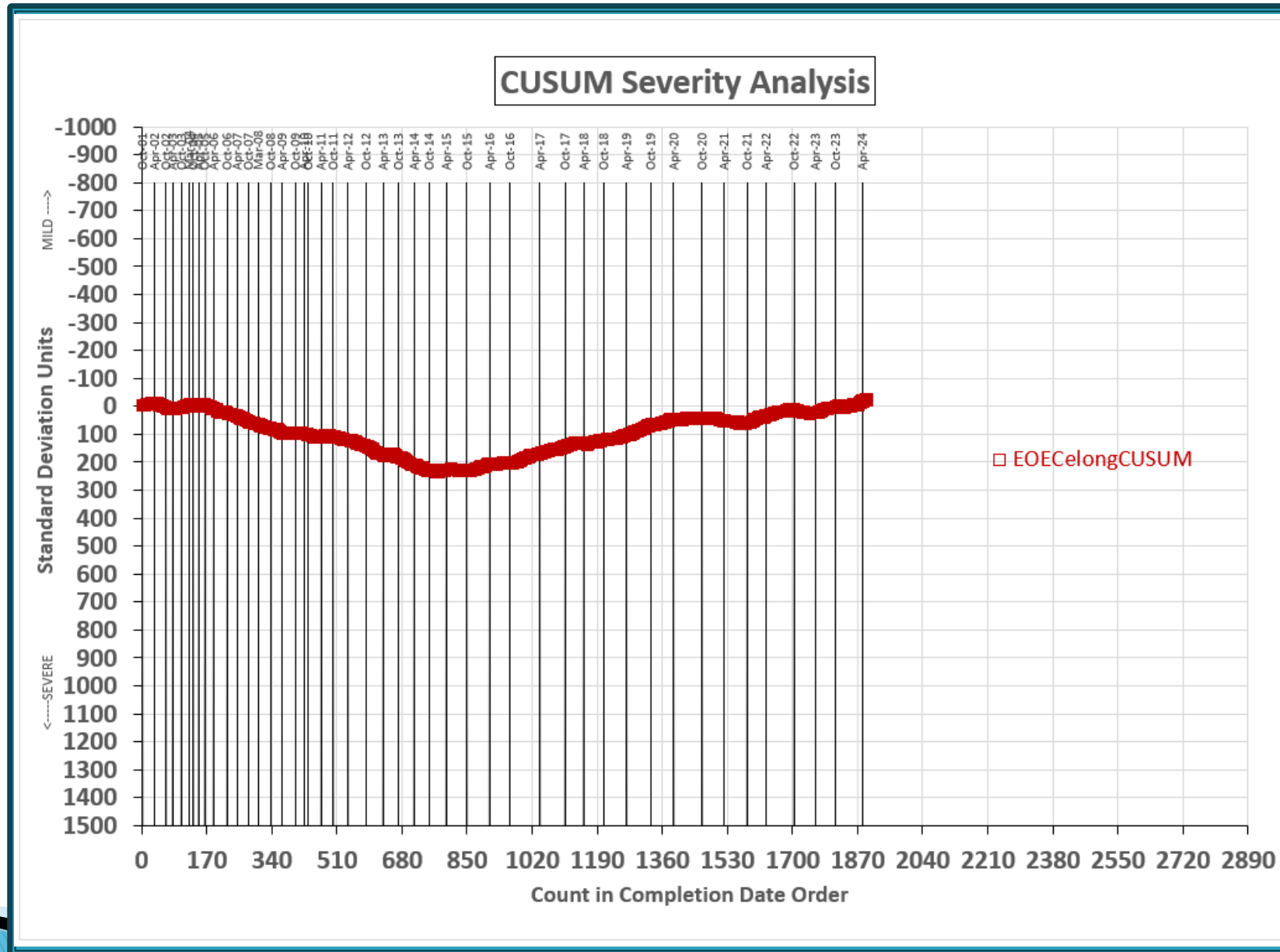
REF SILICON TENSILE STRENGTH CHANGE CORRECTED AVG

CUSUM Severity Analysis



EOECtenstrCUSUM

REF SILICON ELONGATION CHANGE CORRECTED AVG



□ EOECelongCUSUM

EOEC Test Severity

Ethylene Acrylate “VAMAC” (MAC)

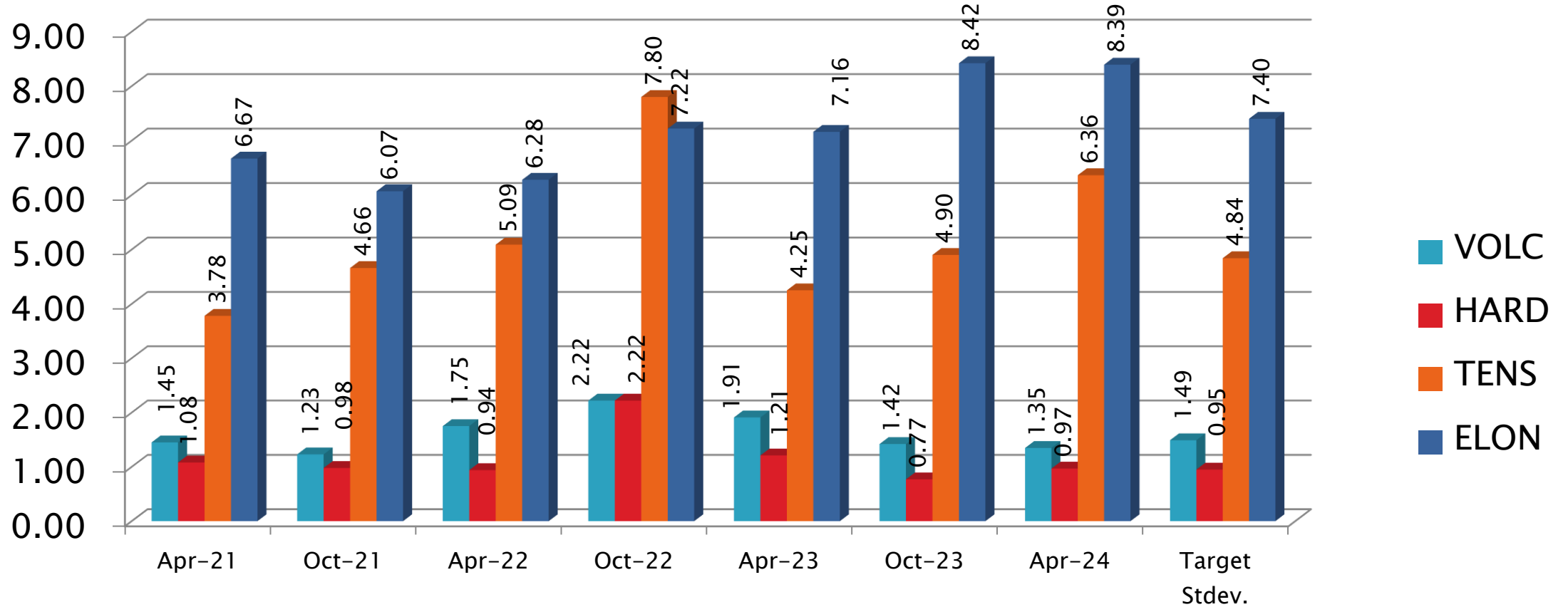
Parameter	Period Mean Δ/s	Status
Volume Change	0.8692	Severe
Points Hardness Change	-0.8372	Mild
Tensile Strength Change	-0.8080	Mild
Elongation Change	-0.5785	Mild

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EOEC Precision Estimates - VAMAC



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EOEC Precision Estimates by Lab: MAC

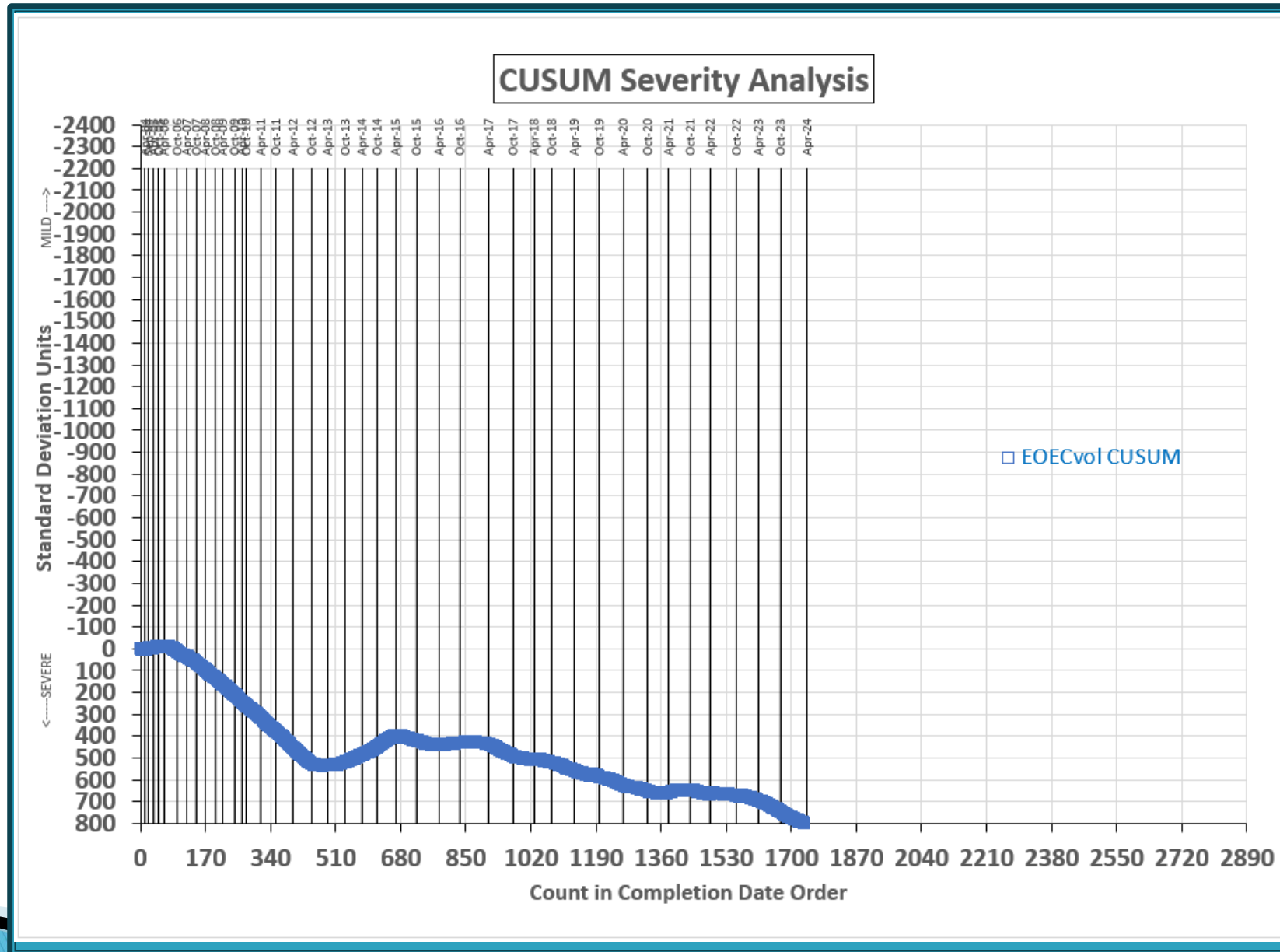
Test Parameter	Statistic	LTMS Lab						
		A	B	G	I	L	P	V
	n=	26	9	18	11	3	0	2
Volume	Mean	19.166	19.612	21.473	20.091	17.677		16.630
	Pooled s	0.7189	0.1715	0.6536	0.8355	0.4895		0.1838
	Mean /s	0.4200	0.7196	1.9683	1.0409	-0.5794		-1.2819
Hardness	Mean	-8.1538	-9.0000	-8.5556	-7.8182	-6.6667		-9.000
	Pooled s	0.7317	0.8660	0.7838	1.1677	0.5774		1.4142
	Mean /s	-0.7093	-1.6000	-1.1322	-0.3560	0.8561		-1.6000
Tensile Strength	Mean	-21.700	-21.478	-19.033	-14.3455	-9.6333		-20.400
	Pooled s	7.4073	3.8271	4.9725	3.0814	0.9292		1.4142
	Mean /s	-1.316	-1.2702	-0.7652	0.2034	1.1770		-1.0475
Elongation	Mean	-39.477	-42.078	-36.511	-42.4818	-31.900		-41.150
	Pooled s	7.1250	2.6186	12.569	4.8754	5.0478		0.2121
	Mean /s	-0.6104	-0.9619	-0.2096	-1.0165	0.4135		-0.8365

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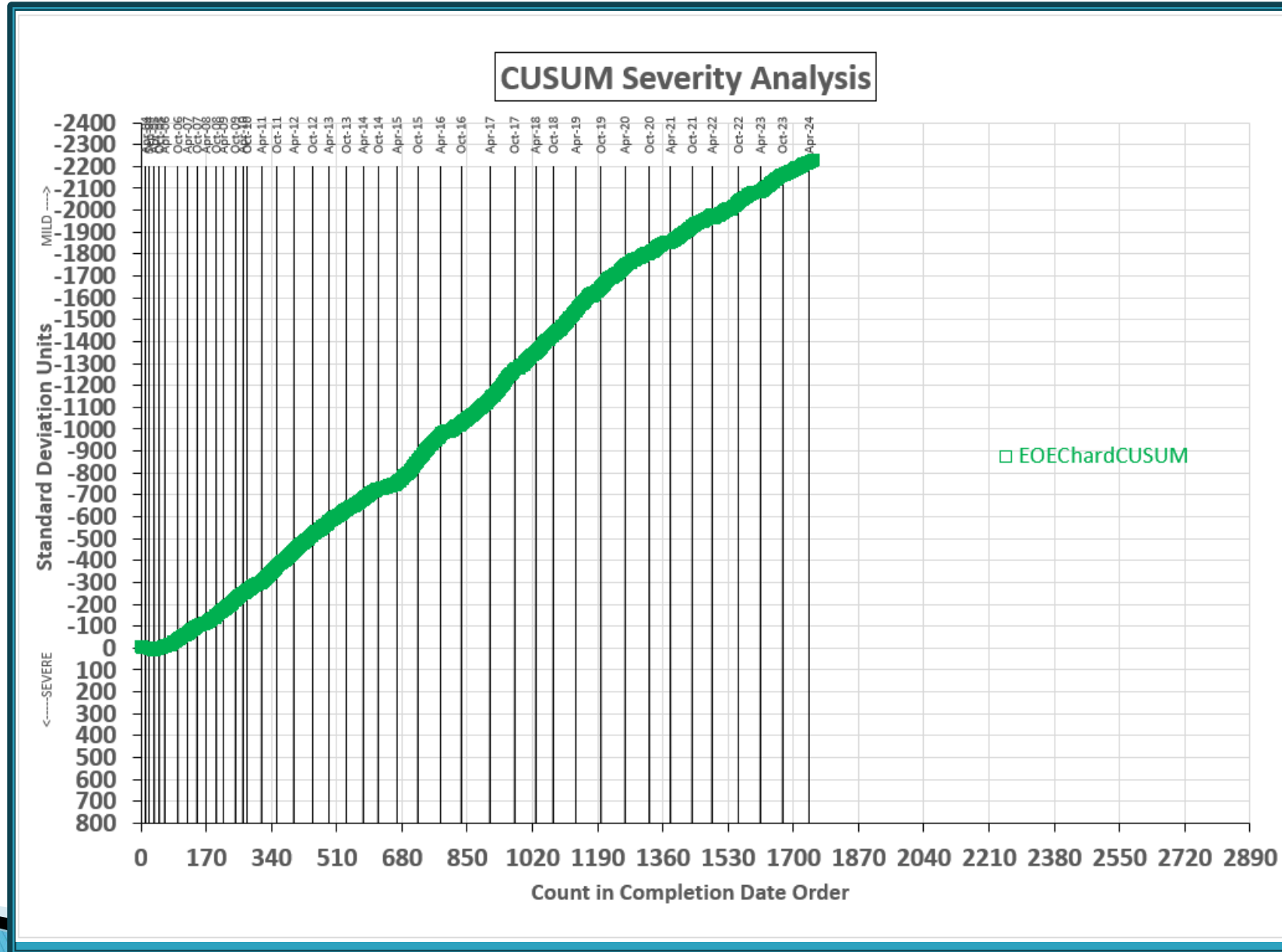


REFERENCE VAMAC G VOLUME CHANGE CORRECTED AVERAGE



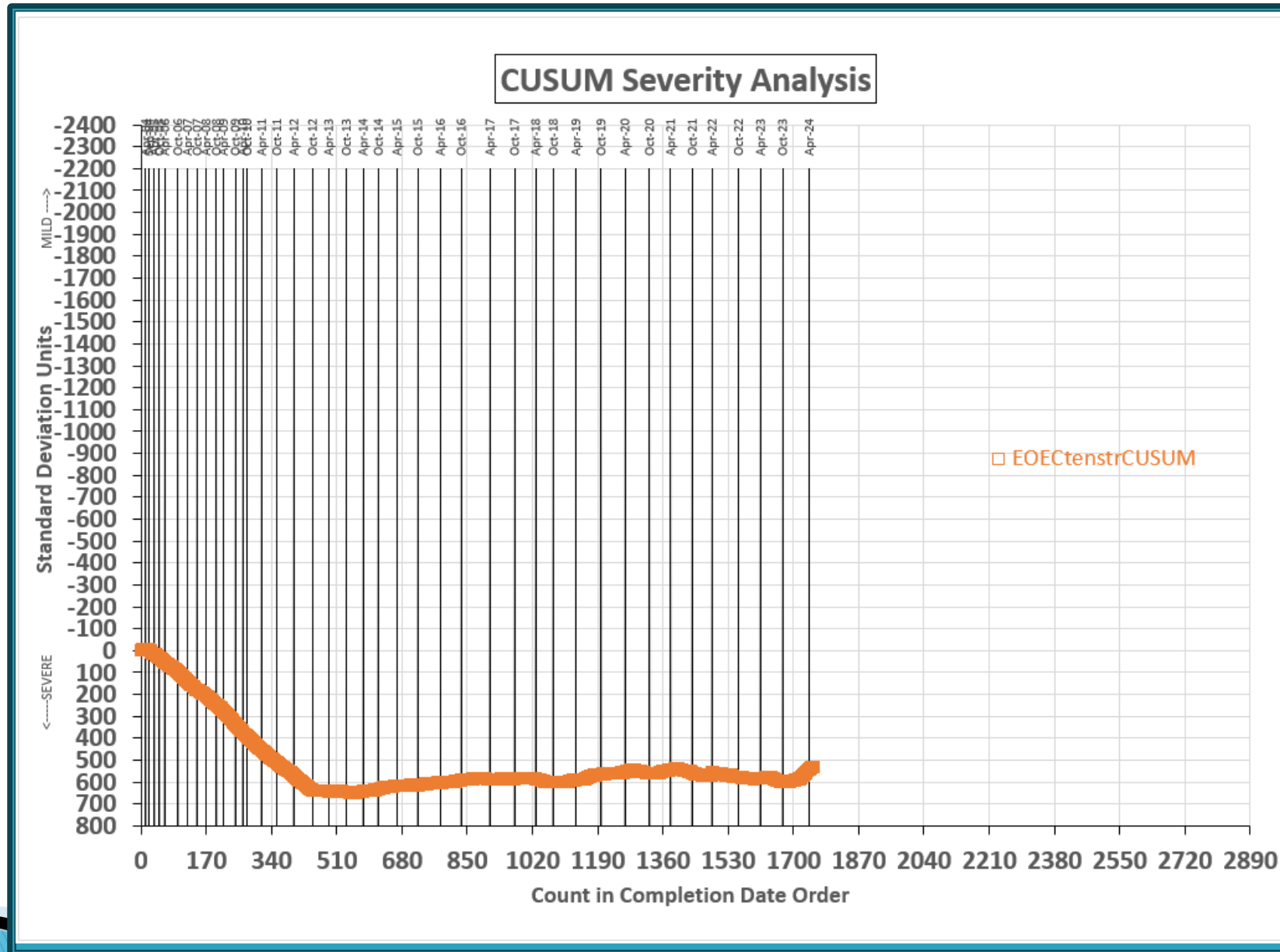
□ EOECvol CUSUM

REF VAMAC G POINTS HARDNESS CHANGE CORRECTED AVG



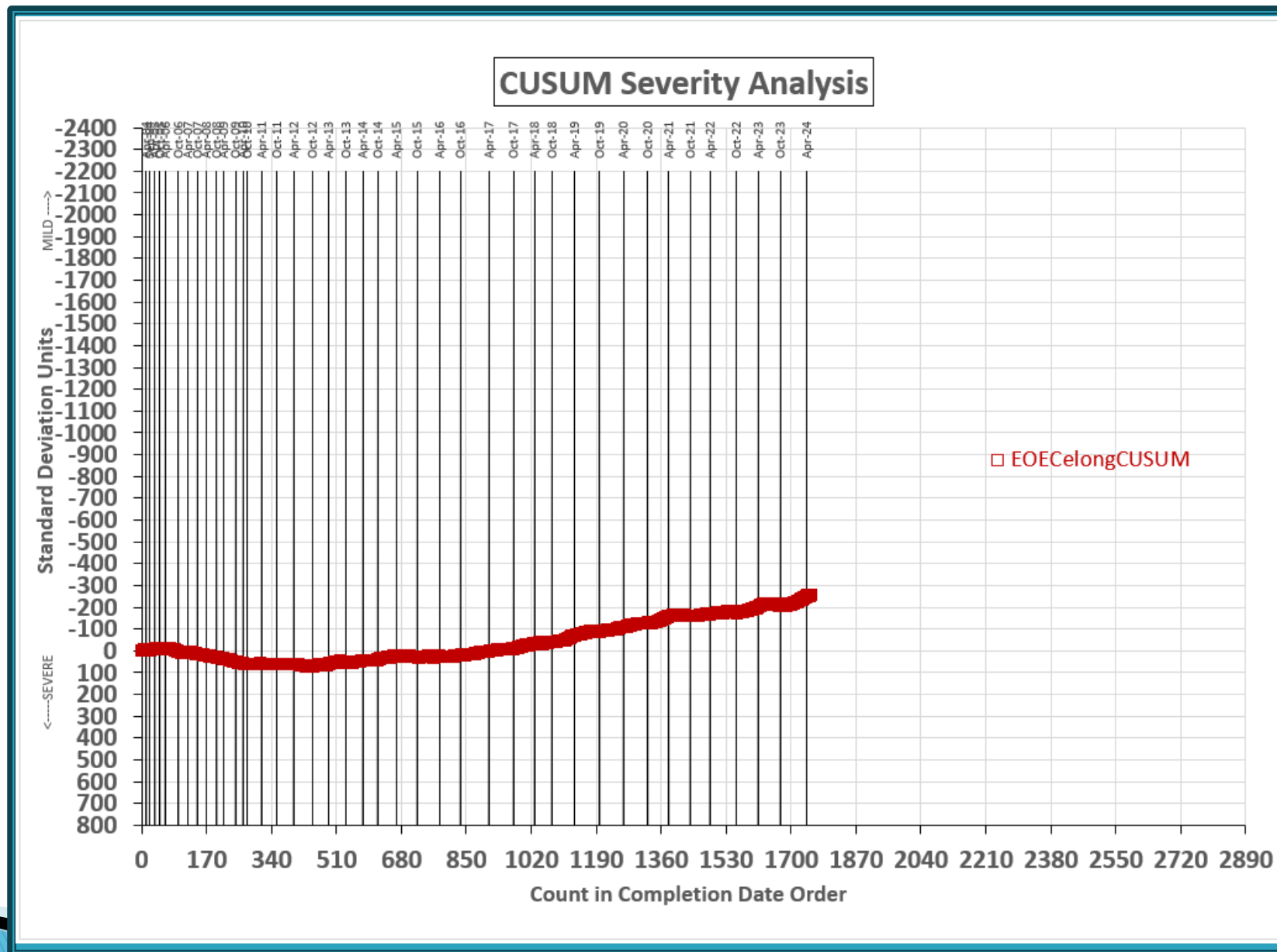
□ EOEChardCUSUM

REF VAMAC G TENSILE STRENGTH CHANGE CORRECTED AVG



□ EOECtenstrCUSUM

REF VAMAC G ELONGATION CHANGE CORRECTED AVG



□ EOECelongCUSUM

Information Letters & Technical Updates*

Test	Date	IL or Memo Number	Topic
EOEC	20240305	M24-005	Adjusted Specification Limits for EOEC D7216 Tests

*Available from TMC Website

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Reference Oil Inventory Estimated Life

EOEC & LDEOC

Oil	TMC Inventory Gallons	Gallons Shipped Past 6 Months	Estimated Life ^C
SL107 ^{A, B}	1742	229	~3.5 years

^A TMC Inventory is used across several test methods

^B SL107 has fully replaced oil 1006; Oil 1006 is no longer used as an EOEC Reference Fluid

^C Use Rate of SL107 will accelerate due to addition of five new Elastomers to D7216:
FOUR: ILSAC GF-7
ONE: PC-12

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ASTM Reference Testing Semi-Annual Report D7216 LDEOC

October 1, 2023 to March 31, 2024

ASTM D 7216

Engine Oil Elastomer Compatibility (EOEC/LDEOC)

OHT CURRENT ELASTOMER BATCH CODES FOR ASTM D7216

AS OF: 4/23/2024

EOEC	
OHT PART NUMBER	BATCH CODE
OHTEOEC-NBR-A	31
OHTEOEC-ACM-B	32
OHTEOEC-FKM-A	31
OHTEOEC-MAC-A	24

LDEOC	
OHT PART NUMBER	BATCH CODE
OHTLDEOC-HNBR1-A	32
OHTDLEOC-FKM1-A	29
OHTLDEOC-ACM1-B	26
OHTLDEOC-VMQ1-A	42
OHTLDEOC-AEM1-B	31
OHTLDEOC-ACM2-A	1
OHTLDEOC-AEM2-A	1
OHTLDEOC-FKM3-A	1
OHTLDEOC-AEM3-A	1

LDEOC Test Activity

Test Status		Ethylene Acrylate	Fluoroelast.	Nitrile	Polyacrylate	Silicone	Total
	LABS	8	8	8	8	8	
Acceptable Calibration Test	AC	79	79	79	79	75	391
Failed Calibration Test	OC	2	1	2	1	3	9
Operationally Invalid, by lab	LC	0	0	0	0	0	0
Operationally Invalid, by TMC	RC	0	0	0	0	0	0
Aborted	XC	1	0	1	0	0	2
Acceptable Informational Run	NN	4	3	0	0	0	7
Unacceptable Informational Run	MN	0	0	0	0	0	0
Total		86	83	82	80	78	409

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Calibrated Labs and Stands¹

(change shown in parentheses)

Test	Labs	Stands
D7216 LDEOC	8 ² (+1)	N/A

¹ As of 3/31/2024

² One new lab ran a single LDEOCF

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LDEOC Failing Calibration (OC) Tests

Cause	Elastomer	#
TENSILE STRENGTH (MILD)	AEM1,HNBR1	2
VOLUME (MILD)	AEM1	1
VOLUME (SEVERE)	FKM1	1
HARD (S) + TENS (M)	HNBR1	1
HARDNESS (MILD)	ACM1	1
TENSILE STRENGTH (SEVERE)	VMQ1	3
Total		9

There were NINE failing LDEOC Calibration Tests reported this period from FIVE different labs.

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LDEOC Lost Tests

Validity	Cause	No. of Tests
XC	WRONG ELASTOMER USED (AEM1)	1
XC	TEMPERATURE CONTROLLER FAILURE (HNBR1)	1
Total		2

*Invalid (LC,RC) and Aborted (XC) calibration tests

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LDEOC Test Severity

Ethylene Acrylate (AEM1)

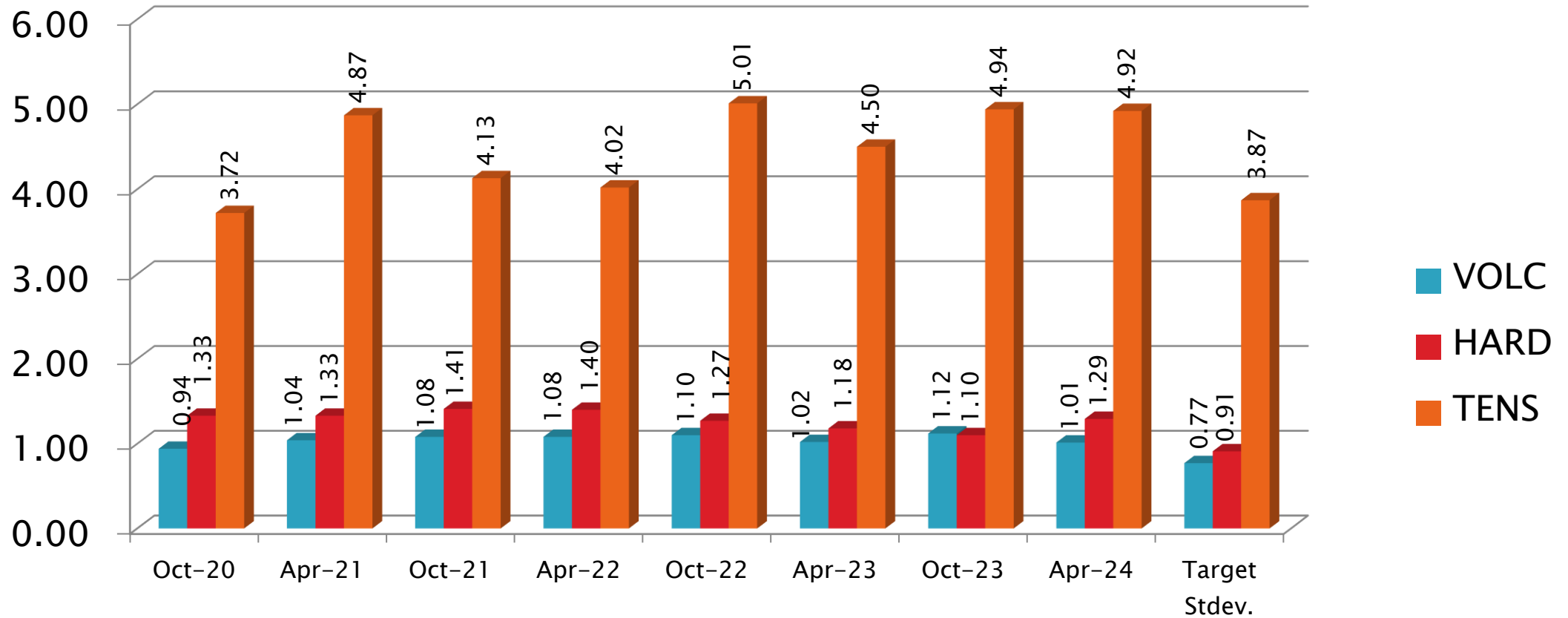
Parameter	Period Mean Δ/s	Status
Volume Change	-0.9322	Mild
Points Hardness Change	-0.1068	Slightly Mild
Tensile Strength Change	-0.7157	Mild

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LDEOC Precision Estimates – Ethylene Acrylate



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LDEOC Precision Estimates by Lab: AEM1

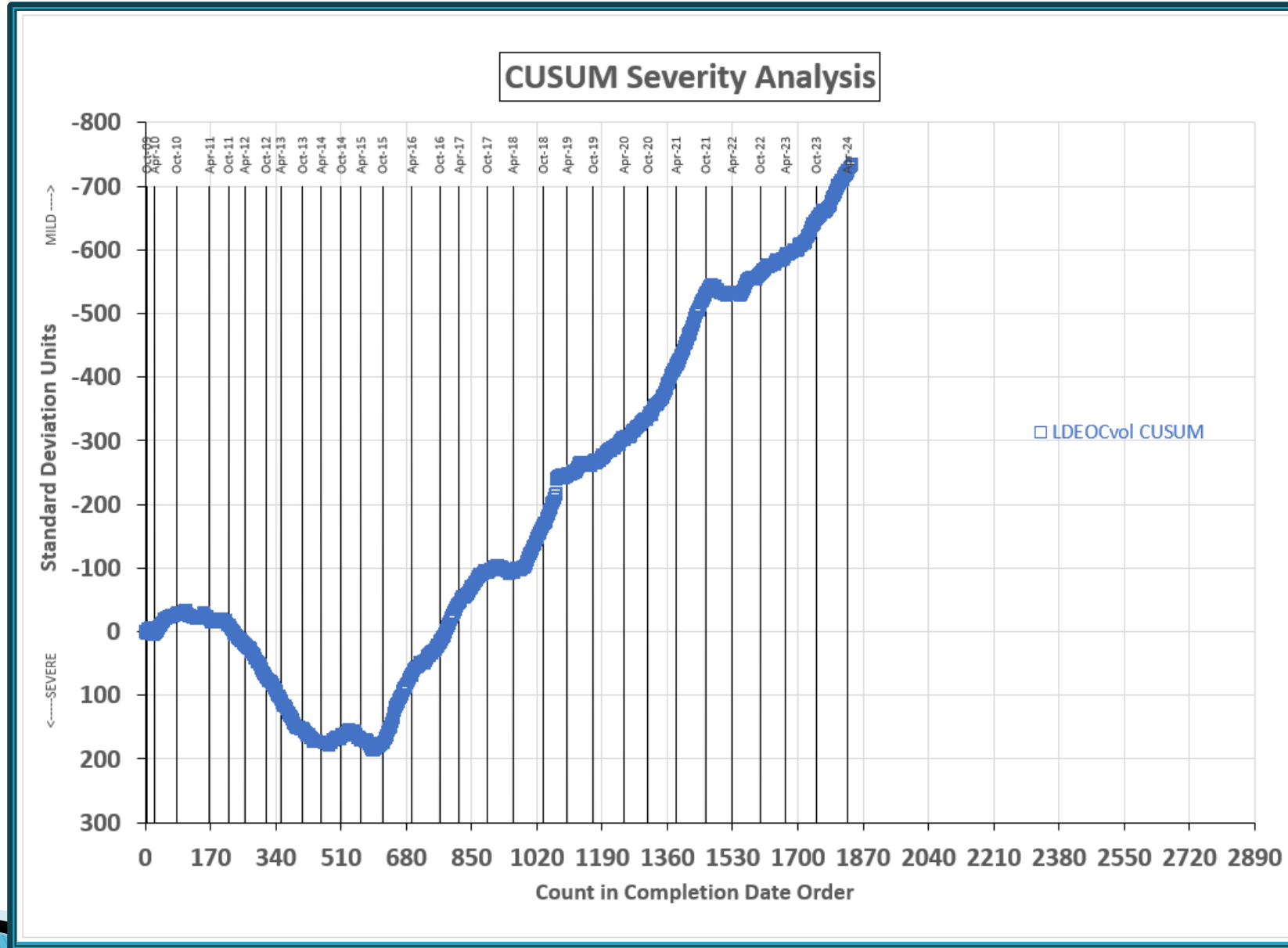
Test Parameter	Statistic	LTMS Lab							
		A	B	E	G	I	L	P	V
	n=	29	3	1	25	10	2	3	8
Volume	Mean	22.831	23.650	21.760	24.466	24.098	22.870	23.373	22.348
	Pooled s	0.4019	0.2007	N/A	0.5854	1.1713	0.7920	0.6038	0.4119
	Mean /s	-1.7783	-0.7142	-3.1688	0.3449	-0.1325	-1.7273	-1.0736	-2.4058
Hardness	Mean	-12.828	-13.000	-14.000	-13.040	-12.500	-11.500	-12.000	-13.000
	Pooled s	0.8892	1.0000	N/A	1.7907	0.7071	0.7071	1.7321	1.3093
	Mean /s	-0.1072	-0.2967	-1.3956	-0.3407	0.2527	1.3516	0.8022	-0.2967
Tensile Strength	Mean	-19.300	-25.500	-18.9000	-17.172	-21.530	-13.750	-20.167	-18.838
	Pooled s	4.6974	3.3151	N/A	4.7680	4.4290	2.0506	8.5448	5.3628
	Mean /s	-0.6357	-2.2377	-0.5323	-0.6026	-1.2112	0.7984	-0.8596	-0.5161

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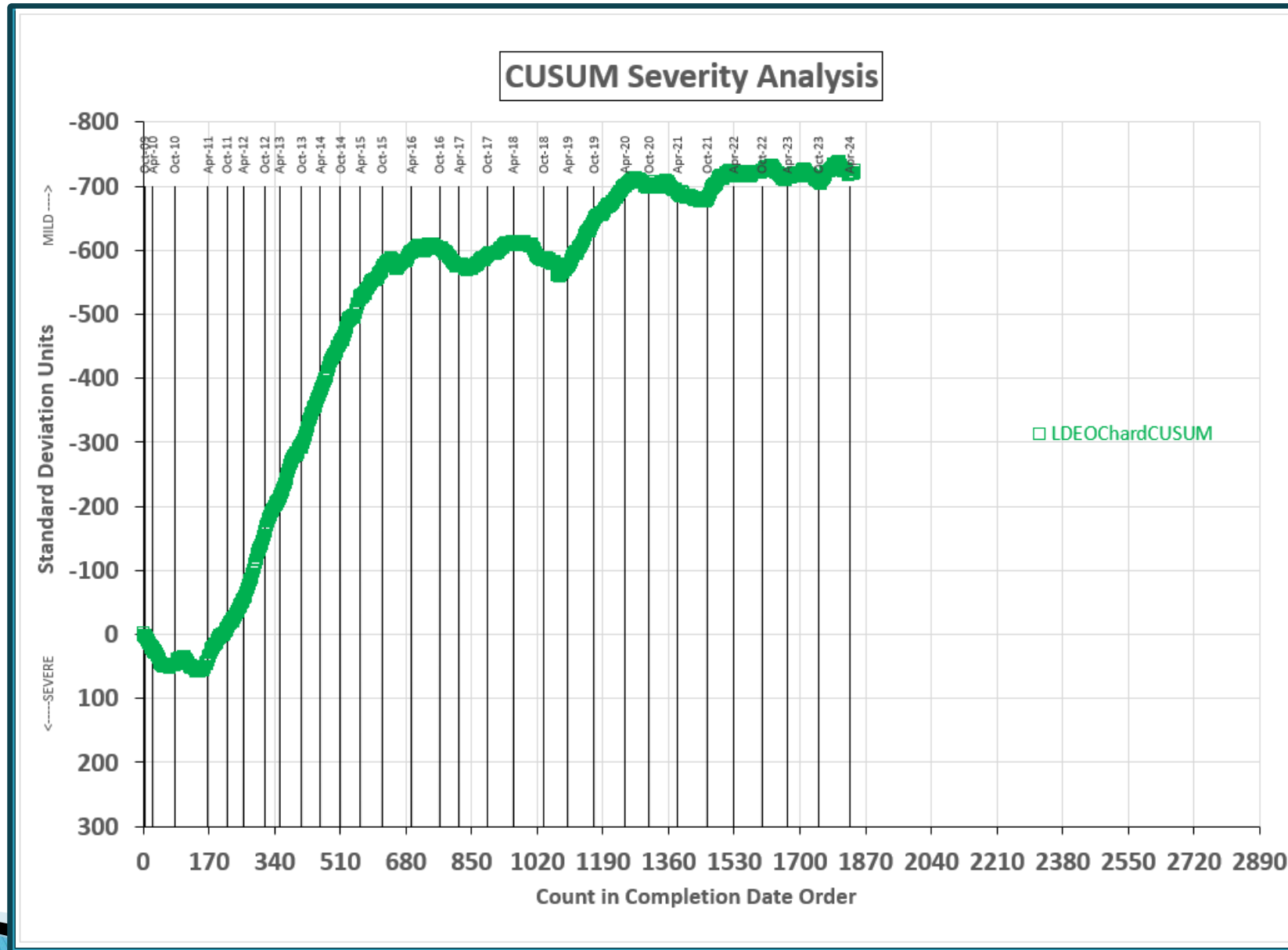
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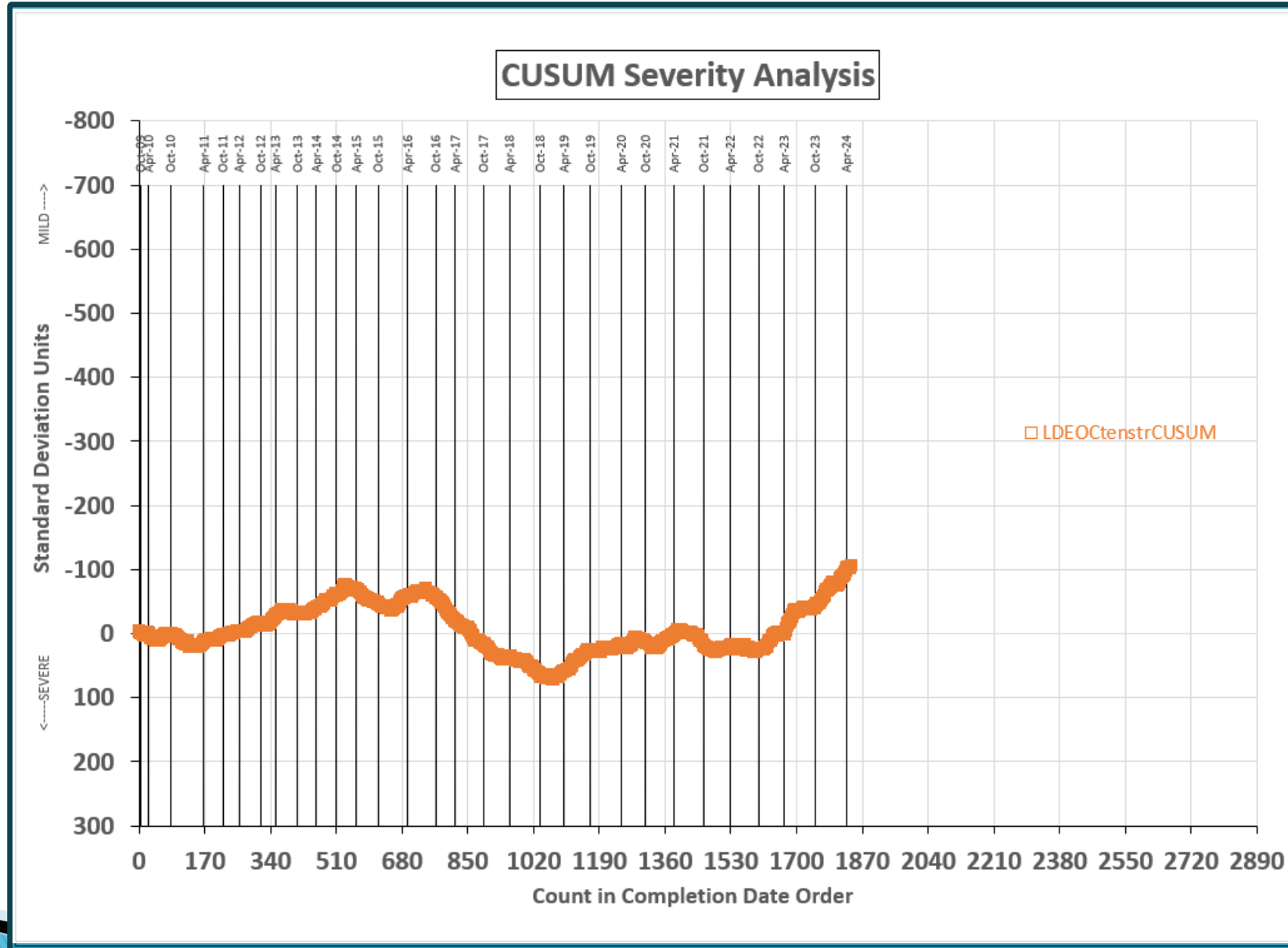
REF ETH ACRYLATE VOLUME CHANGE FINAL



REF ETH ACRYLATE POINTS HARDNESS CHANGE FINAL



REF ETH ACRYLATE TENSILE STRENGTH CHANGE FINAL



LDEOC Test Severity

Fluoroelastomer (FKM1)

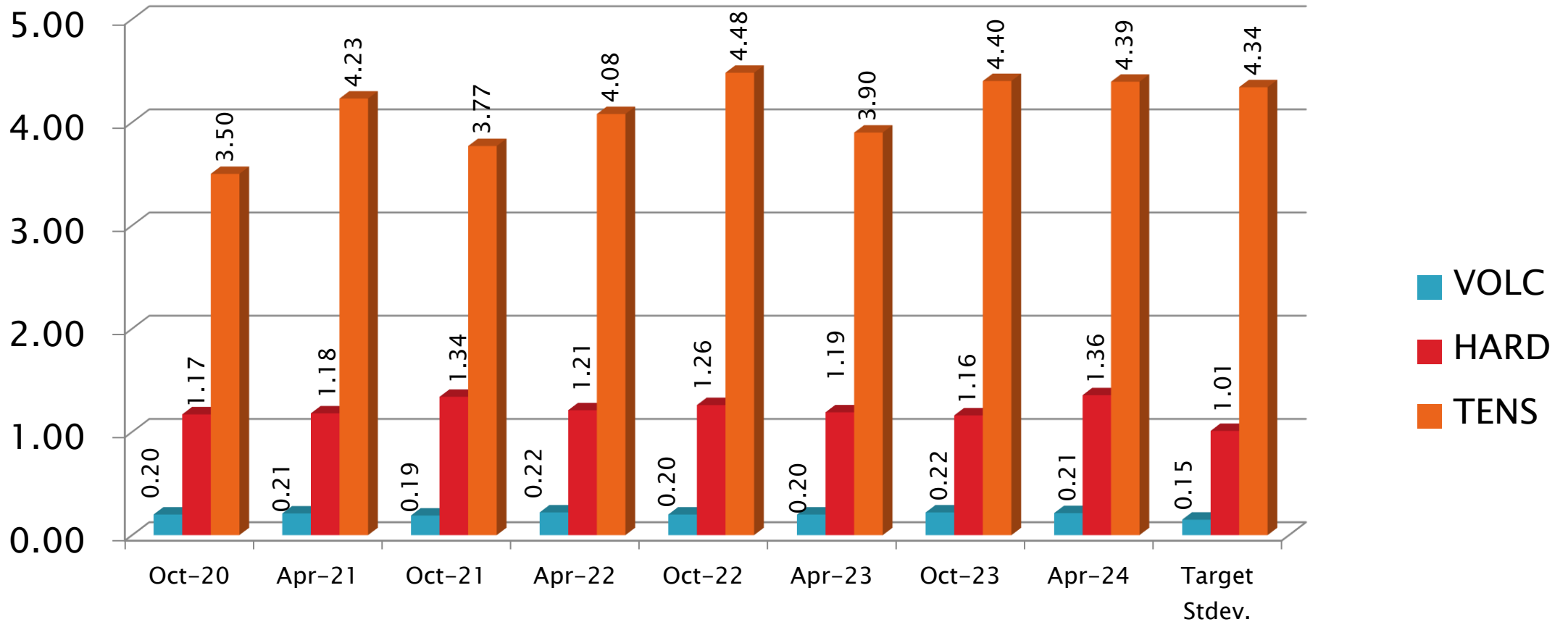
Parameter	Period Mean Δ/s	Status
Volume Change	-0.8483	Mild
Points Hardness Change	0.2970	Severe
Tensile Strength Change	0.3669	Severe

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LDEOC Precision Estimates – Fluoroelastomer



*One 1006 reference oil result not included in this table

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LDEOC Precision Estimates by Lab: FKM1

Test Parameter	Statistic	LTMS Lab*							
		A	B	E	G	I	L	P	V
	n=	29	3	1	24	10	2	2	8
Volume	Mean	0.5072	0.4967	0.5400	0.5642	0.8140	0.5150	0.3950	0.4525
	Pooled s	0.1874	0.0907	N/A	0.1574	0.3201	0.1202	0.2051	0.1268
	Mean /s	-1.1517	-1.2222	-0.9333	-0.7722	0.8933	-1.1000	-1.9000	-1.5167
Hardness	Mean	4.4828	5.3333	4.0000	3.8750	4.1000	3.0000	3.0000	6.7500
	Pooled s	0.7378	1.1547	N/A	1.4540	0.7379	0.0000	1.4142	0.7071
	Mean /s	0.3790	1.2211	-0.0991	-0.2228	0.0000	-1.0891	-1.0891	2.6238
Tensile Strength	Mean	-56.890	-59.967	-60.100	-53.4458	-51.150	-59.500	-54.200	-62.1875
	Pooled s	2.5215	0.3512	N/A	4.5878	1.9179	2.1213	0.07071	1.2529
	Mean /s	0.1176	-0.5914	-0.6221	0.9111	1.4401	-0.4839	0.7373	-1.1031

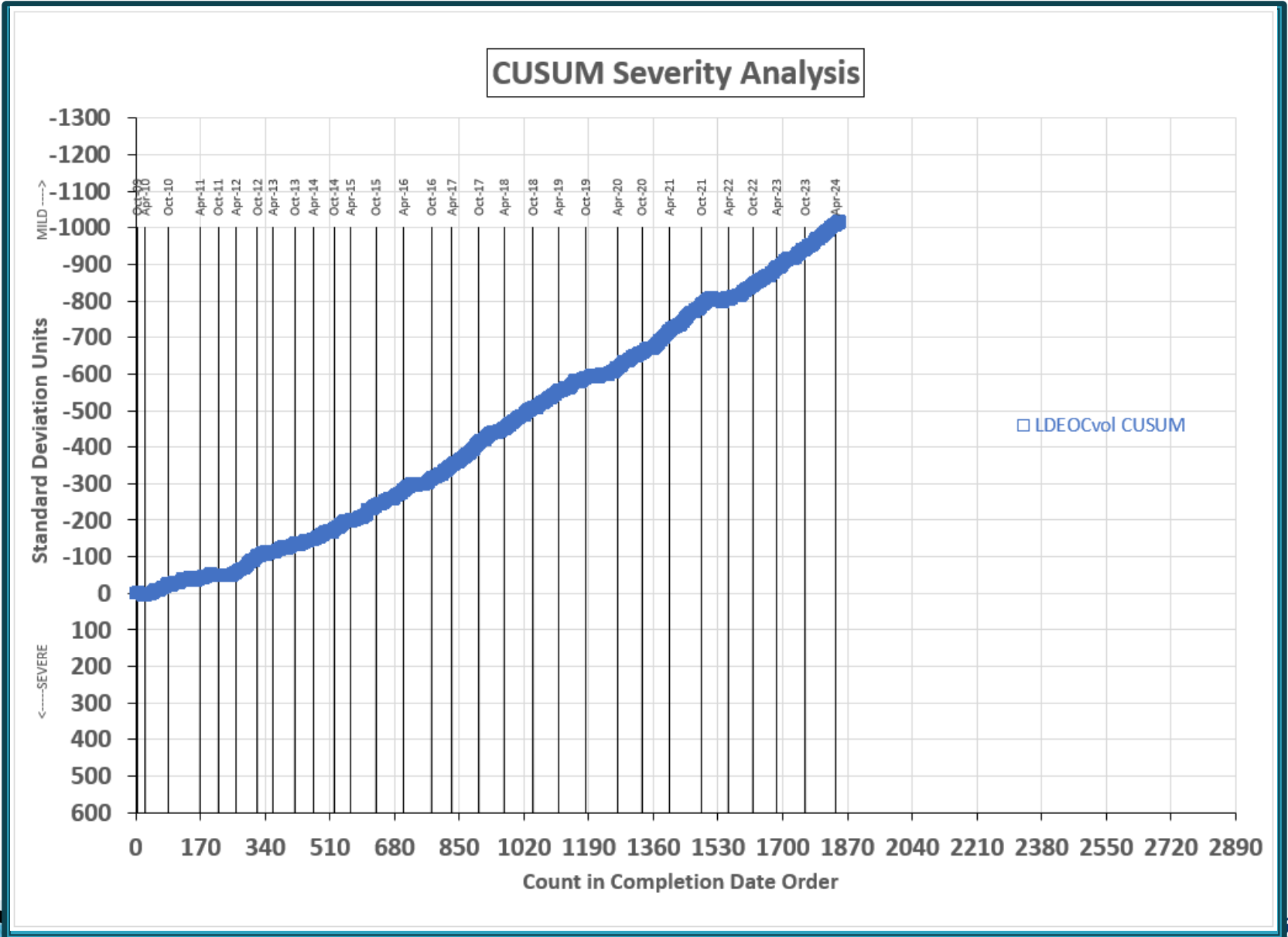
*Lab BB ran a single LDEOCF test (AC).. Statistics withheld from this table.

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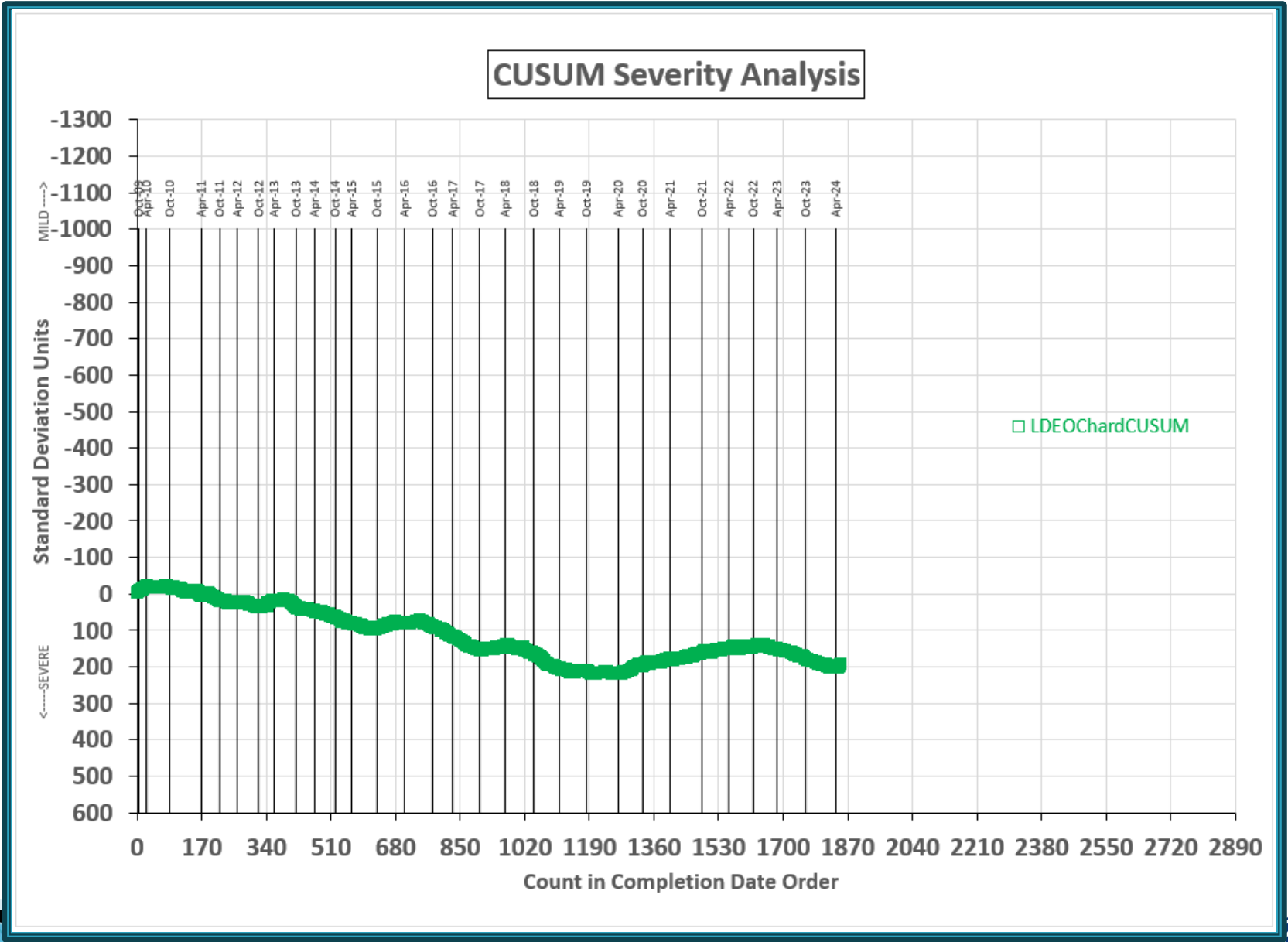
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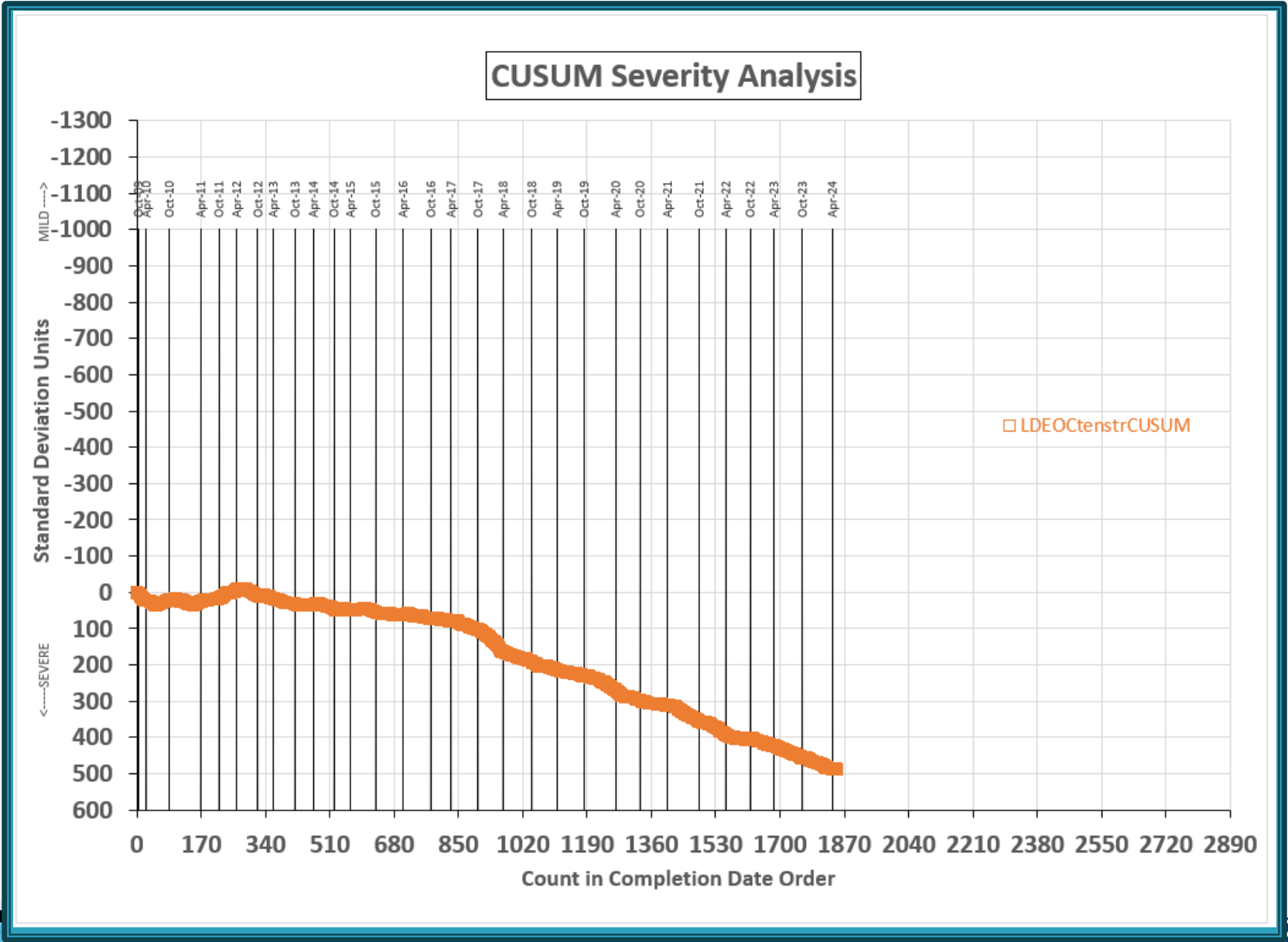
REF FLUOROELASTOMER VOLUME CHANGE FINAL



REF FLUORO POINTS HARDNESS CHANGE FINAL



REF FLUORO TENSILE STRENGTH CHANGE AVERAGE



LDEOC Test Severity

Nitrile (NBR1)

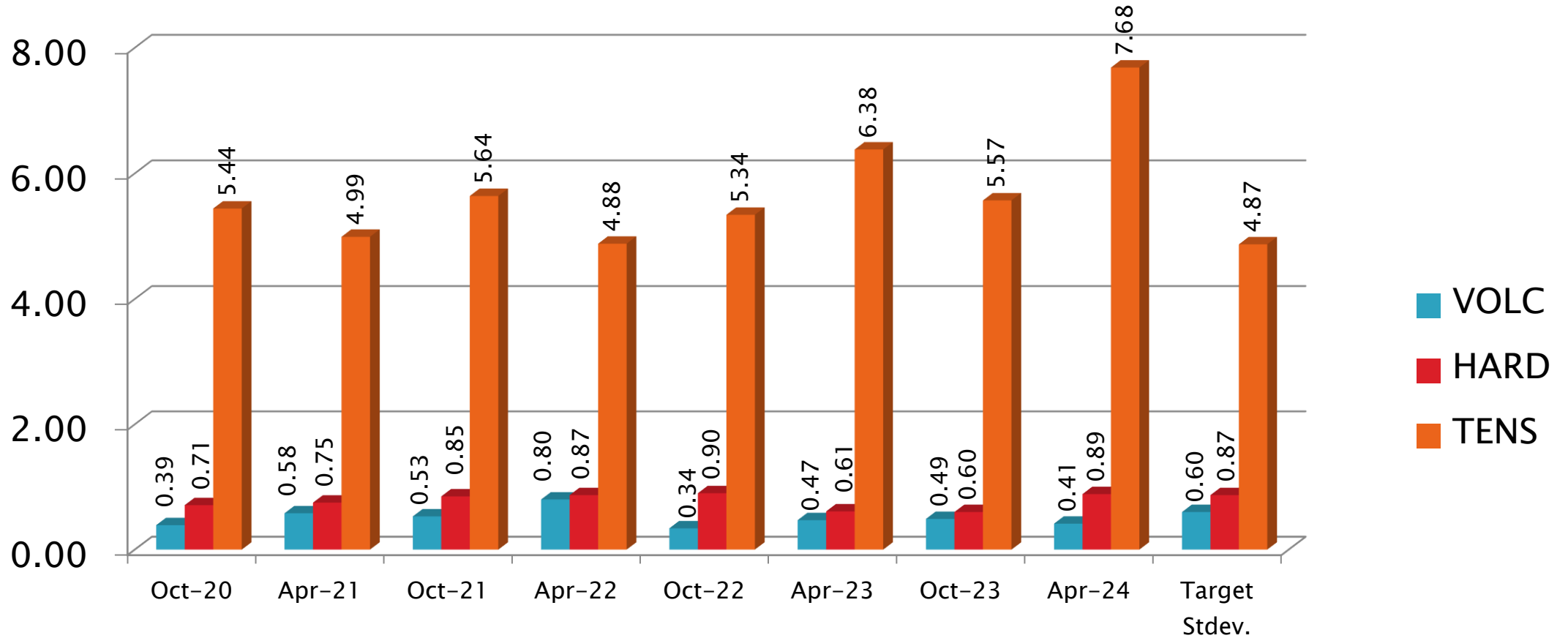
Parameter	Period Mean Δ/s	Status
Volume Change	1.2395	Severe
Points Hardness Change	-0.7155	Mild
Tensile Strength Change	-0.9769	Mild

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LDEOC Precision Estimates – Nitrile



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LDEOC Precision Estimates by Lab: NBR1

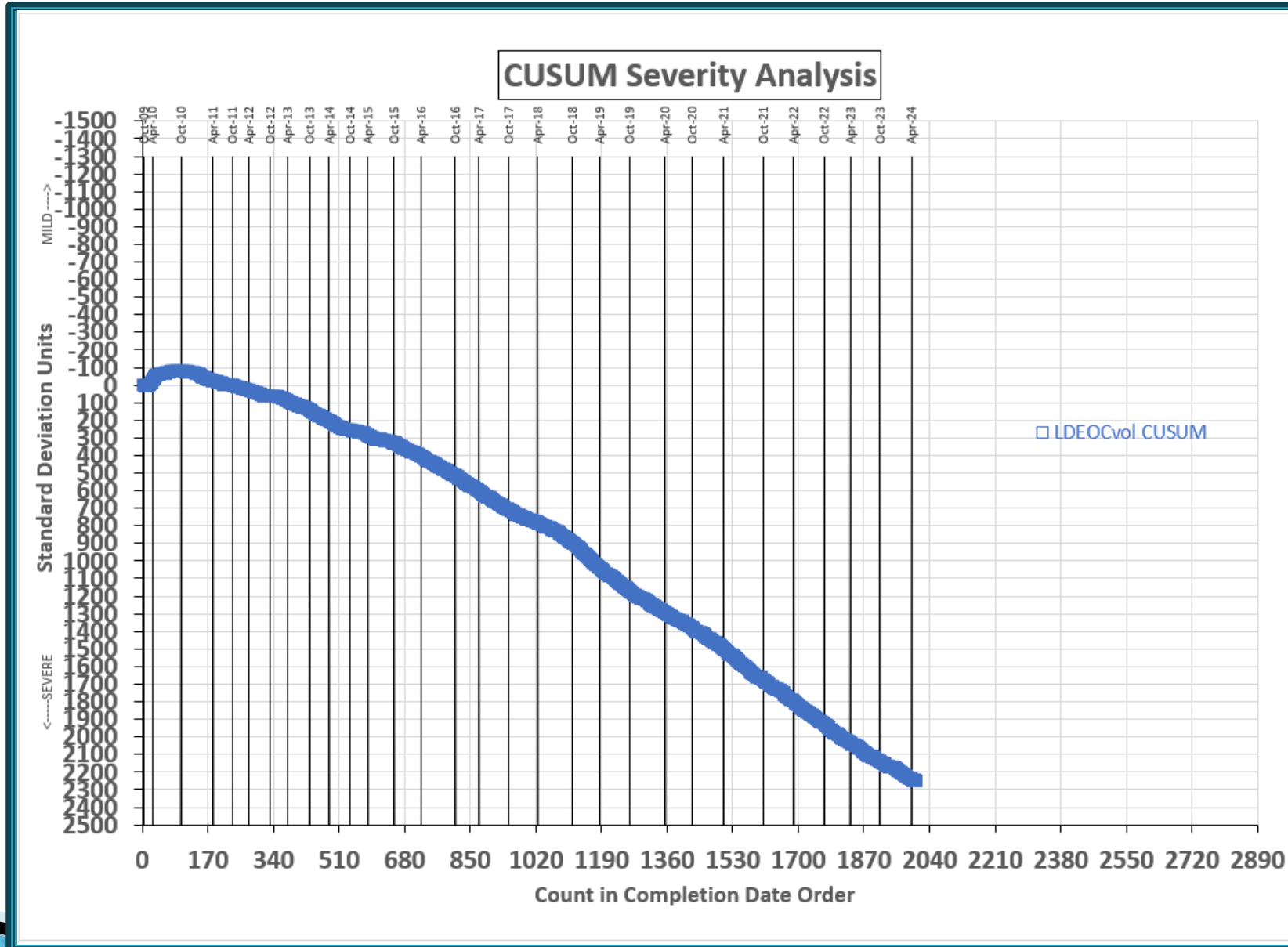
Test Parameter	Statistic	LTMS Lab							
		A	B	E	G	I	L	P	V
	n=	32	3	1	22	10	3	2	8
Volume	Mean	1.0212	1.1900	1.1300	0.9582	1.4300	1.3133	0.8600	0.9675
	Pooled s	0.1924	0.1153	N/A	0.5567	0.6461	0.0376	0.0000	0.1917
	Mean /s	1.1688	1.4500	1.3500	1.0636	1.8500	1.6556	0.9000	1.0792
Hardness	Mean	-2.0312	-1.0000	-1.0000	-2.0455	-1.1000	-1.3333	-2.0000	-1.6250
	Pooled s	0.5379	1.0000	N/A	0.7222	1.5951	1.1547	0.0000	0.7440
	Mean /s	-0.9784	0.2069	0.2069	-0.9948	0.0920	-0.1762	-0.9425	-0.5115
Tensile Strength	Mean	1.2031	2.7333	4.9000	0.2409	-1.4100	11.733	1.0500	2.2625
	Pooled s	4.9051	1.8175	N/A	11.389	6.9974	7.1842	2.8991	5.9035
	Mean /s	-0.9788	-0.6646	-0.2197	-1.1764	-1.5154	1.1834	-1.0103	-0.7613

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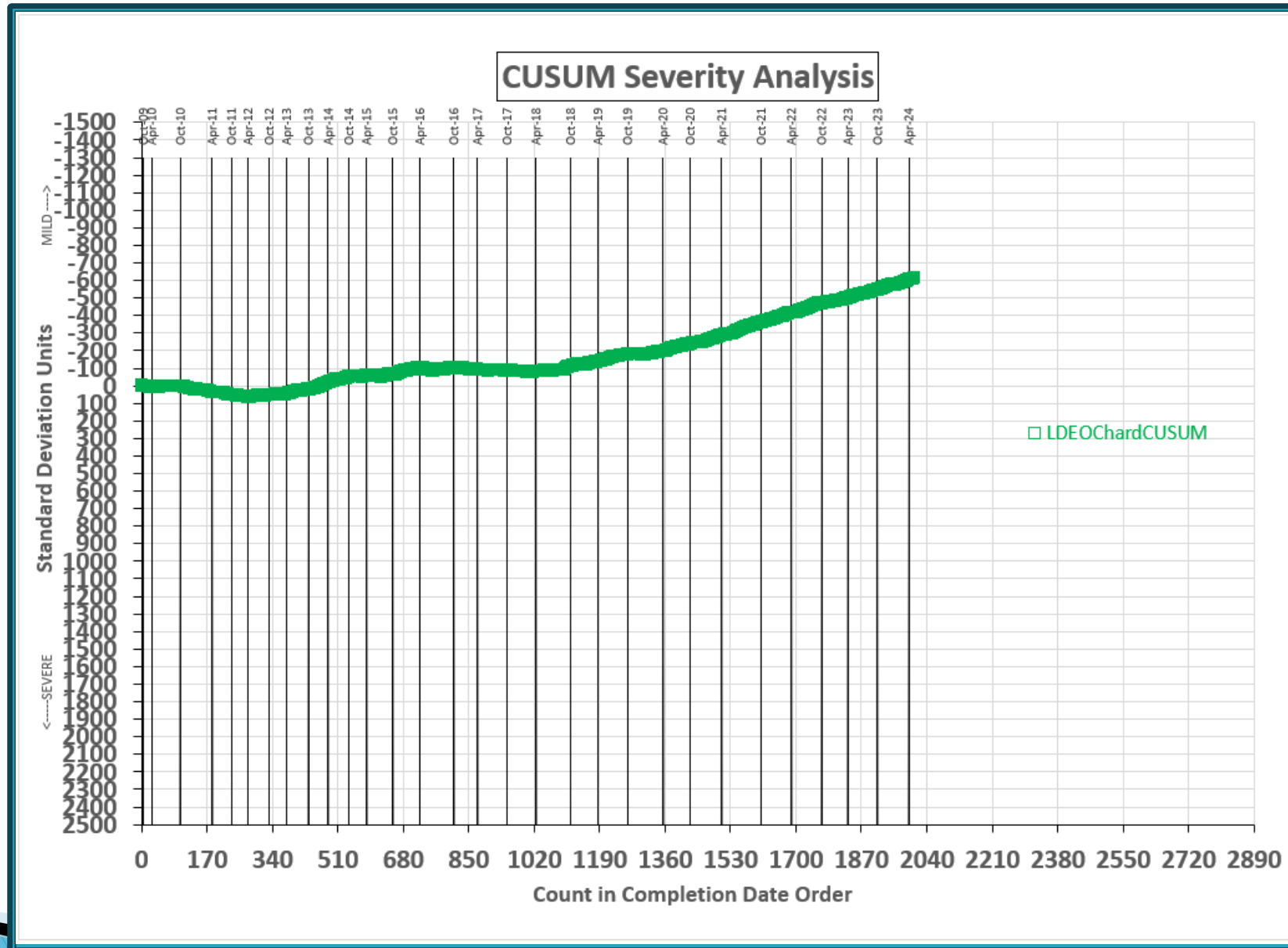
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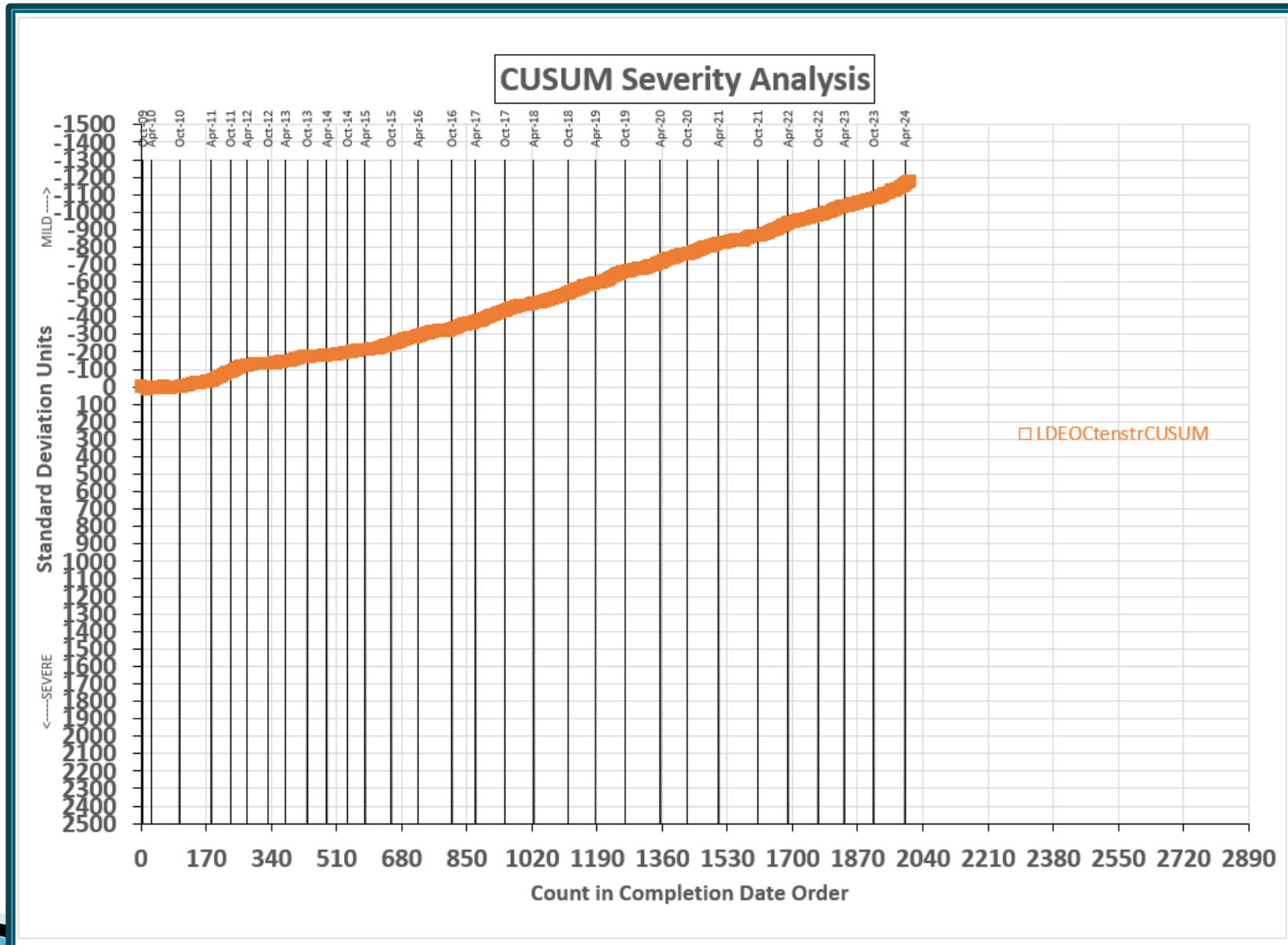
REFERENCE NITRILE VOLUME CHANGE FINAL



REF NITRILE POINTS HARDNESS CHANGE AVERAGE



REF NITRILE TENSILE STRENGTH CHANGE FINAL



LDEOC Test Severity

Polyacrylate (ACM1)

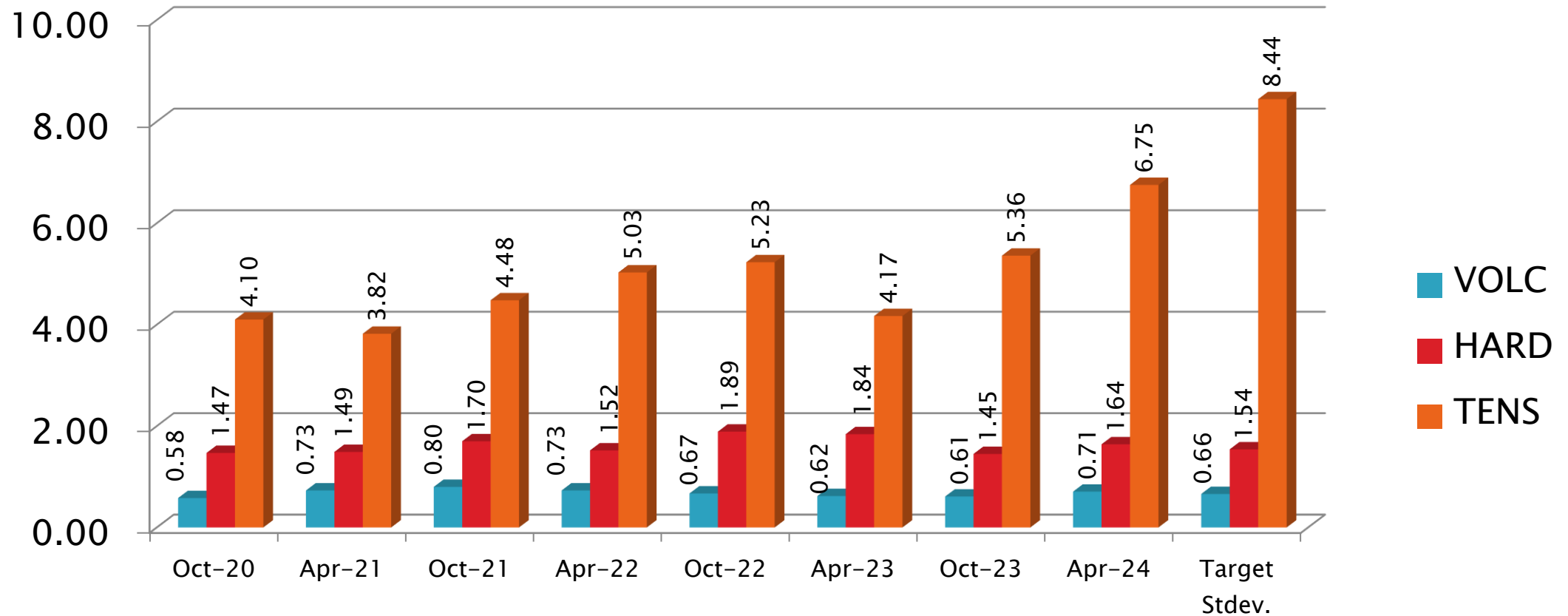
Parameter	Period Mean Δ/s	Status
Volume Change	-0.1879	Slightly Mild
Points Hardness Change	-1.1055	Mild
Tensile Strength Change	-0.5477	Mild

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LDEOC Precision Estimates – Polyacrylate



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LDEOC Precision Estimates by Lab: ACM1

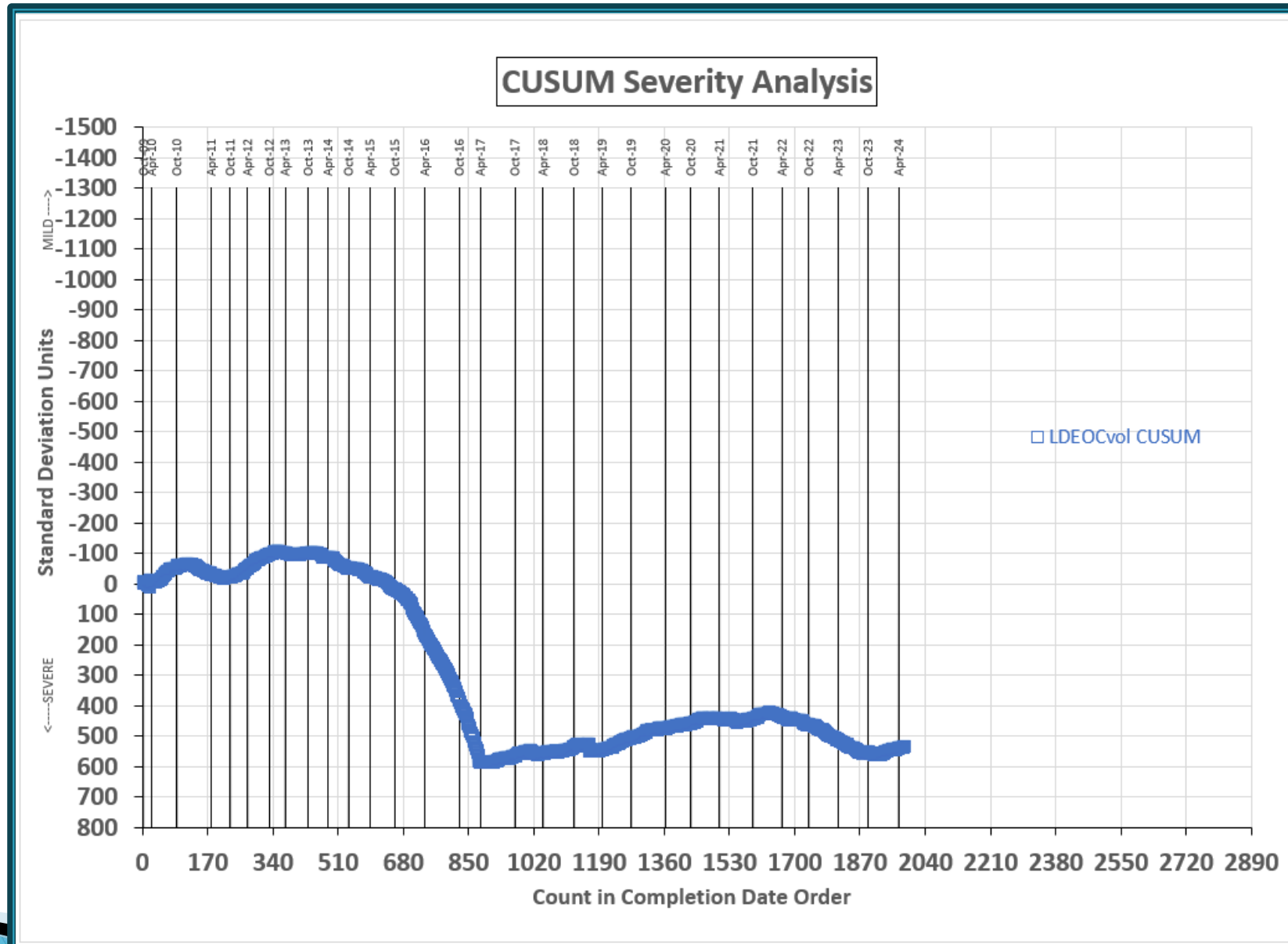
Test Parameter	Statistic	LTMS Lab							
		A	B	E	G	I	L	P	V
	n=	29	3	1	24	10	2	2	9
Volume	Mean	1.8528	2.4467	1.5300	1.9396	2.8200	2.3550	1.9900	1.4911
	Pooled s	0.4565	0.0808	N/A	0.7453	1.3032	0.0354	0.6364	0.2781
	Mean /s	-0.2989	0.6010	-0.7879	-0.1673	0.3515	0.4621	-0.0909	-0.8468
Hardness	Mean	-2.2759	-1.6667	-6.0000	-1.5833	-1.0000	-1.5000	0	-2.7778
	Pooled s	1.0986	0.5774	N/A	2.1653	1.0541	0.7071	2.8284	0.8333
	Mean /s	-1.3415	-0.9459	-3.7597	-0.8918	-0.5130	-0.8377	0.1364	-1.6674
Tensile Strength	Mean	-3.1000	-1.8333	0.6000	-2.2083	-1.6100	-0.4000	-2.4500	0.6889
	Pooled s	7.1313	0.5508	N/A	8.7420	4.4155	3.2527	2.8991	3.7082
	Mean /s	-0.6730	-0.5229	-0.2346	-0.5673	-0.4964	-0.3531	-0.5960	-0.2241

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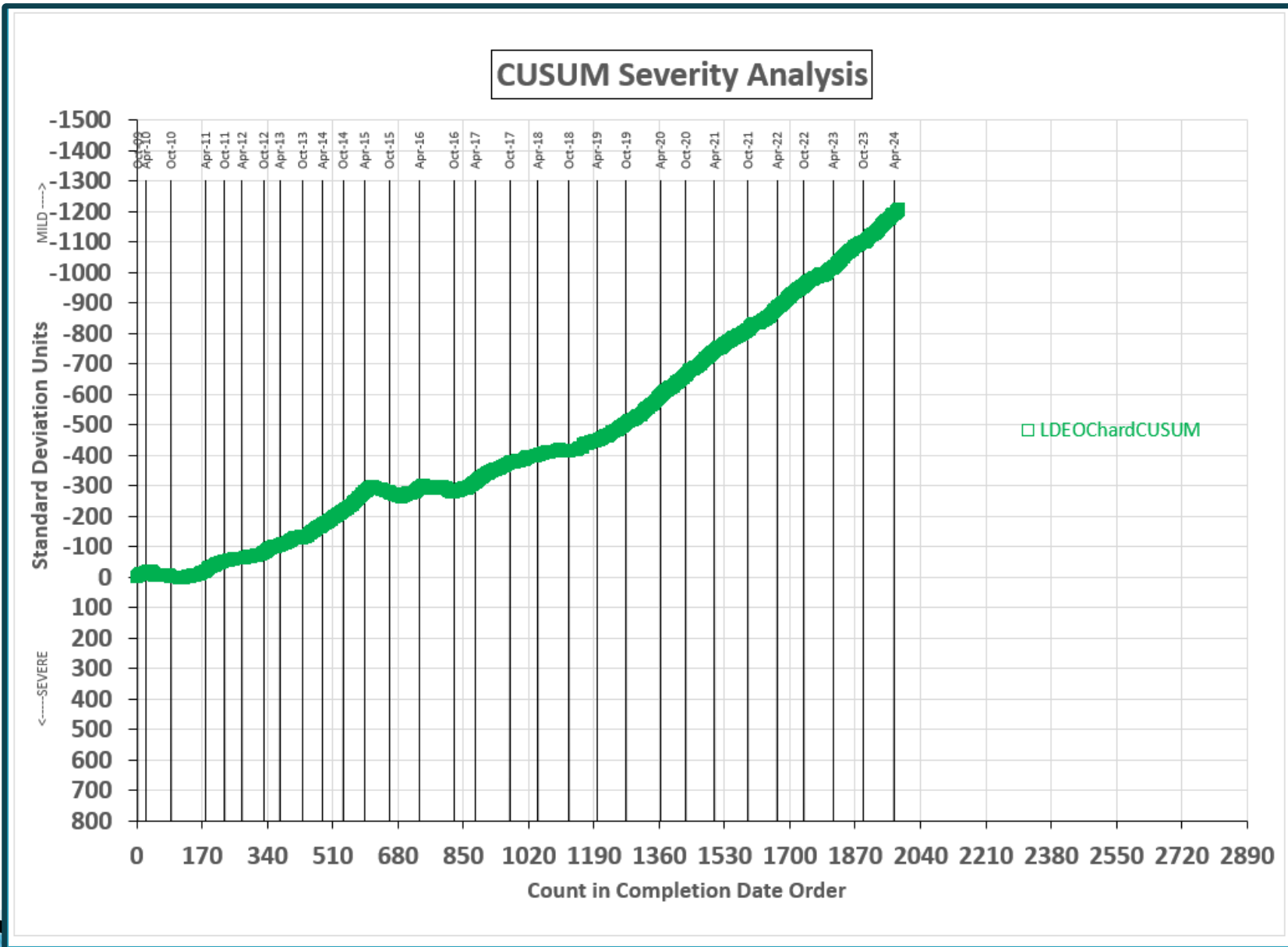
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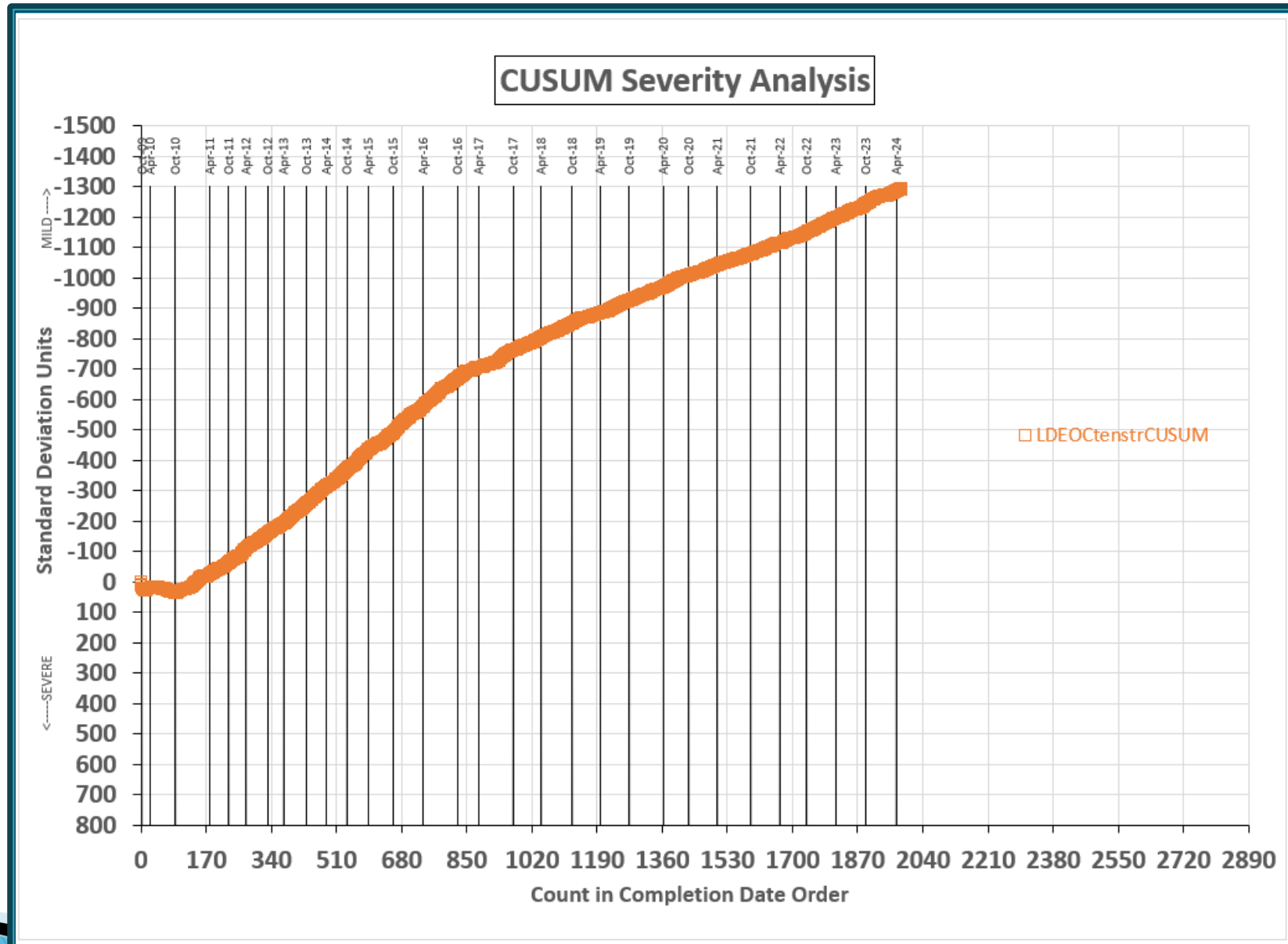
REF POLYACRYLATE VOLUME CHANGE FINAL



REF POLYACRYLATE POINTS HARDNESS CHG FINAL



REF POLYACRYLATE TENSILE STRENGTH CHG FINAL



LDEOC Test Severity

Silicone (VMQ1)

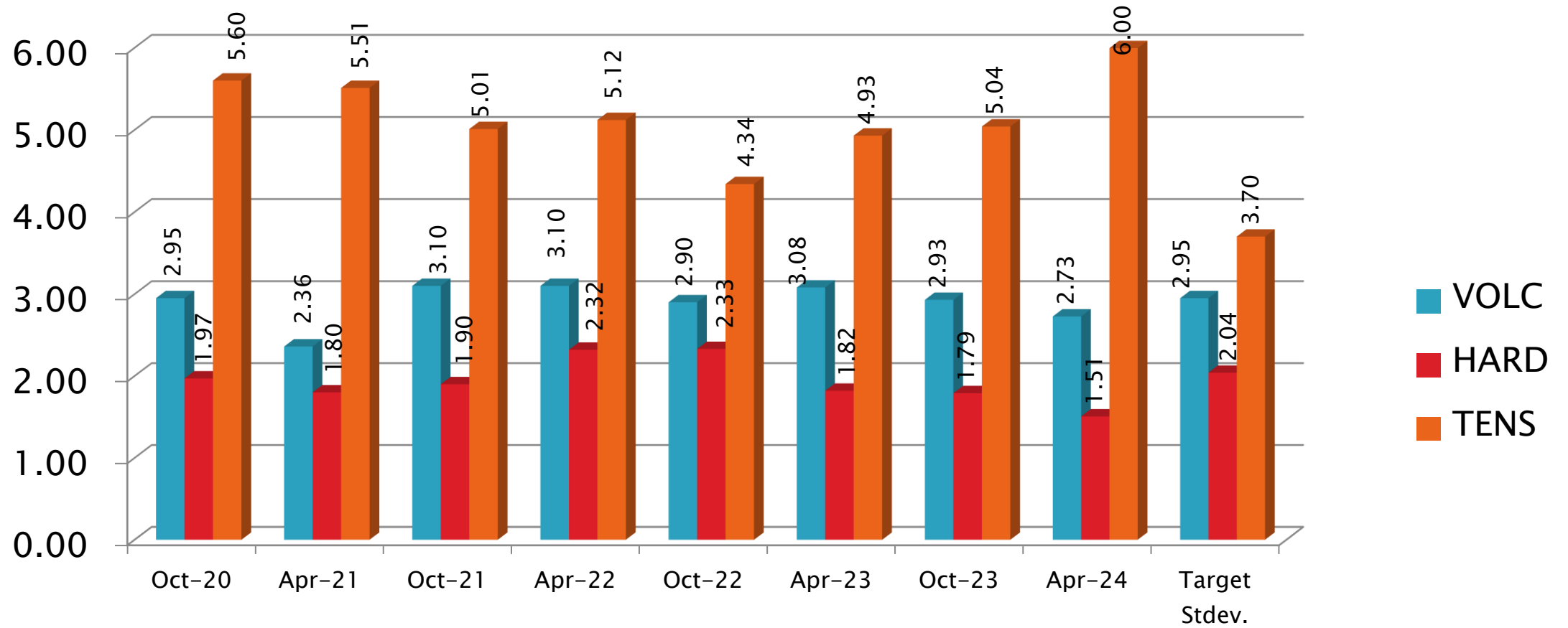
Parameter	Period Mean Δ/s	Status
Volume Change	0.7218	Severe
Points Hardness Change	-0.7476	Mild
Tensile Strength Change	0.1979	Slightly Severe

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LDEOC Precision Estimates – Silicone



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LDEOC Precision Estimates by Lab: VQM1

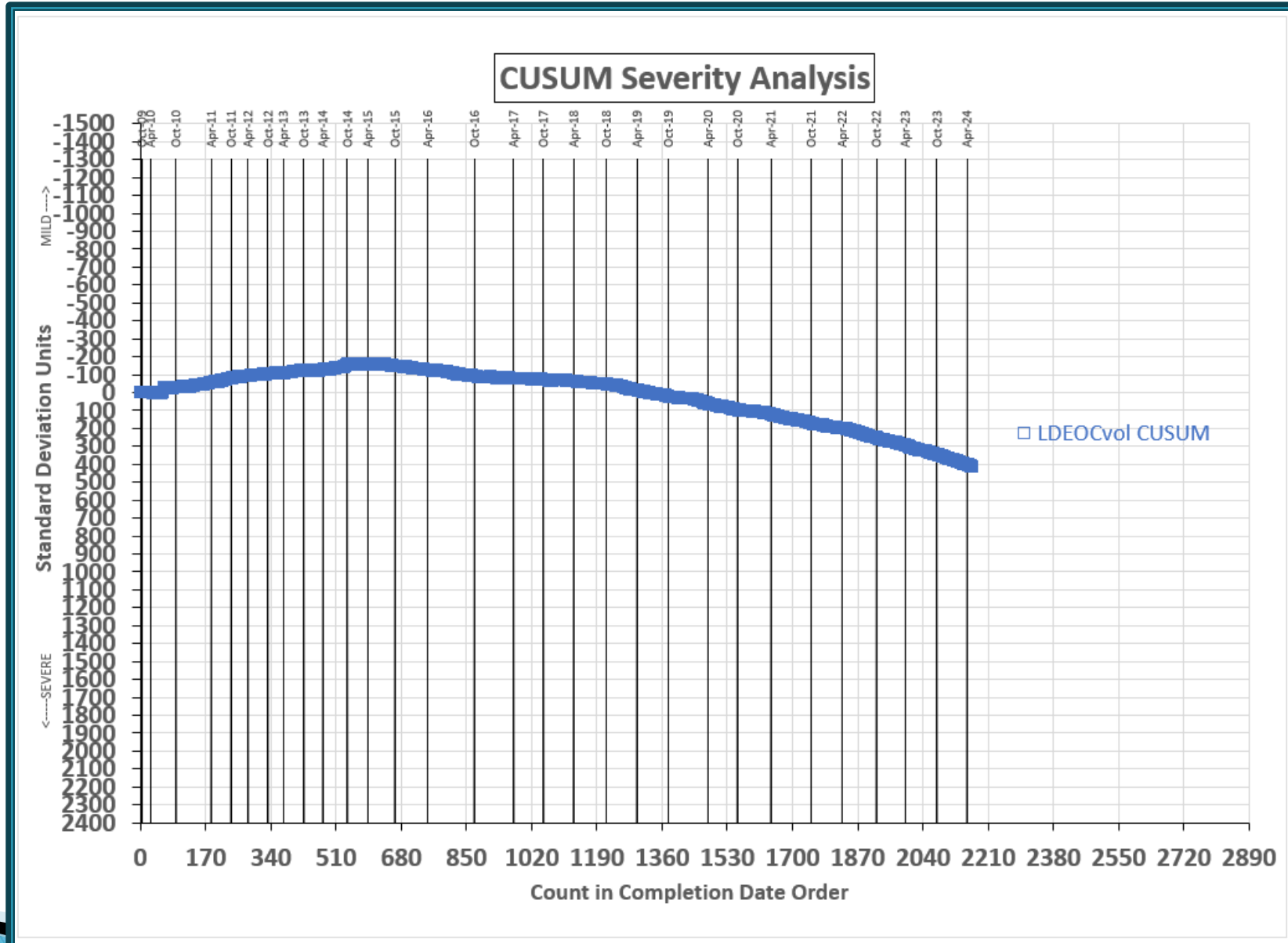
Test Parameter	Statistic	LTMS Lab							
		A	B	E	G	I	L	P	V
	n=	28	3	1	23	10	2	2	9
Volume	Mean	33.707	34.160	31.960	37.703	30.519	30.205	35.130	32.674
	Pooled s	0.6423	0.6183	N/A	1.4523	1.7041	0.4031	0.5091	0.7339
	Mean /s	0.5211	0.6746	-0.0712	1.8756	-0.5600	-0.666	1.0034	0.1710
Hardness	Mean	-23.500	-23.333	-20.000	-24.261	-21.800	-18.000	-24.000	-22.444
	Pooled s	1.0000	0.5774	N/A	1.0098	0.6325	0.0000	0.0000	0.5270
	Mean /s	-0.8922	-0.8105	0.8235	-1.2651	-0.0588	1.804	-1.1373	-0.3747
Tensile Strength	Mean	-33.061	-31.667	-19.200	-33.713	-35.010	-30.150	-35.700	-30.922
	Pooled s	7.0099	2.9939	N/A	6.2065	3.8377	5.0205	0.7071	3.5330
	Mean /s	0.1863	0.5631	3.932	0.0100	-0.3405	0.9730	-0.5270	0.7643

October 1, 2023 – March 31, 2024

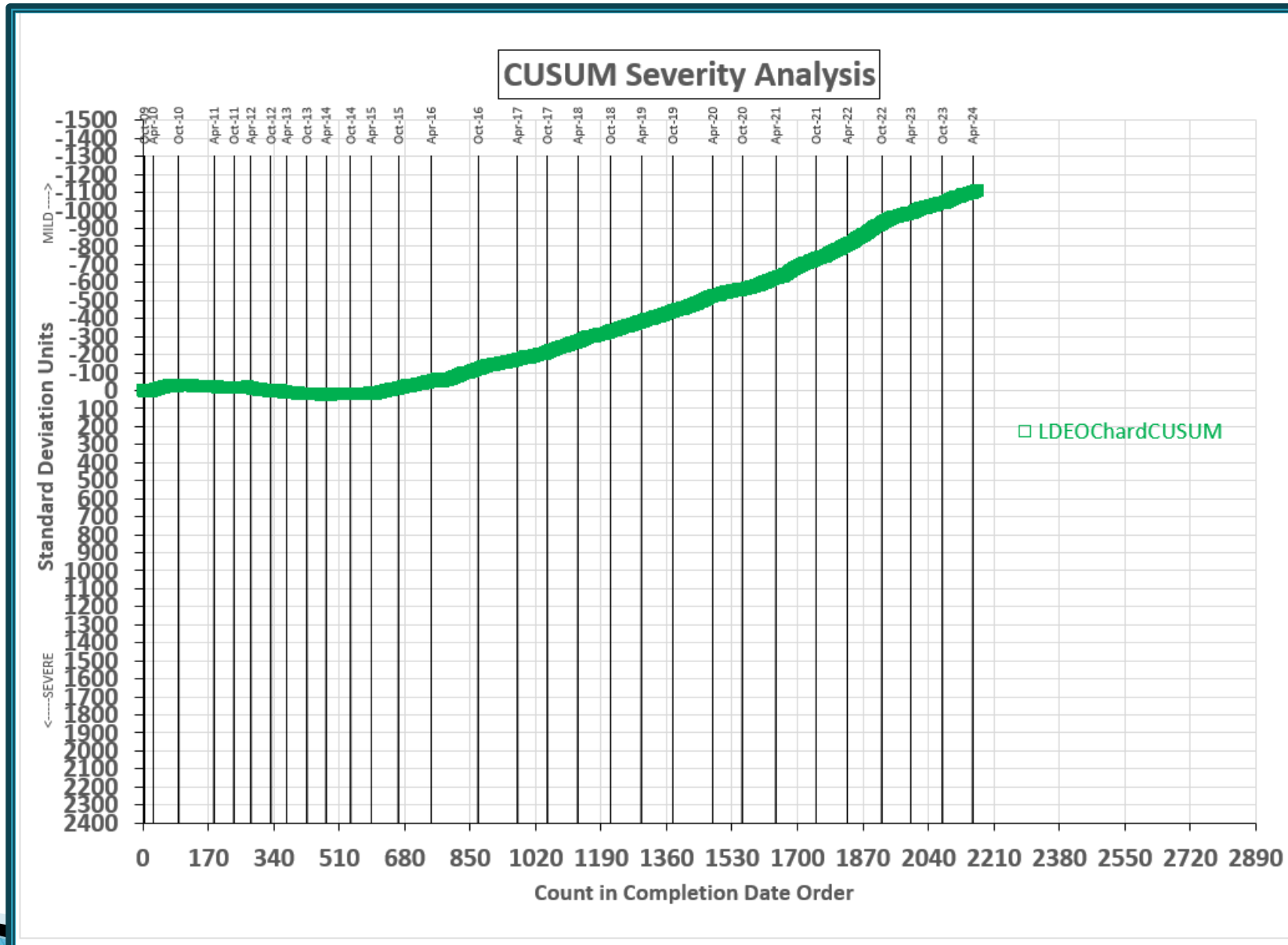
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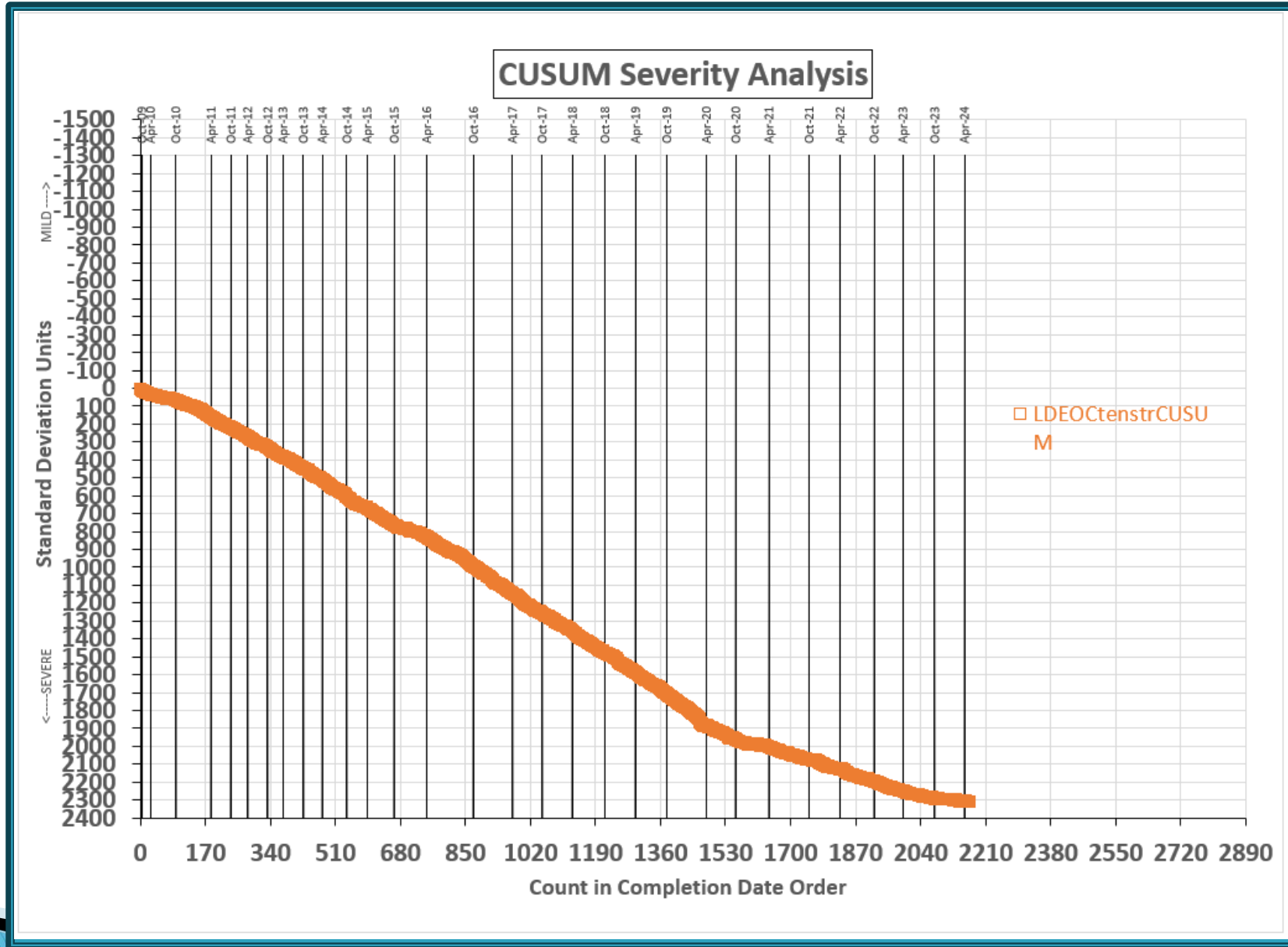
REFERENCE SILICON VOLUME CHANGE FINAL



REFERENCE SILICON POINTS HARDNESS FINAL



REF SILICON TENSILE STRENGTH CHANGE FINAL



Information Letters & Technical Updates*

Test	Date	IL or Memo Number	Topic
LDEOC	20240424	LDEOC-20231005	Report Package Revision Notice - addition of 4 new elastomers.

*Available from TMC Website

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Reference Oil Inventory Estimated Life

EOEC & LDEOC

Oil	TMC Inventory Gallons	Gallons Shipped Past 6 Months	Estimated Life ^C
SL107 ^{A, B}	1742	229	~3.5 years

^A TMC Inventory is used across several test methods

^B SL107 has fully replaced oil 1006; Oil 1006 is no longer used as an EOEC Reference Fluid

^C Use Rate of SL107 will accelerate due to addition of five new Elastomers to D7216:
FOUR: ILSAC GF-7
ONE: PC-12

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D02.B0.07

TMC Monitored Tests



ASTM D 7528

ROBO

October 1, 2023 – March 31, 2024

Calibrated Labs and Stands*

(change since last Semi-Annual report)

Test	Labs	Stands
D7528	5 (+0)	27 (-3)

*As of 3/31/2024

D7528: Oxidation by ROBO

Test Status	Validity Code	No. Tests
Acceptable Calibration Test	AC	84
Failed Calibration Test	OC	7
Operationally Invalidated by Lab	LC, XC	8
Operationally Invalidated After Initially Reported as Valid	RC	0
Total		99

Number of Labs Reporting Data: 5
Fail Rate of Operationally Valid Tests: 7.7% (11.6% last period)

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D7528: Oxidation by ROBO

Statistically Unacceptable Tests (OC)	No. Of Tests
Natural Log (MRV Viscosity) Severe	1
Natural Log (MRV Viscosity) Mild	6
Total	7

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D7528: ROBO Failed Tests by Lab

Failed Parameter	LTMS Lab					Number of Tests
	A	BC	AQ	G	AM	
Natural Log (MRV Viscosity) Severe	1	0	0	0	0	1
Natural Log (MRV Viscosity) Mild	2	1	0	3	0	6
Total	3	1	0	3	0	7

- SEVEN different units from THREE different labs reported failing calibration tests

D7528: Oxidation by ROBO

Operationally Invalid (LC, RC) or Aborted (XC) Calibration Tests

Test Status	Cause	No. of Tests
Invalidated by Lab (LC)	Volatiles > 60%	1
Invalidated by Lab (LC)	Test conducted at incorrect MRV Test Temp.	1
Invalidated by Lab (LC)	Power Outage during test	1
Aborted Test (XC)	Test Temperature off Spec	1
Aborted Test (XC)	Issue with NO2 Valve	1
Aborted Test (XC)	Stirrer Motor Failed	1
Aborted Test (XC)	Reaction Vessel Broke	1
Aborted Test (XC)	Oil oxidation so severe, sample could run MRV	1
Totals		8

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D7528: Oxidation by ROBO

Period Precision and Severity Estimates

Natural Log (MRV Viscosity)	n	df	Pooled s	Mean Δ/s
Targets Updated 20211021¹	80	77	0.1551	-----
4/1/19 through 9/30/19	95	91	0.2492	-0.32
10/1/19 through 3/31/20	158	153	0.2723	-0.10
4/1/20 through 9/30/20	119	113	0.2264	-0.76
10/1/20 through 3/31/21	113	108	0.3188	-0.11
4/1/21 through 9/30/21	116	110	0.1992	-0.37
10/1/21 through 3/31/22	106	102	0.2103	-0.36
4/1/22 through 9/30/22	105	101	0.1868	-0.06
10/1/22 through 3/31/23	94	91	0.2000	0.11
4/1/23 through 9/30/23	103	100	0.1990	-0.11
10/1/23 through 3/31/24	91	88	0.1741	-0.12

¹Updated targets to include latest primary reference oils 434-3, 435-1 and 436

D7528: Oxidation by ROBO

NO ₂ Delivery Mechanism	Number of Total Tests	Number Of AC Tests	Pass Rate (%)	Number of Labs	Number of Rigs	LAB ID's
Dilute	40	38	95.0	2	13	G,AM
Liquid	51	46	90.2	4	14	A,AQ,BC,G
BOTH (Totals)	91	84	92.3	5*	27	A, AM, AQ, BC, G

*One lab is conducting tests with both NO₂ delivery methods.

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D7528: Oxidation by ROBO

Precision, Performance (Mean Δ/s) by Lab and NO₂ Delivery Mechanism

NO ₂ Delivery		Reference Oil 434-3	Reference Oil 435-1	Reference Oil 436	TOTAL
Dilute	No. of Runs	10	19	11	40
	Mean	10.7426	11.0329	10.3614	10.7756
	Pooled s	0.1529	0.1744	0.1462	0.16201
	Mean Δ/s	-0.54	-0.04	0.23	-0.09
Liquid	No. of Runs	11	26	14	51
	Mean	10.6894	11.0387	10.3591	10.7768
	Pooled s	0.1894	0.2170	0.1048	0.1871
	Mean Δ/s	-0.92	-0.01	0.21	-0.15
BOTH	No. of Runs	21	45	25	91
	Mean	10.7174	11.0362	10.3601	10.7763
	Pooled s	0.1709	0.1980	0.1219	0.1741
	Mean Δ/s	-0.74	-0.03	0.22	-0.12

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D7528: Oxidation by ROBO

Period Performance (Mean Δ/s) by Lab and NO₂ Delivery Mechanism

NO ₂ Delivery Mechanism	LAB A (all L)	LAB AM (all D)	LAB AQ (all L)	LAB BC (all L)	LAB G (mix)
Dilute	n = 0	n = 6	n = 0	n = 0	n = 34
	N/A	0.45	N/A	N/A	-0.19
Liquid	n = 37	n = 0	n = 3	n = 4	n = 7
	-0.02	N/A	0.19	-1.34	-0.30
BOTH	n = 37	n = 6	n = 3	n = 4	n = 41
	-0.02	0.45	0.19	-1.34	-0.21

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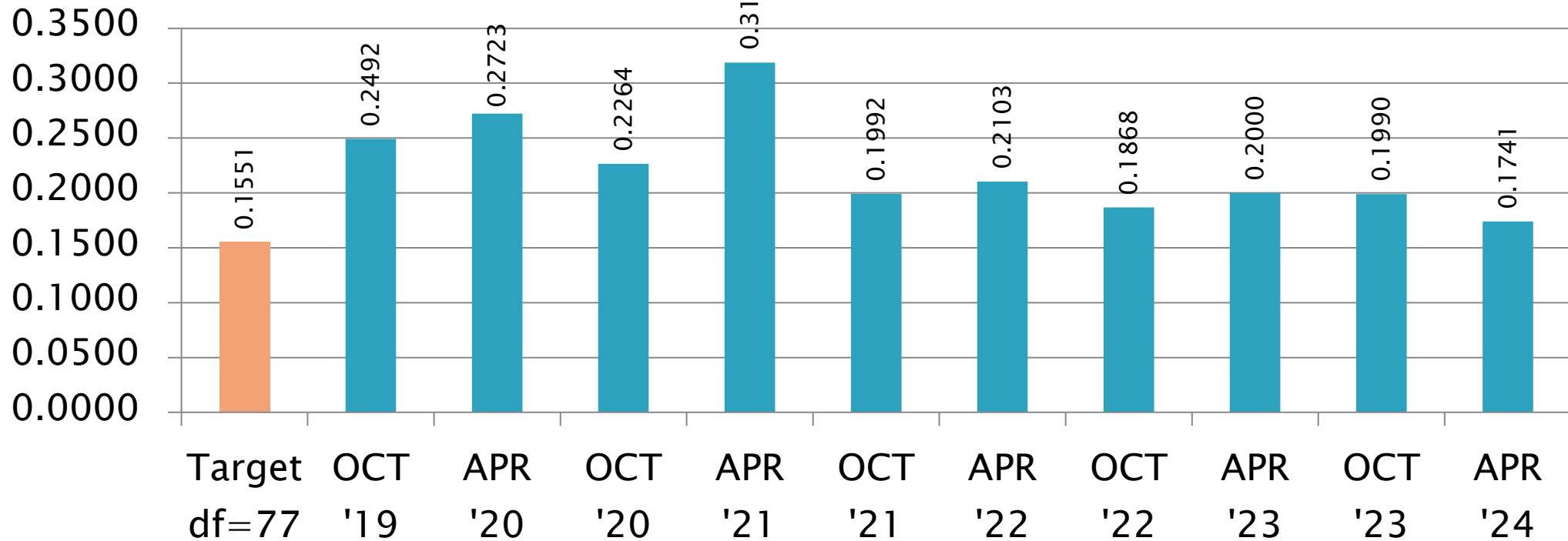


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D7528: Oxidation by ROBO

Natural Log (MRV Viscosity)

Pooled s



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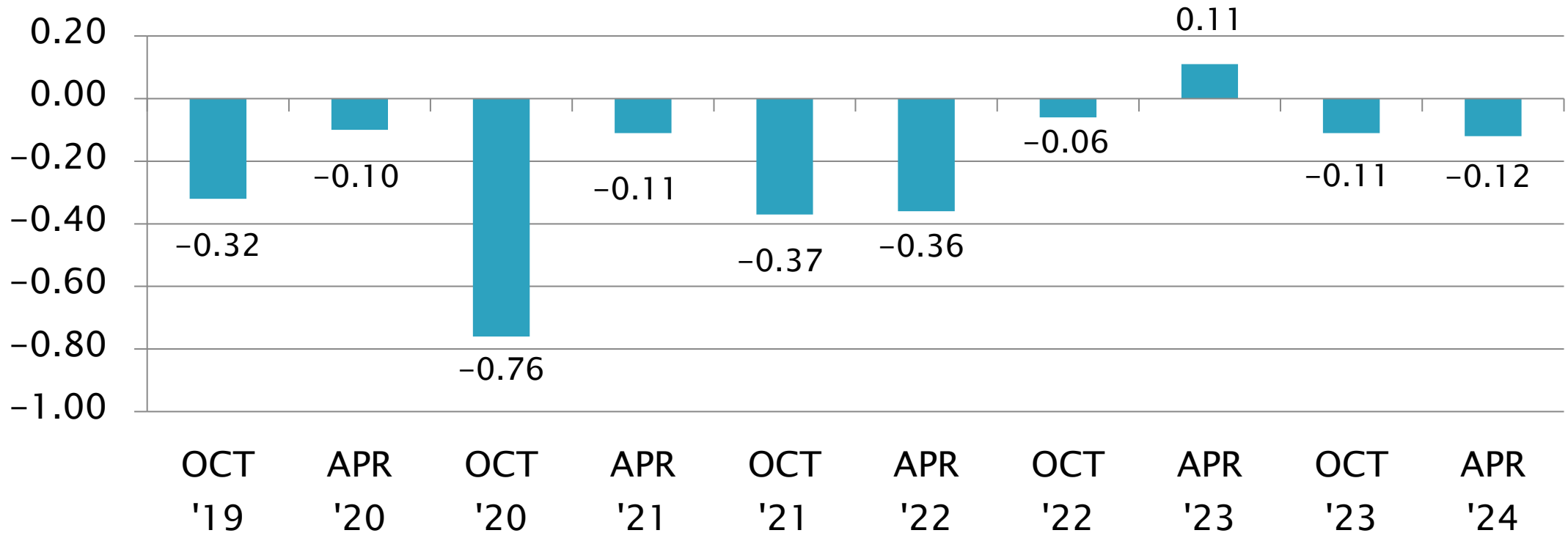
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D7528: Oxidation by ROBO

Natural Log (MRV Viscosity)
Mean Δ/s



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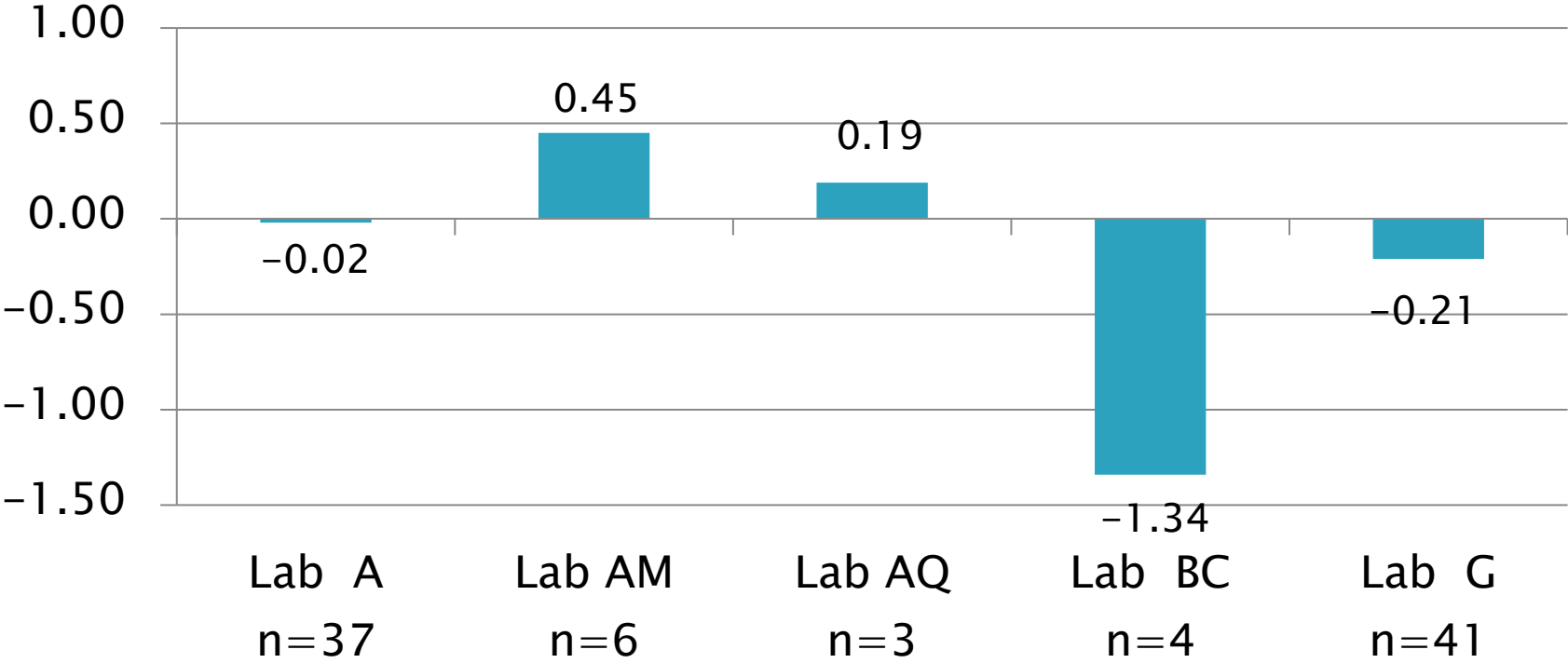
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D7528: Oxidation by ROBO

Natural Log (MRV Viscosity)
Mean Δ/s



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D7528: Oxidation by ROBO

- ▶ Precision (Pooled s) improved to 0.17 and is close to target (0.15).
- ▶ Severity (Mean Δ/s) has remained mild at -0.12 and close to last semesters severity of -0.11 .
- ▶ CUSUM severity plot was mild and looks to be continuing in this trend in the current semester.
- ▶ Same number of labs, but three less stands were calibrated this semester.

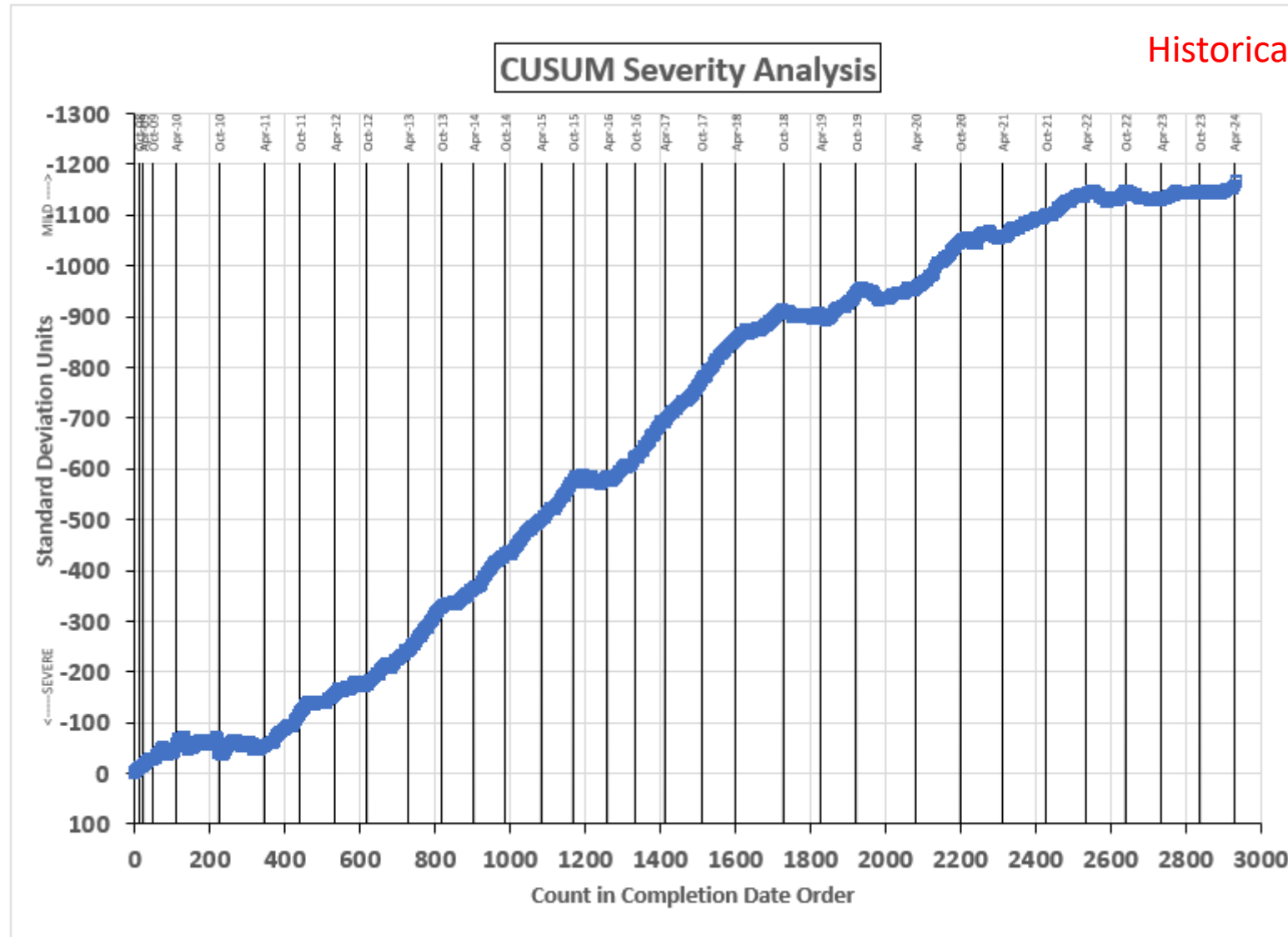
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AGED OIL MRV APPARENT VISCOSITY

Historical Chart



Last 200 Data Points

AGED OIL MRV APPARENT VISCOSITY

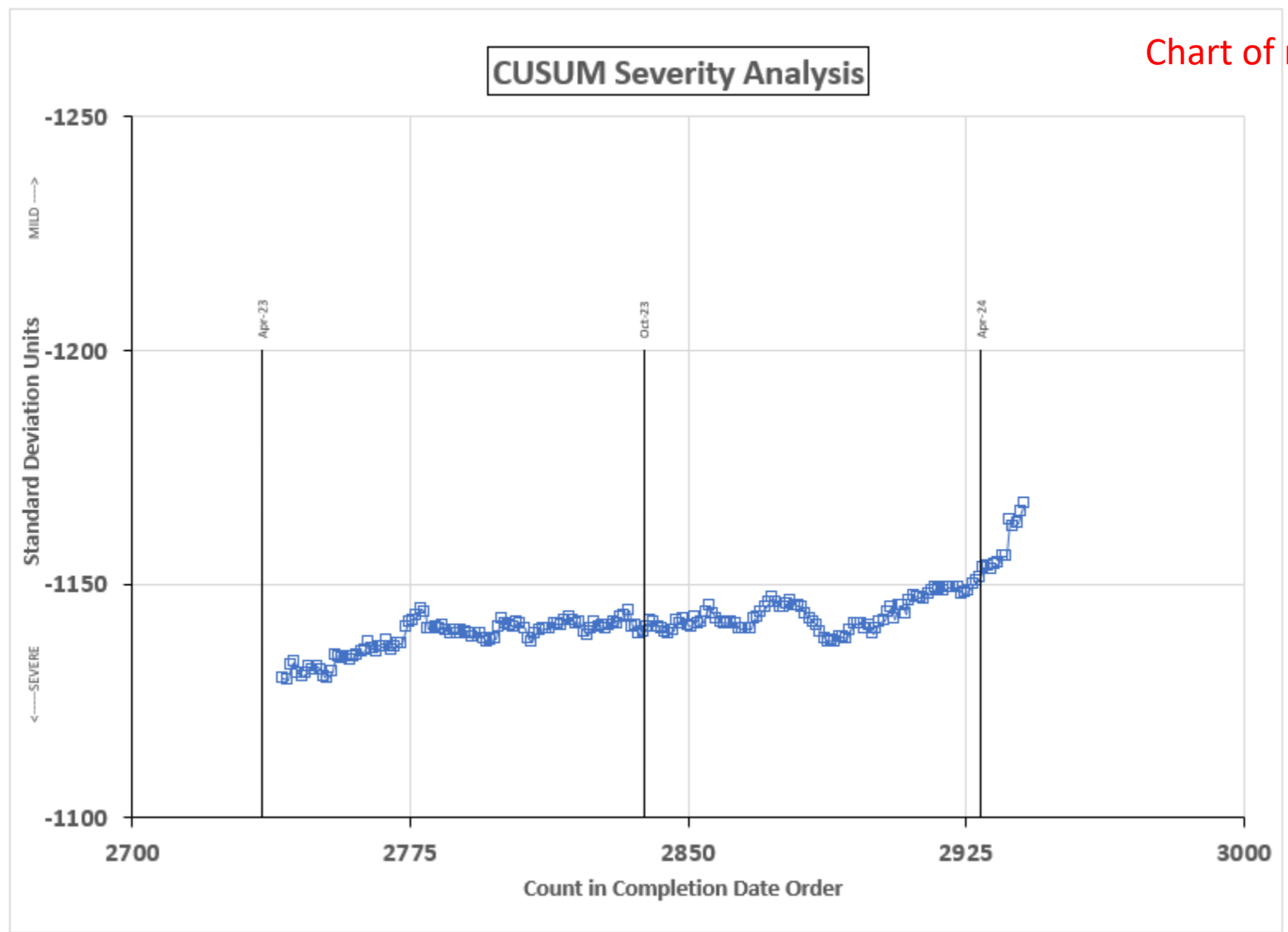
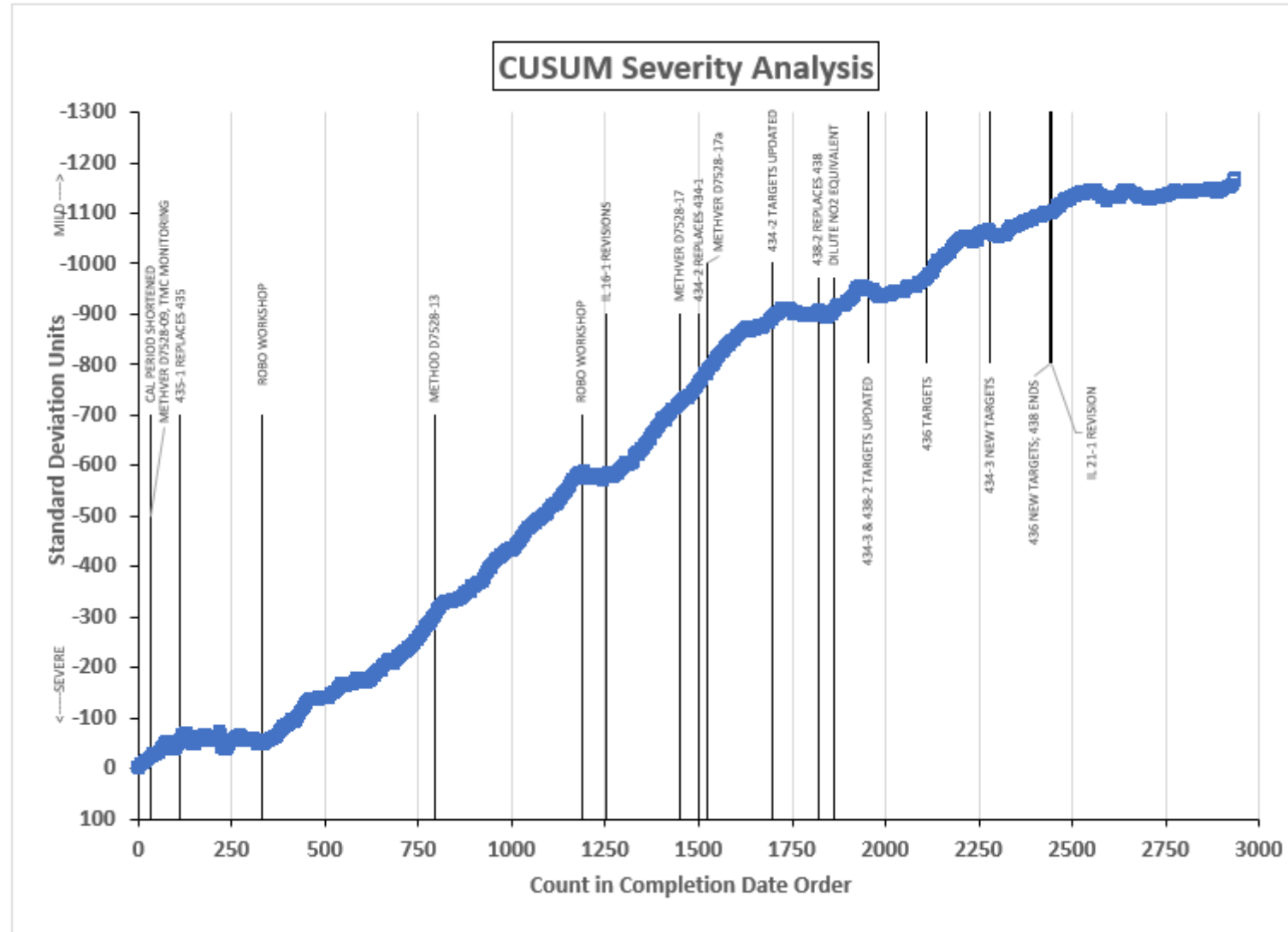


Chart of recent results

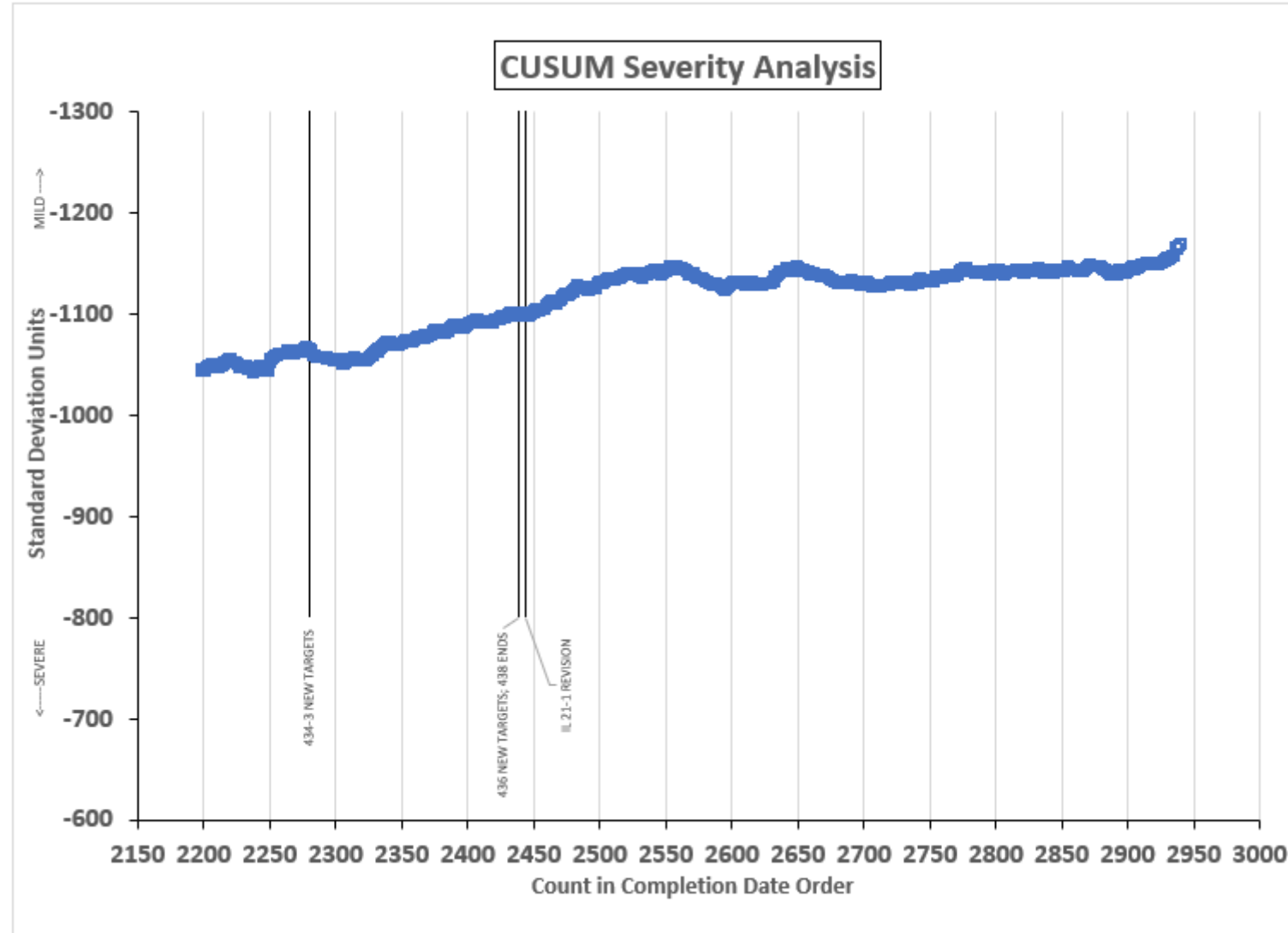
AGED OIL MRV APPARENT VISCOSITY



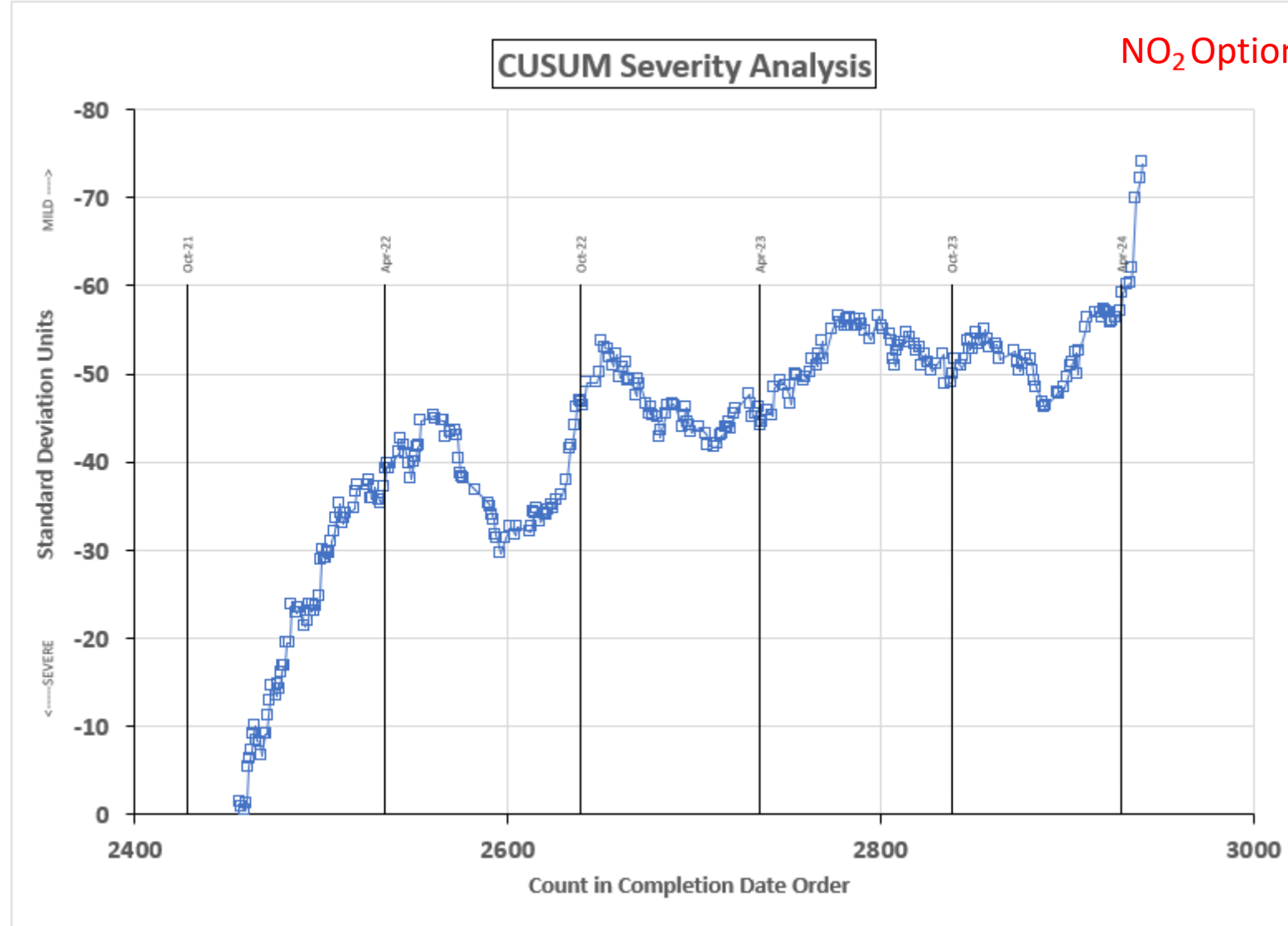
ROBO TEST INDUSTRY OPERATIONALLY VALID DATA

Last 750 Data Points

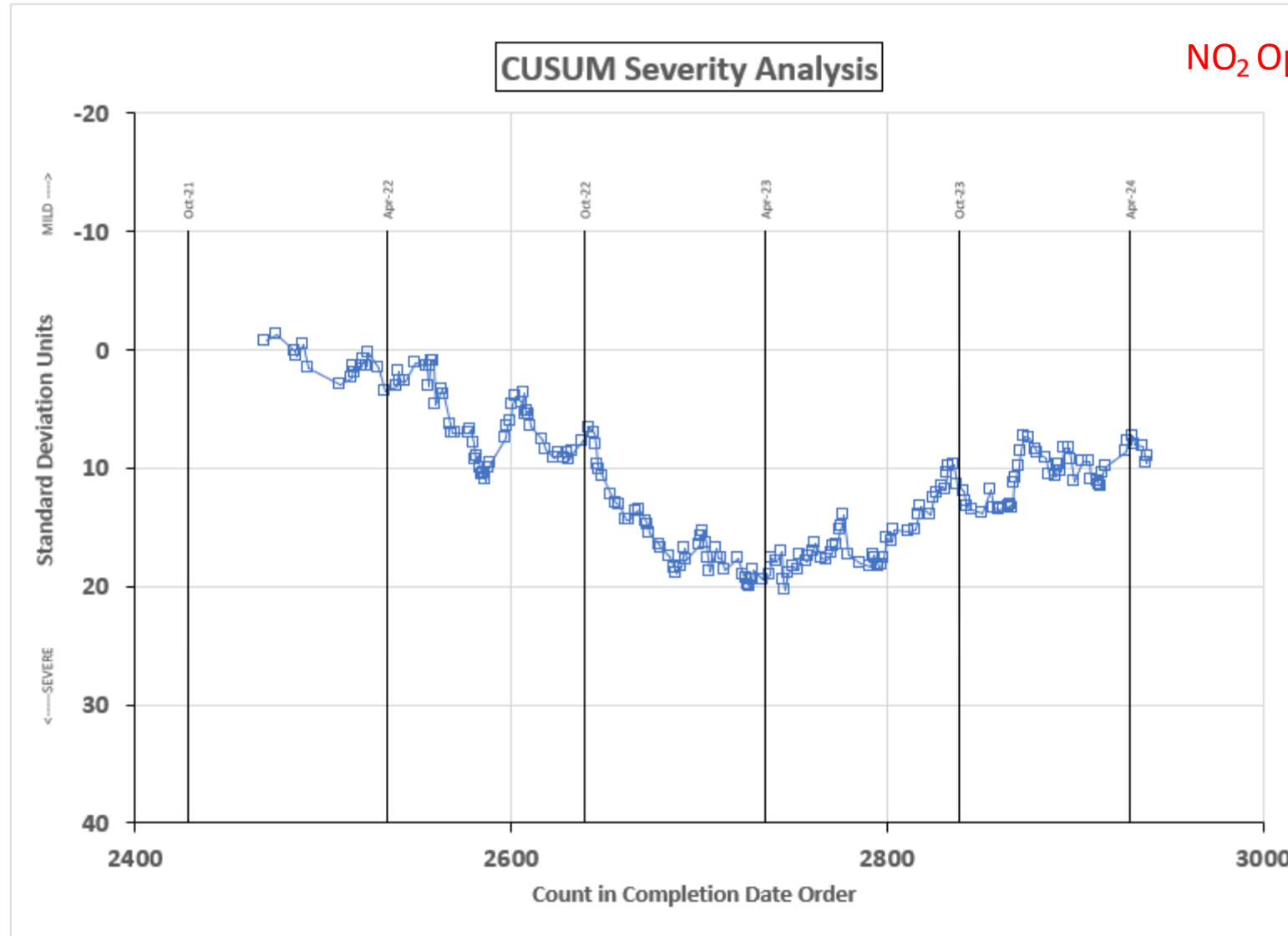
AGED OIL MRV APPARENT VISCOSITY



ROBO TEST INDUSTRY OPERATIONALLY VALID DATA
NO2 Option L ONLY
AGED OIL MRV APPARENT VISCOSITY



ROBO TEST INDUSTRY OPERATIONALLY VALID DATA
NO2 Option D ONLY
AGED OIL MRV APPARENT VISCOSITY

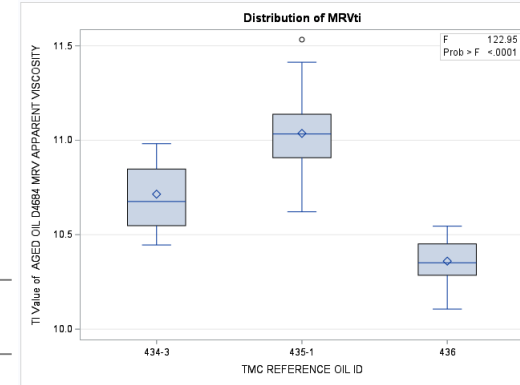
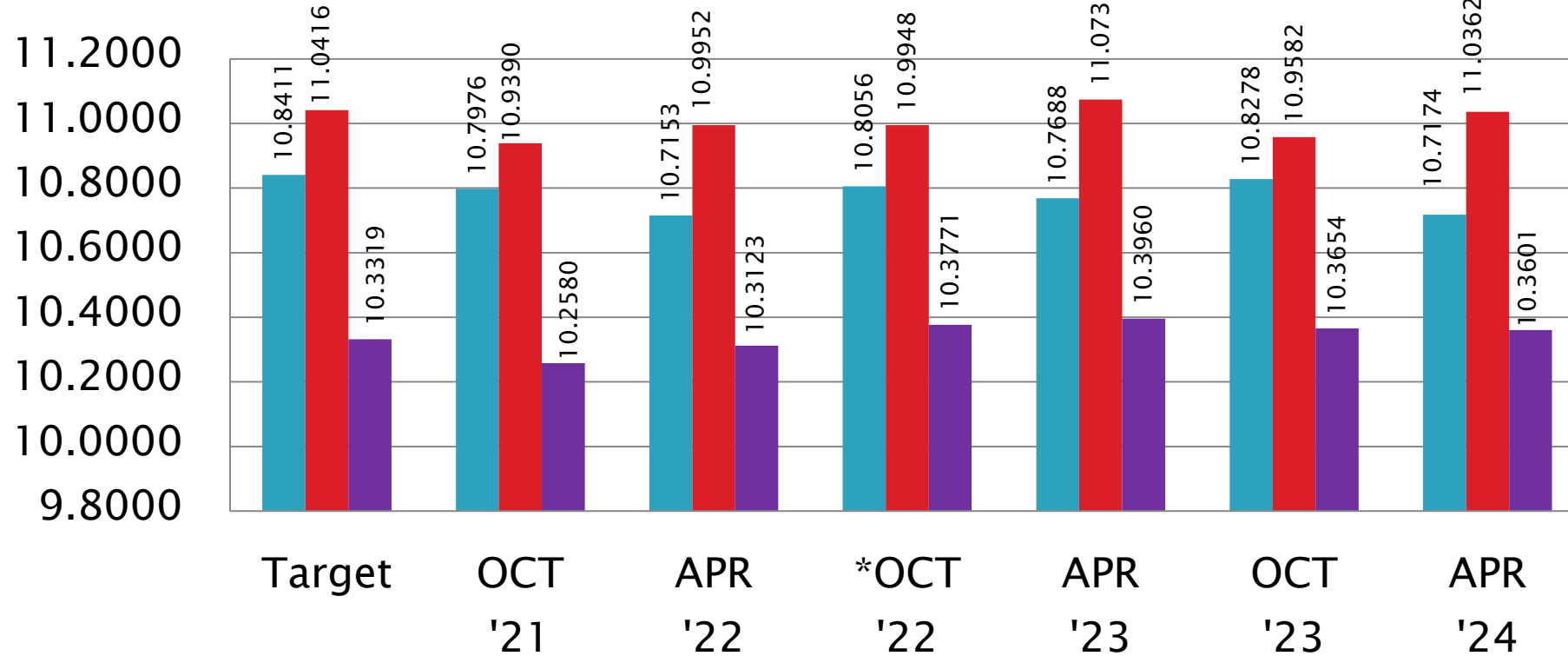


NO₂ Option D Chart

D7528: Oxidation by ROBO

Natural Log (MRV Viscosity)

Mean



- Oil 434-3
- Oil 435-1
- Oil 436

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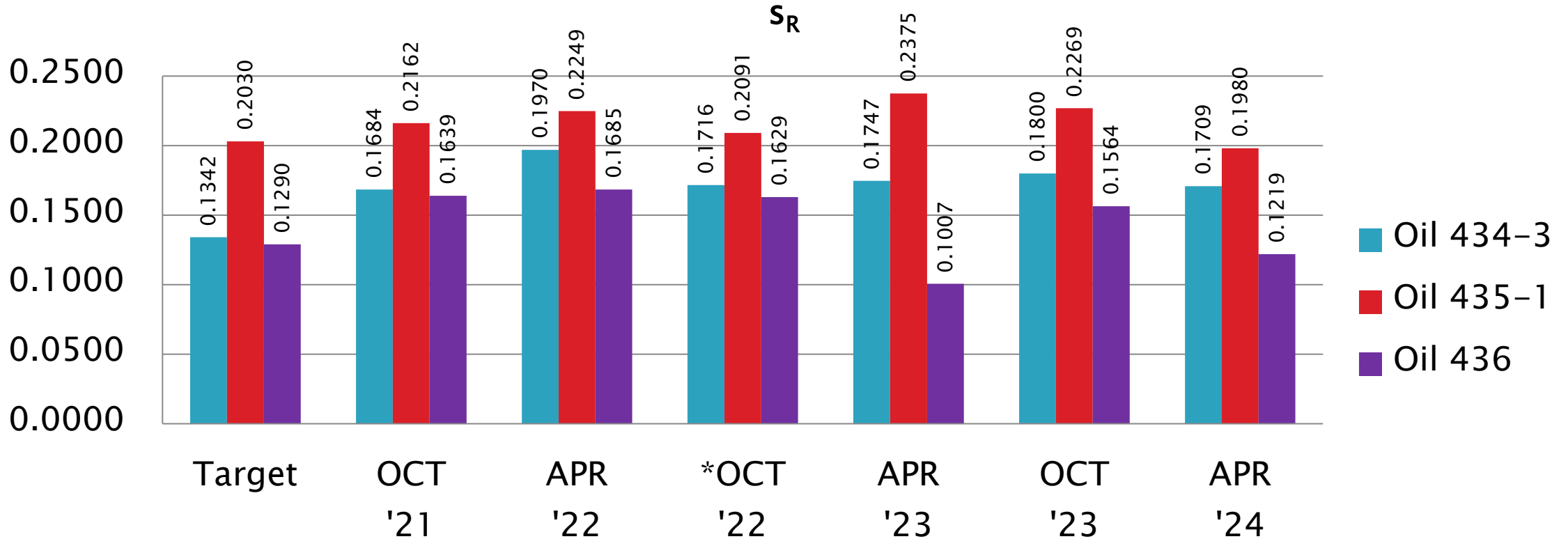
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D7528: Oxidation by ROBO

Natural Log (MRV Viscosity)



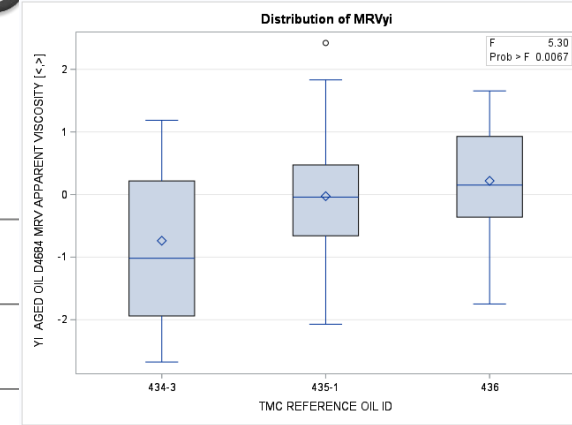
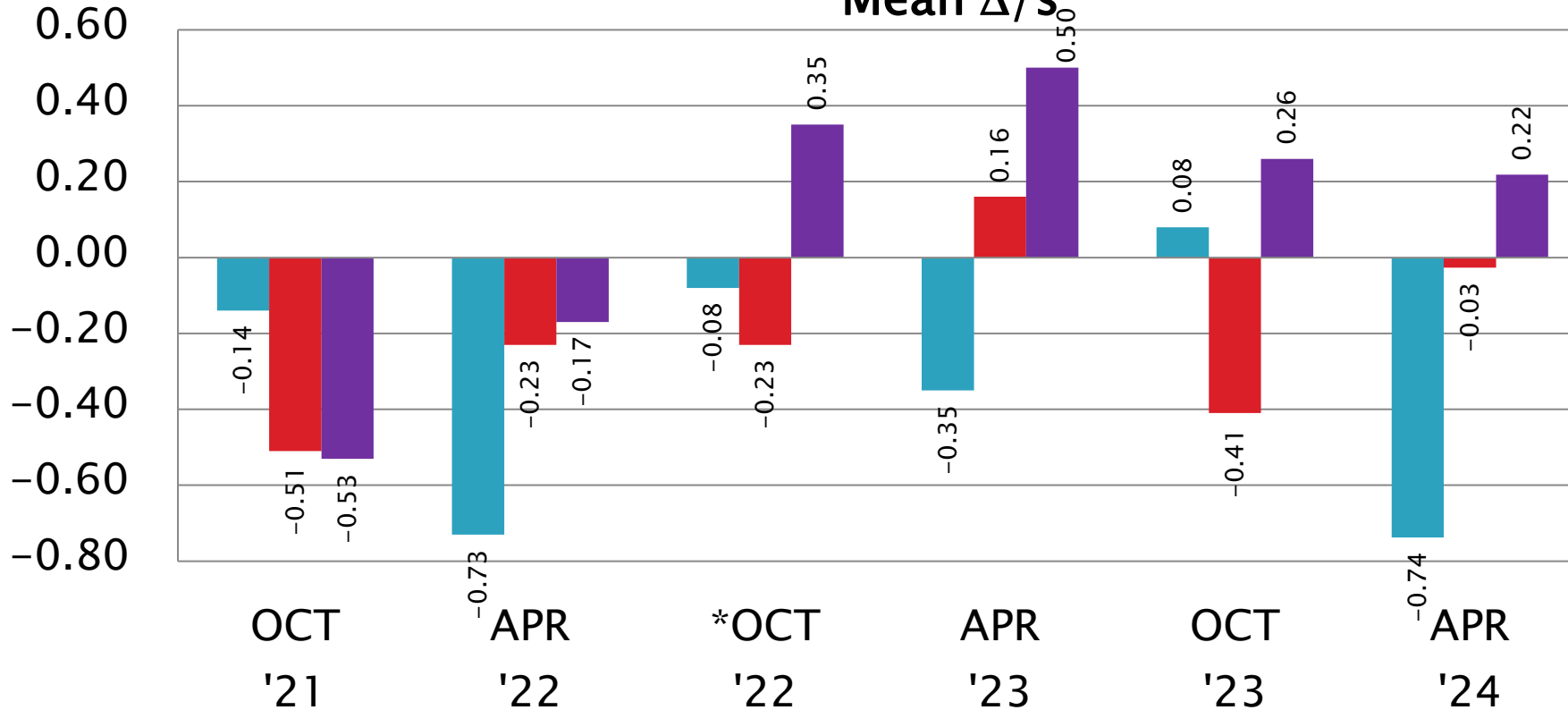
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D7528: Oxidation by ROBO

Natural Log (MRV Viscosity)
Mean Δ/s



- Oil 434-3
- Oil 435-1
- Oil 436

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Reference Oil Inventory

ROBO

Oil	Year Rec'd By TMC ^A	Tests	TMC Inventory, gallons	Gallons Shipped last 6 months	Estimated Life
434-3 ^B	2017	ROBO	18.39	4.42	2 years
435-1	2008	ROBO	46.70	4.55	5 years
436 ^B	2014	ROBO	33.57	3.40	4.5 years

^A Integrity of TMC reference oils is confirmed annually by analytical QC testing of chemical and physical properties.

^B Multi-test oil; estimated aliquot reserved for bench testing.

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Reference Oil Inventory



As of 9/30/2023

Reference Oil Inventory: April 2024

<u>Original Blend</u>	<u>Section</u>	<u>Oil</u>	<u>Tests</u>	<u>Year</u>	<u>Blend Quantity</u>	<u>TMC Inventory</u>	<u>Estimated Life</u>
44	BENCH	44-5	D6594	2022	54	52	> 5
52	BENCH	52	D6417	1995	100	59.4	> 5
55	BENCH	55	D6417	1995	100	65.9	> 5
58	BENCH	58	D6417, D6417QC, GI	1998	159	110.2	> 5
66	BENCH	66	D6082	2002	108	67.7	> 5
75	BENCH	75-1 (75-2)	TEOST	2016	10	1.22	1
77	BENCH	77-3	EOWT	2015	900	404.8	> 5
79	BENCH	79	EOFT, EOWT	2014	1026	154.7	1.7
82	BENCH	82-1	BRT	2008	10	1.5	2
86	BENCH	86	BRT	2017	54	49.1	>5
87	BENCH	87	BRT	2017	98	93.0	>5
90	BENCH	90	D874, D874QC	2005	49.5	3.8	1.5
91	BENCH	91	D874	2006	5	2.99	> 5
92	BENCH	92	D874	2020	52	52.6	> 5
432	BENCH	432	MTEOS	1998	207	101.5	> 5
434	BENCH	434-3	TEOST, ROBO	2017	55	18.4	2
435	BENCH	435-1	ROBO	2008	55	46.7	> 5
435	BENCH	435-2	TEOST	2010	550	33.4	> 5
436	BENCH	436	ROBO	2014	55	33.6	> 5
820	BENCH	820-2	D874	2001	55	6.0	> 5
1005	BENCH	1005-5	D6594	2015	55	34.9	> 5
1006	BENCH	1006	BRT	1996	55	28.9	>5
1009	BENCH	1009	GI	2002	55	33.6	> 5
FOAMB18	BENCH	FOAM18B	D6082	2018	102	71.1	> 5
GIA17	BENCH	GIA17	GI	2017	10	5.5	> 5
GIC18	BENCH	GIC18	GI	2018	10	8.2	> 5
SL107	BENCH	SL107	EOEC, LDEOC	2019	3868	1742	3.5
VOLC12	BENCH	VOLC12	D5800	2013	55	20.2	> 5
VOLD12	BENCH	VOLD12	D5800	2013	55	18.2	> 5
VOLD18	BENCH	VOLD18	D5800QC	2018	1092	614	> 5
VOLE12	BENCH	VOLE12	D5800	2012	55	16.0	> 5

Additional Information

Additional Information

- ▶ Available on the TMC's Website:
 - Lubricant Test Monitoring System (LTMS) Document
 - CUSUM Severity Plots
 - Reference Data, Period Statistics and Timelines
 - Information Letters and Technical Memos
 - Report Forms & Data Dictionaries
 - Online Store, and more...

- ▶ www.astmtmc.org

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